The transition into Norwegian Sports High Schools

Measures to optimise student athlete management and development

by

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Stavanger, June 2023

Cathrine Nyhus Hagum

Summary

Background: The thesis addresses student athletes attending the optional program subject Elite Sport in Norwegian high schools. The context for the thesis is related to the increasing literature showing the challenges associated with student athletes combining sports and education.

Aims: The overall aim of the thesis was to empirically increase our understanding of student athletes attending Norwegian sports high schools and identify possible measures that can be implemented to optimise the combination of sports and education in student athletes. Three separate studies had specific aims subordinated to the overall aim. The knowledge derived from the thesis can hopefully inform future measures to facilitate good experiences in school, sports and life for student athletes and ensure optimal student athlete management and development.

Methodology: The thesis had a quantitative approach, and the three sub-studies investigated three different samples in Norwegian sports high schools. *Study I* and *II* had a cross-sectional design, whereas *Study III* was a randomised controlled trial. The statistical methods applied were primarily structural equation modelling (SEM) in Mplus and general linear model (GLM) in SPSS. This included confirmatory analysis (CFA), exploratory factor analysis (EFA), analysis of variance (ANOVA), multivariate analyses of variance (MANOVA) and chi-square (χ^2) test. The data from the three sub-studies are the basis of four separate papers presented in this thesis. In addition to the four papers, the thesis consists of a synopsis that further elaborates the thesis's position in the research field and the underlying theoretical stance. The synopsis further describes the alignment and consistency between the theoretical stance and the thesis's approach, design, methods, instruments, and statistical analyses. A discussion of the implications of the study's main

findings, limitations and opportunities for further research is also included in the synopsis.

Results: In *Paper I*, the main aim was to translate a questionnaire measuring training distress in athletes and examine its factorial validity. The results showed that the questionnaire could be considered an accepted psychometric tool with some modifications.

In *Paper II*, the main aim was to describe training volume and training distress in student athletes studying Elite Sport. The results showed differences in training volume for sports, but not for gender, school year and program. Girls experienced more physical and psychological training distress than boys. Results showed differences in perceived physical and psychological training distress between school years with different training volumes.

Paper III examined perceived relationships and communication (relational coordination) within and between student athletes, club coaches, school coaches, schoolteachers, parents, and health personnel. The results showed that student athletes, club coaches, and school coaches perceived moderate to weak relational coordination with parents, schoolteachers, and health personnel. Student athletes' relational coordination score with parents was the only strong score observed. Furthermore, the results reveal notable differences in student athletes' relational coordination with the roles according to their characteristics.

Paper IV investigated the effect of communication and coordination combined with a progressive and individualised sport-specific training program to reduce all-complaint injuries in student athletes transitioning to a high school sports academy. The results indicated a significant between-group difference in injuries, where the control group had 1.8 times higher injury risk than the experimental group following enrolment.

Conclusion: The knowledge generated via this thesis can be used to inform future measures that aim to enhance the combination of sports and education in student athletes for optimal development. In summary, this thesis highlights a holistic view of student athletes and suggests that those involved with the student athletes should consider the whole picture, including physiological, psychological, biomechanical, and other life factors, for optimal student athlete management and development. Regular monitoring over time using an electronic diary available for all the roles involved with the student athlete can have educational purposes and help school coaches and club coaches to track student athletes' training load, training distress stress and injury status. High-quality relationships and communication between all of the involved roles are vital components for optimal development of student athletes. A particular focus should be on critical transitional phases, such as transitioning from middle to high school. Close follow-up during such periods can contribute to a safer transition to the increased demands student athletes face after enrolment to an elite sports high school.

Sammendrag på norsk (Summary in Norwegian)

Bakgrunn: Avhandlingen omhandler idrettselever som er tilknyttet det valgfrie programfaget Toppidrett i norske videregående skoler. Bakgrunnen for avhandlingen er relatert til den økte mengden litteratur som peker på utfordringene som er forbundet med idrettselever som kombinerer idrett og skole.

Formål: Avhandlingens overordnede formål var å empirisk øke kunnskapen om idrettselever i norske idrettsskoler og identifisere mulige tiltak som kan iverksettes for å optimalisere kombinasjonen av idrett og skole for idrettselever. Tre separate delstudier hadde spesifikke formål underordnet avhandlingens overordnede formål. Kunnskapen hentet fra avhandlingen kan forhåpentligvis informere om tiltak som kan legge til rette for gode opplevelser i skolen, idretten og i hverdagslivet ellers for idrettselever, samt sikre best mulig ledelse og utvikling av idrettselever.

Metode: Avhandlingen hadde en kvantitativ tilnærming, og de tre delstudiene undersøkte tre ulike utvalg i norske videregående idrettsskoler. *Studie I* og *II* hadde et tverrsnittsdesign, mens *Studie III* var en randomisert kontrollert studie. De statistiske metodene som ble brukt for å nå forskningsmålene var primært strukturell ligningsmodellering (structural equation modeling, SEM) i Mplus og generaliserte lineære modeller (general linear model, GLM) i SPSS. Dette inkluderte bekreftende faktoranalyse (cofirmatory factor analysis, CFA), eksplorerende faktoranalyse (exploratory factor analysis, EFA), variansanalyse (analysis of variance, ANOVA), multivariate variansanalyser (multivariate analysis of variance, MANOVA) og kjikvadrattest. Dataene fra de tre delstudiene er grunnlaget for fire separate vitenskapelige artikler presentert i denne avhandlingen. I tillegg til de fire artiklene består avhandlingen av en synopsis som ytterligere utdyper avhandlingens posisjon i forskningsfeltet og det underliggende

teoretiske standpunktet. Synopsisen beskriver videre sammenhengen og konsistensen mellom det teoretiske standpunktet og oppgavens tilnærming, metoder, design, instrumenter og statistiske analyser. Implikasjonene av studiens hovedfunn, begrensninger og muligheter for videre forskning diskuteres også i synopsisen.

Resultater: I *Paper I* var hovedformålet å oversette et spørreskjema som måler treningsrelatert stress hos idrettselever og undersøke spørreskjemaets faktorielle gyldighet. Resultatene viste at spørreskjemaet kunne betraktes som et akseptert psykometrisk verktøy med noen modifikasjoner.

I *Paper II* var hovedformålet å beskrive treningsvolum og treningsrelatert stress hos idrettselever tilknyttet programfaget Toppidrett. Resultatene viste forskjeller i treningsvolum for type idrett, men ikke for kjønn, skoleår og programfag. Jenter opplevde mer fysisk og psykisk treningsrelatert stress enn gutter. Resultatene viste også forskjeller i opplevd fysisk og psykisk treningsbelastning mellom skoleår med ulikt treningsvolum.

Paper III undersøkte opplevd relasjon og kommunikasjon (relasjonell koordinering) innen og mellom idrettselever, klubbtrenere, skoletrenere, skolelærere, foreldre og helsepersonell. Resultatene viste at idrettselever, klubbtrenere og skoletrenere opplevde moderat til svak relasjonell koordinering med foreldre, skolelærere og helsepersonell. Idrettselevers relasjonelle koordinasjon med foreldre var den eneste sterke skåren som ble observert. Videre viste resultatene forskjeller i idrettselevers relasjonelle koordinering med de ulike rollene i henhold til deres karakteristika.

Paper IV undersøkte effekten av kommunikasjon og koordinering kombinert med et progressivt og individualisert idrettsspesifikt treningsprogram for å redusere skader hos idrettselever som starter på programfaget Toppidrett i videregående skole. Resultatene indikerte en signifikant forskjell mellom gruppene i forekomsten av skader, der kontrollgruppen hadde 1,8 ganger høyere skaderisiko enn forsøksgruppen etter oppstart på idrettsskolen.

Konklusjon: Kunnskapen fra denne avhandlingen kan gi informasjon om tiltak som kan bidra til å optimalisere kombinasjonen av idrett og skole hos idrettselever for best mulig utvikling. Oppsummert fremhever avhandlingen et helhetlig syn på idrettselever og foreslår at involverte personer bør betrakte helheten, inkludert fysiologiske, psykologiske, biomekaniske og andre livsfaktorer for best mulig ledelse og utvikling av idrettselever. Regelmessig monitorering over tid ved hjelp av en elektronisk dagbok som er tilgjengelig for alle personene som er involvert med idrettseleven kan ha pedagogiske formål og hjelpe skoletrenere og klubbtrenere med å ha en oversikt over idrettselevens treningsbelastning, treningsrelatert stress og skadestatus. Relasjoner og kommunikasjon av høy kvalitet mellom alle involverte personer er viktig for en best mulig utvikling av idrettselever. Et spesielt fokus bør være på kritiske overgangsfaser, som for eksempel overgangen fra ungdomsskolen til videregående skole. Tett oppfølging i slike perioder kan bidra til en tryggere overgang til de økte kravene idrettselever møter etter oppstart på en idrettsskole.

List of papers

The thesis is based on the following research papers, which are referred to by Roman numerals:

I: Hagum, C. N., & Shalfawi, S. A. I. (2020). The Factorial Validity of the Norwegian Version of the Multicomponent Training Distress Scale (MTDS-N). *International journal of environmental research and public health*, *17*(20), 7603. https://doi.org/10.3390/ijerph17207603

II: Hagum, C. N., Tønnessen, E., & Shalfawi, S. A. I. (2022). Progression in training volume and perceived psychological and physiological training distress in Norwegian student athletes: A cross-sectional study. *PLoS One*, *17*(2). https://doi.org/10.1371/journal.pone.0263575

III: Hagum, C. N., Tønnessen, E., Nesse, M. A., & Shalfawi, S. A. I. (2023). A holistic analysis of team dynamics using relational coordination as the measure regarding student athlete total load: A cross-sectional study. *Sports*, *11*(5), 104. https://doi.org/10.3390/sports11050104

IV: Hagum, C. N., Tønnessen, E., Hisdal, J., & Shafawi, S. A. I. (2023). The effect of progressive and individualised sport-specific training on the prevalence of injury in football and handball student athletes: a randomised controlled trial *Frontiers in sports and active living*, *5*, 1-11. https://doi.org/10.3389/fspor.2023.1106404

Abbreviations

ASQ	Adolescent Stress Questionnaire
ASQ-N	The Norwegian Adolescent Stress Questionnaire
CI	Confidence Interval
DDA	Descriptive Discriminant Analysis
IOC	International Olympic Committee
M	Mean
MANOVA	Multivariate Analyses of Variance
MTDS	Multicomponent Training Distress Scale
MTDS-N	The Norwegian Multicomponent Training Distress Scale
OSTRC	Oslo Sports Trauma Research Center
OSTRC-H2	Oslo Sports Trauma Research Center on Health Problems
RC	Relational Coordination
RCT	Randomised Controlled Trial
RPE	Rating of Perceived Exertion
SD	Standard Deviation

Table of Contents

Acknowledgements iv

Summary vi

Sammendrag på norsk (Summary in Norwegian) ix

List of papers xii

Abbreviations xiii

1 Definition of terms 21

1.1 Dual career 21

1.1.1 Elite Sport program 21

1.2 Load 21

1.3 Training load 21

1.3.1 External and internal load 21

1.3.2 Psycho-physiological load 22

1.4 Non-sports load 22

1.5 Health problems 22

1.5.1 Injury and illness 22

1.5.2 Substantial health problems 23

2 Introduction 24

3 Aims of the thesis 26

4 Theory 29

4.1 Dual career 29

4.2 Norwegian elite sport schools 29

4.3 The Elite Sport program 30

4.4 Load 32

4.4.1 Training load 32

4.4.2 Life load 33

4.5 Progression in training load 35

4.6 Training load and injury risk 37

4.6.1 Methods of estimating injury risk 39

4.6.2 Prevalence of injuries and injury location 41

4.6.3 Developing robust athletes 42

4.7 Team Dynamics Theory 43
4.8 Holistic Ecological Approach 44
4.9 Relational Coordination theory 46
4.9.1 Communication dimensions 48
4.9.2 Relationship dimensions 49
5 Methodology 50
5.1 Quantitative study design 50
5.2 Research design 50
5.2.1 The cross-sectional design 51
5.2.2 The experimental design 51
5.3 Sample and procedure 52
5.4 Participants 53
5.5 Ethical approvals 54
5.6 Data collection and measures 54
5.6.1 Physiological and psychological training distress 54
5.6.2 Relational Coordination 55
5.6.3 Non-sports load 55
5.6.4 Training load monitoring 55
5.6.5 Health problem surveillance 56
5.6.6 Load management 57
5.7 Data management and statistical analyses 58
5.7.1 Paper Ⅰ 59
5.7.2 Paper Ⅱ 59
5.7.3 Paper Ⅲ 60
5.7.4 Paper Ⅳ 60
6 Results 62
6.1 Training volume and perceived training distress (Paper Ⅰ and Paper Ⅱ) 62
6.1.1 Paper I 62
6.1.2 Paper II 63
6.2 Perceived communication and coordination (Paper Ⅲ) 65
6.3 The effect of communication and individualised sport-specific training on injury (Paper Ⅳ) 67
7 Discussion 69

7.1 Training volume and perceived training distress 69
7.1.1 Training distress in student athletes 69
7.1.2 Training volume in student athletes 71
7.2 Perceived communication on coordination 76
7.3 The effect of communication and individualised sport-specific training on injury 78
7.3.1 Injury location 79
7.4 Methodological considerations 84
7.4.1 General strengths and limitations 84
7.4.2 Study design 84
7.4.3 Participants and sample size 85
7.4.4 Attrition and missing data 86
7.4.5 Specific for Study Ⅲ 87
7.5 Validity 88
7.5.1 Internal validity 88
7.5.2 External validity 91
7.5.3 Construct validity and statistical conclusion validity 92
7.6 Ethical considerations 93
8 Conclusion and implications 96
8.1 Practical implications and future research 97
9 References 98
Paper I 127
Paper II 172
Paper III 197
Paper IV 219
Appendices 233
Appendix 1 – Copyright Figure 2 233
Appendix 2 – Copyright Figure 3 234
Appendix 3 – Copyright Figure 4 239
Appendix 4 – Copyright Figure 5 244
Appendix 5 – Copyright Figure 6 249
Appendix 6 – NSD Study Ⅰ and Ⅱ 250

Appendix 7 – NSD Study Ⅲ 252
Appendix 8 – REK Study Ⅲ 254
Appendix 9 – Informed consent Study Ⅰ 257
Appendix 10 – Informed consent Study Ⅱ 260
Appendix 11 – Informed consent Study Ⅱ 263
Appendix 12 – Informed consent Study Ⅲ 266
Appendix 13 – MTDS-N 269
Appendix 14 – RCS – Student atheltes 271
Appendix 15 – RCS – School coaches 275
Appendix 16 – RCS – Club coaches 278
Appendix 17 – ASQ-N 282
Appendix 18 – OSTRC-H2 283

Table of Figures

Figure 1 – An overview of the coherence between the overall theme in the thesis, the three sub-studies, and the four research papers..... 27
Figure 2 – Strategies for progressing training load from the athlete's floor (i.e., current capacity) to the ceiling (i.e., required capacity). The basement illustrates inadequate capacity to sustain normal training loads, while the penthouse illustrates greater load capacity than previously possible due to raising the floor. From "How much? How fast? How soon? Three simple concepts for progressing training loads to minimize injury risk and enhance performance," by Gabbett, T. J., 2020, J*ournal of orthopaedic & sports physical therapy*, *50*(10), 570-573. Reprinted with permission (Appendix 1).. 36
Figure 3 – The updated workload-injury aetiology model showing the multifactorial, non-linear nature of athletes' injury risk, initially designed by Meeuwisse et al. (2007). The figure illustrates that load is the vehicle that drives athletes to or from injury. From "How do training and competition workloads relate to injury? The workload—injury aetiology model", by Windt, J., & Gabbett, T. J., 2016, *British journal of sports medicine*, *51*(5), 428-435. Repreinted with permission (Appendix 2)............. 38
Figure 4 – An integrated, holistic view of load capacity, load, health, and performance in sports. The solid lines represent positive relationships, while the dotted lines represent negative relationships. From "Load, capacity and health: critical pieces of the holistic performance puzzle", by Verhagen, E., and Gabbett, T., 2019, *Br J Sports Med*, *53*(1), 5-6. https://doi.org/10.1136/bjsports-2018-099819. Reprinted with permission (Appendix 3).. 39
Figure 5 – Moderators (green boxes and arrows) and circular causation (red boxes and circles) align to develop physical capacity and injury resilience in athletes. From "In pursuit of the 'Unbreakable'Athlete: what is the role of moderating factors and circular causation?», by Gabbett, T. J., Nielsen, R. O., Bertelsen, M. L., Bittencourt, N. F. N., Fonseca, S. T., Malone,

S., Møller, M., Oetter, E., Verhagen, E., & Windt, J., 2019, *British journal of sports medicine*, *53*(7), 394-395. Reprinted with permission (Appendix 4). 43
Figure 6 – Positive and negative mutually reinforcing cycles of Relational Coordination. Adapted from "Revisiting relational coordination: A systematic review", by Bolton, R., Logan, C., & Gittell, J. H., 2021, *The Journal of Applied Behavioral Science*, *57*(3), 290-322. Reprinted with permission (Appendix 5). 47
Figure 7 – Overview of the sub-studies, papers, research design and participants in the thesis 53
Figure 8 – An overview of the training load recording process for a football player 56
Figure 9 – Weekly training volume for gender, type of sport, school program and school year. SGS = Specialization in general studies; SPE = Sports and physical education. 65
Figure 10 – The quality of relational coordination among the participants. Black boxes indicate roles that were not surveyed. Arrows from one box to another indicate the roles perceived quality of relational coordination. Lines between two boxes indicate a mutual quality of relational coordination between the roles. 66
Figure 11 – The prevalence of health problems during 22 weeks. The summer holiday was from week 24 to week 31. The school started in week 32. 68

Appendices

Appendix 1 – Copyright Figure 2 233
Appendix 2 – Copyright Figure 3 234
Appendix 3 – Copyright Figure 4 239
Appendix 4 – Copyright Figure 5 244
Appendix 5 – Copyright Figure 6 249
Appendix 6 – NSD Study I and II 250
Appendix 7 – NSD Study III 252
Appendix 8 – REK Study III 254

Appendix 9 – Informed consent Study Ⅰ 257
Appendix 10 – Informed consent Study Ⅱ 260
Appendix 11 – Informed consent Study Ⅱ 263
Appendix 12 – Informed consent Study Ⅲ 266
Appendix 13 – MTDS-N 269
Appendix 14 – RCS – Student atheltes 271
Appendix 15 – RCS – School coaches 275
Appendix 16 – RCS – Club coaches 278
Appendix 17 – ASQ-N 282
Appendix 18 – OSTRC-H2 283

1 Definition of terms

1.1 Dual career

The term dual career refers to individuals who pursue sports and education or vocational endeavours (Cartigny et al., 2021; Stambulova et al., 2015).

1.1.1 Elite Sport program

As long as a school offers a program in Elite Sport, the school is considered an “elite sport school ” or “top sport school” (Kristiansen & Houlihan, 2017).

1.2 Load

Load is defined as the burden from sport and non-sport as a stimulus applied to a person’s biological system (Soligard et al., 2016). This thesis will refer to the burden from sports and non-sport as the total load.

1.3 Training load

Training load is defined as the cumulative stress placed on a person from a single or several structured or unstructured training sessions over a given period (Soligard et al., 2016).

1.3.1 External and internal load

Training load is either external and/or internal (Impellizzeri et al., 2005), depending on whether one refers to measurable aspects taking place internally or externally to the athlete (Impellizzeri et al., 2019). External load is defined as the work done by an athlete measured independently of one’s internal characteristics (Wallace et al., 2009). Internal load is the relative physiological and psychological stress imposed on an athlete (Halson, 2014; Wallace et al., 2009).

1.3.2 Psycho-physiological load

Psycho-physiological load is the psycho-physiological stress an athlete experiences in response to a specific external load (Kalkhoven et al., 2021). A common psycho-physiological measure is the rating of perceived exertion (RPE) (Kraemer et al., 2012, p. 397). The psycho-physiological stress experienced by an athlete is believed to contribute significantly to the training outcome (Kalkhoven et al., 2021).

1.4 Non-sports load

Non-sports load is the cumulative amount of stress placed on a person from non-sport activities, including all physiological and psychological stimuli/ stressors outside of sports (Soligard et al., 2016).

1.5 Health problems

A health problem is defined as any condition that is considered to be a reduction in a person's normal state of full health, regardless of its consequences on sports participation or performance or whether requiring medical attention (Clarsen et al., 2020). A health problem can include injury, illness, pain or mental health conditions (Clarsen et al., 2020). The definition aligns with the IOC consensus statement, which undergoes methods for recording and reporting epidemiological data on injury and illness in sports (Bahr et al., 2020).

1.5.1 Injury and illness

Health problems are classified as injuries if they are disorders of the musculoskeletal system or concussions. If the health problems involve other body systems, such as the respiratory, digestive and neurological systems, as well as non-specific/generalised, psychological and social problems, they are classified as illnesses (Clarsen et al., 2014).

1.5.2 Substantial health problems

Substantial health problems are defined as health problems leading to moderate or severe reductions in the athletes' training volume, a reduction in sports performance of a moderate to a drastic degree, or an absolute inability to participate in the sport (Clarsen et al., 2014).

2 Introduction

Many young people are involved in organized sports in Norway and other Scandinavian countries (Støckel et al., 2010). In Norway, 93% of adolescents have, at some point in their childhood or youth, participated in organized sports (Bakken, 2019). Since 2006, adolescents have been able to choose the optional program subject “Elite Sport” in Norwegian high schools (Kristiansen & Houlihan, 2017; Kårhus, 2016, 2019), which enables the combination of education with sports training and performance development. Today, more than 110 private and public schools offer the program subject Elite Sport (Sæther et al., 2022), and it is one of the most popular program subjects (Kårhus, 2016).

Student athletes in the "Elite Sport" program will likely encounter a substantial increase in psychological and physiological load after enrollment (i.e., the stress associated with academic demands, social commitments, employment, sports participation and training load) (Bjørndal et al., 2017; Kristiansen & Stensrud, 2017; McKay et al., 2019). Hence, the combination of sports and education can be challenging as it demands the development of their full potential in both areas (Christensen & Sørensen, 2009; Kristiansen, 2017). The added stress can lead to fatigue and increase the risk of illness and injury (Eckard et al., 2018b; Jones et al., 2017). Previous research has reported high injury prevalence in student athletes after enrolment into a Norwegian Elite Sport high school (Bjørndal et al., 2021; Moseid et al., 2018). Injuries and absence from training and matches can impede individual development (Jones et al., 2019; Wik et al., 2021), potentially having adverse psychological effects (Haraldsdottir & Watson, 2021; Jones et al., 2019; Von Rosen, Kottorp, et al., 2018). In addition, injuries negatively impact team and individual athletic success (Drew et al., 2017). Hence, balancing stress and recovery is crucial for continuous high-level performance (Kellmann et al., 2018).

Multiple people are involved with and influence the student athlete (e.g., club coaches, school coaches, schoolteachers, parents, health personnel, and peers), as most student athletes will participate in club training sessions in the evening, in addition to training during school hours. Consequently, effective coordination and communication are necessary to ensure optimal training load management, foster athletic and academic development and prevent adverse outcomes (Felton & Jowett, 2013; Jowett & Poczwardowski, 2007; Jowett & Shanmugam, 2016; Kristiansen & Stensrud, 2020; Murray, 2017; West et al., 2020). Several tools have been developed to monitor athletes' physical internal and external training loads (Impellizzeri et al., 2019; Impellizzeri et al., 2020). In recent years, athlete self-report measures (ASRMs) have gained considerable popularity as an athlete monitoring strategy (Taylor et al., 2012; Windt et al., 2019). Their popularity stems from the low cost, ease of use, and the growing body of literature that has shown ASRMs to be sensitive to the risk of illness and injury compared to physiological biomarkers (Saw et al., 2016). Notably, a holistic approach (i.e., focusing on the whole person) to athlete monitoring should be adopted to consider physiological and psychological factors, especially for younger athletes with significant physiological and lifestyle changes (Sabato et al., 2016; Thompson et al., 2022).

Despite the focus on health problems and challenges associated with the combination of education and sport participation, practical measures which can be used in elite sport schools to promote optimal athlete development remain unclear. This thesis focuses on student athletes in Norway and evaluates their training volume, training distress, and all-complaint injuries. In addition, the thesis evaluates the relation coordination regarding student athletes' total load within and between student athletes and the vital roles around them.

3 Aims of the thesis

The overall aim of the thesis was to empirically increase the knowledge about student athletes attending Norwegian sports high schools and identify possible measures to optimise the combination of sports and education in student athletes.

Three original sub-studies were planned and completed to achieve the overall aim of the thesis. Through four research papers with their specific aims, it was possible to explore the overall aim from various perspectives. *Study I* was a cross-sectional study of Norwegian student athletes (*Paper I* and *II*). *Study II* was a cross-sectional study of student athletes, school coaches and school coaches from a Norwegian county (*Paper III*). Based on the acquired knowledge from these studies, we completed *Study III*, a randomised controlled trial in football and handball players transitioning to a Sport Academy High School (*Paper IV*). Figure 1 illustrates an overview of the coherence between the overall theme in the present thesis, the three sub-studies, and the four research papers.

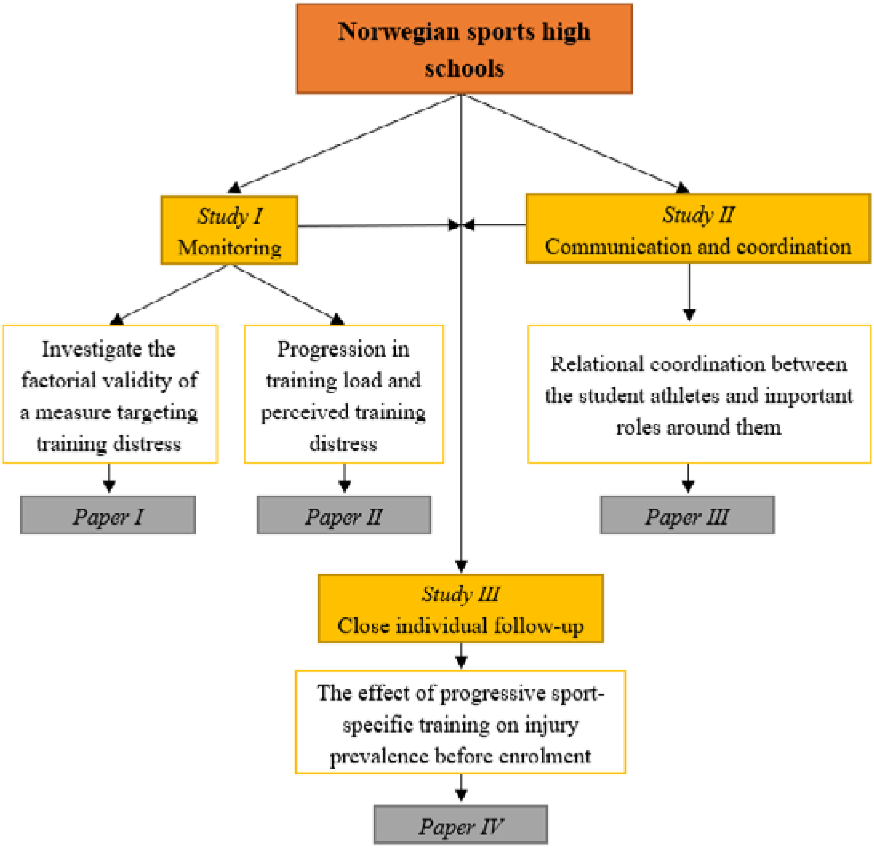

Figure 1 – An overview of the coherence between the overall theme in the thesis, the three sub-studies, and the four research papers

The specific aims for each paper included in the thesis were:

Paper I: To investigate the factorial validity of the Norwegian version of the Multicomponent Training Distress Scale (MTDS-N) among student athletes attending the optional program subject Elite Sport in Norwegian high schools.

Paper II: To describe Norwegian student athletes´ weekly training volume in high schools and determine whether there were differences in training volume according to gender, type of sport, school program, and school level. Another aim was to investigate whether weekly training volume, gender, type of sport, school program, or school level influenced responses to the dimensions in the Norwegian Multicomponent Training Distress Scale (MTDS-N) and whether there were any interaction effects between these variables.

Paper III: To investigate relational communication regarding student athletes' total load within and between Norwegian student athletes, club coaches, school coaches, schoolteachers, parents, and health personnel.

Paper IV: To evaluate the effectiveness of communication and coordination combined with designing a progressive and individualised sport-specific training program for reducing all-complaint injuries in youth female and male football and handball players transitioning to a sports academy high school.

4 Theory

This chapter starts with describing the term dual career, Norwegian sports high schools and the Elite Sport program. An outline of load, training load and life load follow this. Then, the chapter focuses on the progression in training load and injury risk. Finally, the chapter explains Team Dynamic Theory, the Holistic Ecological Approach and the theory of Relation Coordination.

4.1 Dual career

The term dual career refers to individuals who pursue sports and education or vocational endeavours (Cartigny et al., 2021; Stambulova et al., 2015). A dual career can start at a young age and span through the individual's developmental years, where the demands in sports and school vary in typology, volume, intensity, and organization (Condello et al., 2019). There are several career stages and transitions related to the athletic, psychological, psychosocial, academic/vocational, and financial dimensions of student athletes, which occur at different times and have a reciprocal influence on the holistic development (i.e., physical, academic/vocational, psychosocial and psychological domain) of a person (Stambulova & Wylleman, 2019). Dual career experiences can be categorized into three pathways: 1) A dual career pathway, which represents a balance between sport and education; 2) a sporting pathway represents a sport-dominant approach to dual career; and 3) an educational pathway represents an education-dominant approach (Cartigny et al., 2021).

4.2 Norwegian elite sport schools

Organised competitive sport for children and youth is primarily carried out in the school system in many countries, including Australia and the United States. However, in the Scandinavian countries, voluntary competitive sport for children and youth is usually organized outside the context of school, which can be referred to as the "Scandinavian model" (Ferry et al., 2013; Ibsen & Seippel, 2010; Støckel et al., 2010).

In 1981, the first private Norwegian elite sports school was established by Roger Elstad in Bærum (Kristiansen & Houlihan, 2017). Initially this was a school for alpine skiers and was named the Norwegian Alpine Gymnasium (NAG) (Kristiansen & Houlihan, 2017). Over time, the school expanded to include a more comprehensive range of sports (Kristiansen & Houlihan, 2017). Today, NAG is known as the Norwegian College of Elite Sport (NTG), and together with Wang Elite Sport which was established in 1984 (Wang, n.d.), they are the two major providers of intensive sport training in combination with higher education in Norway (Kristiansen & Houlihan, 2017). Former students at these schools have had sporting careers both at an international and national level. For instance, since 1981, former students of NTG have won more than 50 medals in the Olympic Games, 180 medals in Senior World Championship, 200 medals in Junior World Championship, and over 750 world cup medals (Fredheim, 2016). Furthermore, out of 35 athletes who qualified for the 2015 winter European Youth Olympic Festival (EYOF), 14 (40%) were students from NTG and five (14%) were students from Wang (Kristiansen & Houlihan, 2017).

4.3 The Elite Sport program

In 2006, Elite Sport was introduced as an optional program in public schools (Kristiansen & Houlihan, 2017; Kårhus, 2016, 2019). Through the Elite Sport program, students would have opportunities to combine education with sports at a high-performance level regionally, nationally and internationally (The Norwegian Directorate for Education and Training, 2006, p. 2). Furthermore, the program's purpose outlined that youth athletes wanting to pursue targeted and systematic training in competitive sports should be allowed to do so (The Norwegian

Directorate for Education and Training, 2006, p. 2). More than 110 public and private schools offer Elite Sport today (Sæther et al., 2022). As long as a school offers a school program in Elite Sport, the school is considered an “elite sport school ” or “top sport school” (Kristiansen & Houlihan, 2017). The student athletes can choose between “specialization in general studies” with the optional program subject Elite Sport or “sports and physical education” with the Elite Sport program. Sports and physical education with Elite Sport involve more theoretical and practical subjects related to sports, such as physical activity, sports science, training management, and sports and society, compared to specialization in general studies (Hagum et al., 2022). The aim of top-level sports in high schools is to offer student athletes an education that is adapted to the athletes’ needs, with an increased density of teachers having close contact with the athletes, sports clubs, and associations (Engvik & Gjølme, 2015).

Since no state regulations define a school as a sports school, schools' quality and experiences vary considerably (Kristiansen & Houlihan, 2017). Most public schools deliver “sports-friendly programs”, recruiting athletes based on academic performance (Sæther et al., 2022). During school hours, student athletes are offered five hours of sports training a week (~225–300 min), resulting in 140 hours per year (Utdanningsdirektoratet, 2020). Private schools usually offer “elite sports programs”, recruiting athletes based on formal selection procedures focused on their sports performances (Sæther et al., 2022). Generally, they offer more hours of sports training a week during school hours, and club coaches are often employed as school coaches, reducing the need for coordination concerning training load (Henriksen et al., 2011). In contrast, public sport-friendly programs seem to have more challenges with coordination (Sæther et al., 2022). However, they focus on and can give individual advice to the student athletes, facilitating self-determination (Sæther et al., 2022).

4.4 Load

Load is defined as the burden from sport and non-sport as a stimulus applied to a person's biological system (Soligard et al., 2016). The burden can arise from single or multiple physiological, psychological or mechanical stressors, and the biological system can include subcellular elements, a single cell, tissues, one or multiple organ systems, or the individual (Soligard et al., 2016).

4.4.1 Training load

Training load is defined as the cumulative amount of stress placed on a person from a single or several structured or unstructured training sessions over a period (Soligard et al., 2016). Training load is the input variable that is controlled to stimulate a preferred training response in athletes. As a generic construct, training load involves a variety of proxy measures and metrics (e.g., mechanical, psycho-physiological and spatiotemporal), which can be described as being external or internal (Kalkhoven et al., 2021).

External load is defined as the work done by an athlete measured independently of one's internal characteristics (Wallace et al., 2009). Internal load is the relative physiological and psychological stress imposed on an athlete (Halson, 2014; Wallace et al., 2009). Any external load will result in physiological and psychological responses in an athlete (i.e., internal load), depending on the interaction and variation in several other biological and environmental factors (Borresen & Lambert, 2009; Impellizzeri et al., 2005). Both external and internal load is critical in determining the training load and subsequent adaptation (Halson, 2014). A combination of external and internal loads may be essential for training monitoring as they both have merit for understanding an athlete's training load (Halson, 2014).

Psycho-physiological load is the psycho-physiological stress an athlete experiences in response to a specific external load (Kalkhoven et al., 2021). A common psycho-physiological measure is the rating of perceived exertion (RPE) (Kraemer et al., 2012, p. 397). The psycho-physiological stress experienced by an athlete is believed to contribute significantly to the training outcome (Kalkhoven et al., 2021)

4.4.2 Life load

Non-sports load (i.e., life load) is the cumulative amount of stress placed on a person from non-sporting activities, including all physiological and psychological stimuli/ stressors outside of sports (Soligard et al., 2016). The combination of sport and education, also referred to as a "dual-career" (Stambulova et al., 2015), can be challenging for young student athletes as it demands the development of their full potential in both areas (Christensen & Sørensen, 2009; Kristiansen, 2017). In addition to training and school loads, athletes typically encounter additional stress from other external sources such as social, work-related, lifestyle, and the athlete–coach relationship (Hamlin et al., 2019). Consequently, there has been considerable interest in recent years in athletes combining sport and education and the impact this has on their health and well-being (Thompson et al., 2022).

It is possible that the demands student athletes face from both sports and school place them at an elevated risk of various mental health concerns compared to non-athlete students (Sudano et al., 2017), which can potentially affect their overall health and wellness (Lopes Dos Santos et al., 2020). Research has indicated that Swedish student athletes in sports schools demonstrate relatively high and stable levels of general psychological well-being during the competitive season (Stenling et al., 2015). Australian student athletes in sports schools spend less time in sedentary leisure and report better general health and social and emotional well-being than non-sport school students (Knowles et al., 2017). German student athletes do not show a higher frequency of disordered eating behaviour and attitudes compared to regular high school students, indicating that sport does not increase the risk of eating disorders (Rosendahl et al., 2009). A lower frequency of disordered eating behaviour was reported in Norwegian adolescent elite athletes compared to age-matched regular high school students in 2010 (Martinsen et al., 2010). In contrast, a subsequent study revealed a higher prevalence of eating disorders in Norwegian student athletes, compared to age-matched controls (Martinsen & Sundgot-Borgen, 2013). Norwegian student athletes appear to be less prone to experiencing psychological distress than age-matched non-sport students, which might be explained by social and cognitive factors (Rosenvinge et al., 2018). This is supported by previous findings in Swiss elite student athletes (Gerber et al., 2011).

A systematic review from 2021 indicated that American student athletes experience mental health conditions and substance abuse at a comparable level to age-matched peers (Kaishian & Kaishian, 2021). A recent systematic scoping review from several countries does not support the notion that student athletes have equal or greater mental health than students not combining sport and school (Kegelaers et al., 2022). This finding is contrary to a previous review, suggesting that due to factors such as higher self-esteem and a more robust social network, student athletes are less likely to suffer from depression compared to non-athletes (Armstrong et al., 2015). Mental health has been associated with developmental factors, showing that older student athletes tend to report more mental health problems (McGuine et al., 2021). A study by Shields et al. (2017) found that the most remarkable changes in psychological responses (e.g., negative mood states, perceived stress, and perceived cognitive deficits) occurred during the period with the highest training load (peak training). Academic load did not differ between rowing student athletes and non-athletes, indicating that training load contributes to a greater degree to negative mood states than academic load (Morgan et al., 1987; Shields et al., 2017).

4.5 Progression in training load

A key training principle is progressive overload (Comfort & Abrahamson, 2010, p. 228). Load must exceed one’s current capacity in order to improve performance (Gabbett, 2020b). To improve tolerance for further load, one should apply small, systematic increases in load which are slightly greater than the load capacity (Morton, 1997; Verhagen & Gabbett, 2019). The training load must cause enough stress to induce the desired training adaptation, a concept associated with the general adaptation syndrome (GAS) (Selye, 1950, 1951), where adaptation is the response to stress and adequate recovery (i.e., supercompensation). The more refined stimulus-fatigue-recovery-adaptation (SFRA) theory supports this concept, suggesting that a greater stressor will result in greater fatigue and adaptation (Verkhoshansky, 1979, 1988). However, if the applied physical load is substantially higher than the athlete's physical capacity, tissue tolerance will be exceeded, and injury can occur (Cook & Docking, 2015). Hence, a balance exists between prescribing an adequate training stimulus to elicit performance benefits and minimising the risk of injury (Gabbett, 2020b). It is not the training per se that is the problem, but more likely, inappropriate prescription of training load and recovery (Gabbett, 2016). When the training load is appropriately progressed, capacity will be improved, sequentially improving the athletes' ability to tolerate further training load (Gabbett et al., 2019).

Gabbett (2020b) provides three key concepts when developing performance programs: the “floor”, the “ceiling”, and time. The floor is the athlete’s current capacity, while the ceiling is the capacity needed to perform sports-specific activities. If the athlete is afforded adequate time, it is possible to progress from the floor to the ceiling in a safe manner (Figure 2, panel A). If time is limited and the gap between the current and required capacity is large (Figure 2, panel B), rapidly increasing training loads is the only way to progress from the floor to the ceiling, which may increase the risk of injury (Gabbett, 2016). More time to bridge the gap between the floor and the ceiling can be a safer solution for athletes (Figure 2, panel C), but a consequence can be that athletes do not reach peak fitness before the start of the season. Another solution is to buy more time prior to the official start of the preseason. By performing a minimum training volume before returning from a prolonged break, one can minimize the detraining effect induced by the offseason, and in that way, ensure a more gradual and systematic progression to the ceiling (Figure 2, panel D). When meeting athletes with an inadequate current capacity to sustain normal training loads (e.g., severely deconditioned state following offseason, illness or injury), the capacity reflects a basement rather than a floor (Figure 2, panel E). Raising the floor means ensuring that athletes take an extended break without allowing their physical capacity to fall to the basement. In addition, a raised floor can give athletes a chance to evolve a greater load capacity than would previously have been possible, in which they might reach "the penthouse" (Figure 2, panel F) (Gabbett, 2020b).

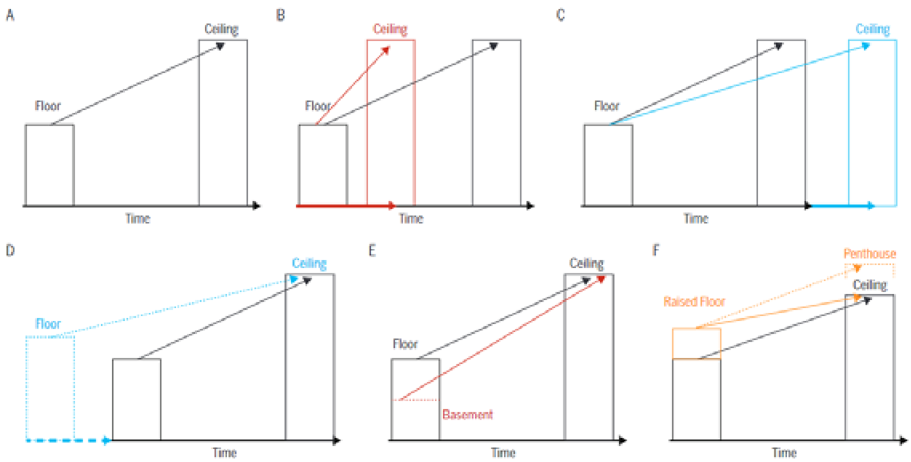

Figure 2 – Strategies for progressing training load from the athlete's floor (i.e., current capacity) to the ceiling (i.e., required capacity). The basement illustrates inadequate capacity to sustain normal training loads, while the penthouse illustrates greater load capacity than previously possible due to raising the floor. From "How much? How fast? How soon? Three simple concepts for progressing training loads to minimize injury risk and enhance performance," by Gabbett, T.

J., 2020, J*ournal of orthopaedic & sports physical therapy*, *50*(10), 570-573. Reprinted with permission (Appendix 1).

4.6 Training load and injury risk

The relationship between training load and injury has been an area of substantial interest for practitioners, researchers, and athletes (Drew & Finch, 2016; Eckard et al., 2018a; Kalkhoven et al., 2021; Soligard et al., 2016; Verhagen & Gabbett, 2019). However, despite abundant literature, a clear causation between injuries and training load is not yet established (Kalkhoven et al., 2021). The aetiology of injury is complex, dynamic, multifactorial, and context-dependent (Bittencourt et al., 2016; Gabbett, 2020a; Windt & Gabbett, 2017). Hence, it is challenging to isolate the effect of training load alone on injury risk (West et al., 2021), and it would be a myopic view to state that load explains all injuries (Gabbett, 2020a). Training load can influence injury risk positively or negatively. The workload-injury aetiology model from Windt and Gabbett (2016) illustrates that load is the vehicle that drives athletes to or from injury (Figure 3). The model was initially designed by (Meeuwisse et al., 2007) but was later expanded by Windt and Gabbett (2016), who incorporated workloads within the causal chain and outlined its known effects. The model illustrates how load contributes to dynamic injury risk through three mechanisms: 1) by exposing athletes to possibly harmful situations, as well as external risk factors, in which increases in training load will increase the possibility of experiencing an injury, 2) by producing fatigue, which represents negative physiological effects changing internal risk factors and increase the risk of injury, and 3) by producing fitness, representing positive physiological adaptations which change internal risk factors in a positive way and consequently reduce subsequent injury risk (Windt & Gabbett, 2016). The model highlights the importance of careful planning of training due to the influence of load on fitness, fatigue and injury risk (Nabhan, 2022).

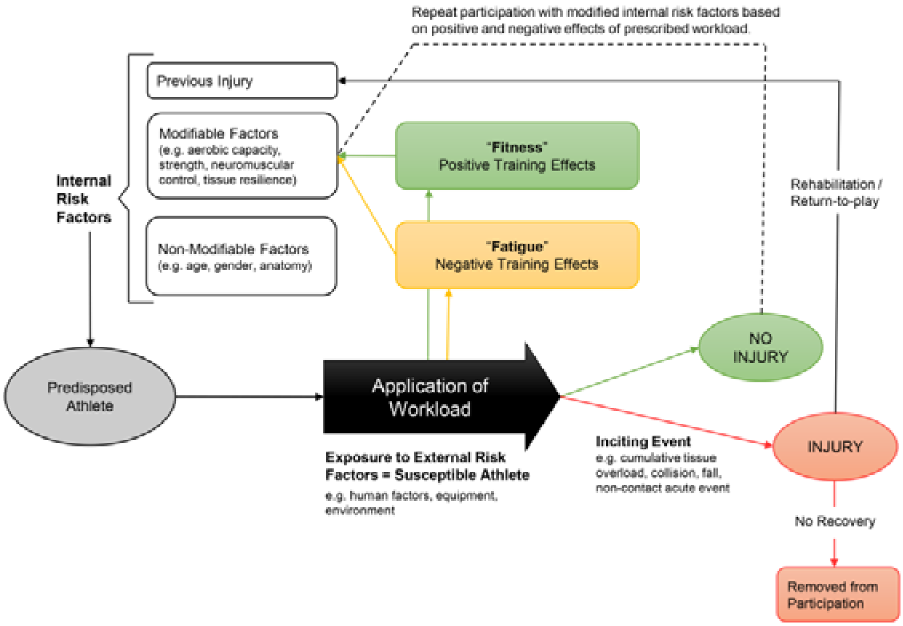

Figure 3 – The updated workload-injury aetiology model showing the multifactorial, non-linear nature of athletes' injury risk, initially designed by Meeuwisse et al. (2007). The figure illustrates that load is the vehicle that drives athletes to or from injury. From "How do training and competition workloads relate to injury? The workload—injury aetiology model", by Windt, J., & Gabbett, T. J., 2016, *British journal of sports medicine*, *51*(5), 428-435. Repreinted with permission (Appendix 2).

Verhagen and Gabbett (2019) illustrate in their model (Figure 4) that the modifiable factors of load and load capacity and the outcomes of health and performance are interlinked, which means that changes in one component will affect the others. For example, an injury will directly affect performance through reduced load capacity, which can impact muscle strength, tissue integrity and, consequently, the ability to perform (Bolling et al., 2019). Therefore, all components must be considered together (Verhagen & Gabbett, 2019). Figure 4 further illustrates that an athlete's load and load capacity (as well as the balance between the components) are influenced by context and environment (Bolling et al., 2018; Windt & Gabbett, 2016). Since context and environment are temporal, the balance between load and load capacity one day may be tipped another day due to fluctuations in, for example, fatigue, motivation, and mental state (Verhagen & Gabbett, 2019).

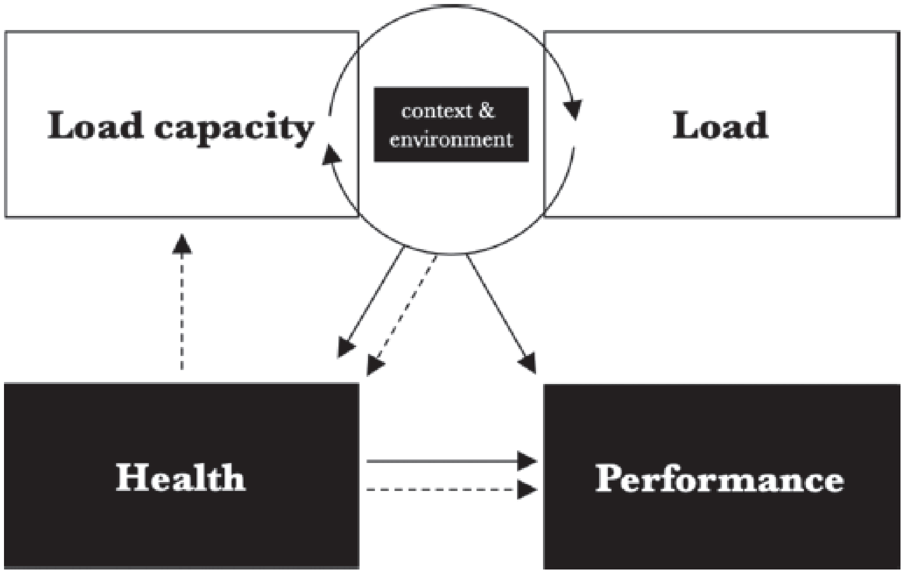

Figure 4 – An integrated, holistic view of load capacity, load, health, and performance in sports. The solid lines represent positive relationships, while the dotted lines represent negative relationships. From "Load, capacity and health: critical pieces of the holistic performance puzzle", by Verhagen, E., and Gabbett, T., 2019, *Br J Sports Med*, *53*(1), 5-6. https://doi.org/10.1136/bjsports-2018-099819. Reprinted with permission (Appendix 3).

4.6.1 Methods of estimating injury risk

The acute: chronic work ratio (ACWR) is a highly popularised method of estimating injury risk (Kalkhoven et al., 2021). However, a randomized controlled trial using the ACWR to manage player load in elite youth football teams did not result in differences in health problems between the experimental and control group (Dalen-Lorentsen et al., 2021). Several factors likely moderate training load, and this study highlights the complexity of the interaction between those factors in predicting injury risk (Bittencourt et al., 2016; Kalkhoven et al., 2021; West et al., 2020). Now, it is clear that the ACWR has several limitations and conceptual flaws (Kalkhoven et al., 2021). Thus, practitioners are advised to consider known moderators of the workload—injury relationship (e.g., age, training and injury history, physical qualities) and interpret load variables (both internal and external) in combination with information on the athlete's well-being, physical and mental preparedness, and other factors known to influence the risk of sustaining an injury (Gabbett et al., 2017; Hulin & Gabbett, 2019). In addition, a practitioner should consider factors influencing the adaptation to the load (e.g., biomechanical factors, psycho-emotional stress, anxiety, academic stress, nutrition and sleep) (Gabbett, 2020a). Adaptation to training is influenced (positively or negatively) by biomechanical components (Vanrenterghem et al., 2017), together with lifestyle factors and life stressors (Calvert et al., 1976; Gabbett et al., 2017), which means that there are multifactorial determinants of both performance and injury (Gabbett, 2020a). For example, research has indicated that youth athletes sleeping less than 8 hours per night have a 1.7 times greater risk of sporting injury than those who slept for 8 hours or more (Milewski et al., 2014). In addition, increased training volume and intensity combined with decreased sleep volume have been shown to increase injury risk twofold in adolescent elite athletes (von Rosen, Frohm, Kottorp, Fridén, et al., 2017). Besides sleep volume, nutritional intake may also be important in understanding injury incidence in adolescent elite athletes, with those reaching the recommended nutritional intake having 64% lower odds of injury (von Rosen, Frohm, Kottorp, Friden, et al., 2017). Psychological factors and characteristics should also be considered when considering injury risk, such as stress (Ivarsson et al., 2017; Mann et al., 2016), anxiety (Li et al., 2017), coping behaviour «self-blame» (Timpka et al., 2015) and perfectionism (Madigan et al., 2018).

4.6.2 Prevalence of injuries and injury location

Research has indicated that elite youth athletes are at high risk of injury after enrolling in a high school sports academy (Bjørndal et al., 2021; Caterisano et al., 2019; Moseid et al., 2019). Previous studies on Norwegian elite youth athletes have indicated that injuries are more common in technical and team sports, with a 37% average weekly injury prevalence after enrolment into a specialized sports high school (Moseid et al., 2018). In youth elite handball players, the average weekly injury prevalence has been reported to be 42%, of which 29% were categorized as substantial injuries (Bjørndal et al., 2021). Similar injury rates have been reported in a 52-week prospective study of Swedish elite adolescent handball players (von Rosen, Heijne, et al., 2018).

In youth sport, the most common injuries involve the lower extremity, with the ankle and knee being the most common injury sites (Caine et al., 2006; Emery et al., 2006). In youth handball players, previous research has indicated high rates of hand and wrist injuries (Mandlik et al., 2021), as well as injuries to the shoulder, knee and ankle (Olsen et al., 2006; Aasheim et al., 2018). A systematic review of handball players indicated that the most commonly injured areas were the lower limbs, with injuries to the knee and the ankle seeming to be the most prevalent (Raya-González et al., 2020). In youth elite football players, injuries to the thigh, knee, ankle, and hip/groin are the most common (Le Gall et al., 2006; Light et al., 2021; Read et al., 2018; Renshaw & Goodwin, 2016; Tears et al., 2018).

A systematic review of youth football players concluded that players lose a significant proportion of their seasonal development potential due to high levels of injuries and long absences from training and matches (Jones et al., 2019). International football players of both sexes are subjected to a high risk of injury, particularly during matches (Sprouse et al., 2020). Research has also indicated that one in four collegiate football and basketball players have musculoskeletal pain before starting a new season, with the back and knee regions being the most common locations (Owoeye et al., 2022). Research has also indicated that ~50% of student athletes push themselves so hard that it affects their enjoyment of the sport and/or results in injury (Skrubbeltrang et al., 2020). Injuries and musculoskeletal pain limit sports involvement and performance and may also have psychological impacts (Haraldsdottir & Watson, 2021; Von Rosen, Kottorp, et al., 2018).

4.6.3 Developing robust athletes

A goal for sports practitioners is to develop robust athletes who can tolerate high training and competition loads (Gabbett et al., 2019). To achieve this goal, one must understand the workload-capacity relationship (Gabbett et al., 2019). Moderators and circular causation play a role in developing athletes' physical capacity and injury resilience (Gabbett et al., 2019). Figure 5 shows the relationship between structure-specific load capacity, sport-specific load capacity, appropriate training load, and moderators and how they affect physical qualities and robustness in athletes. For instance, physical qualities work as a moderator to the relationship between training load and injury. Athletes with well-developed physical qualities (e.g., aerobic fitness, muscular strength in the lower extremities) have a reduced risk of sustaining injury compared to athletes with poorly developed physical qualities (Malone et al., 2019). Gabbett (2020) presents the chicken-or-egg question: does high training load or the ability to tolerate load (i.e., robust athletes) come first? It requires high training loads to develop physical qualities but also well-developed physical qualities to tolerate high training loads. As illustrated in Figure 5, structure-specific load capacity (i.e., a specific structure's ability to withstand load (Nielsen et al., 2018)), which is related to a degree of physical capacity (e.g., speed, strength, and aerobic fitness), allow an athlete to better tolerate training load. Then, using appropriate training load further improves these physical qualities, ultimately generating sport-specific load capacity (T. J. Gabbett, 2020).

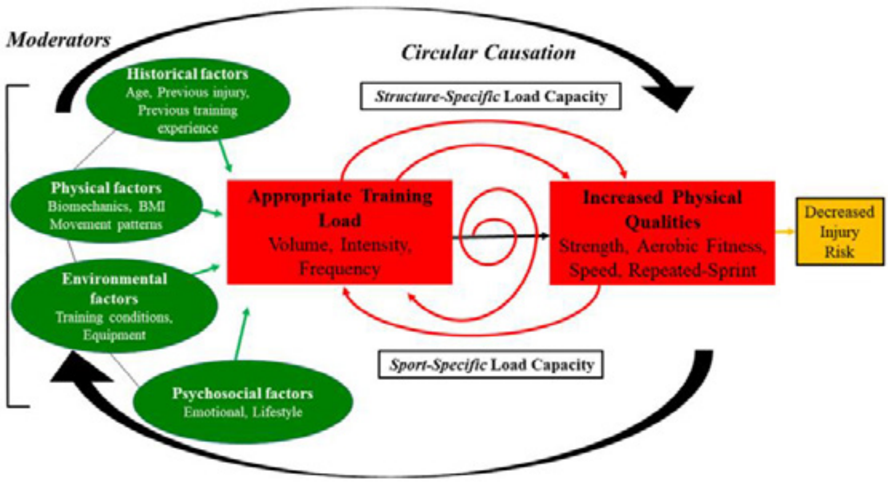

Figure 5 – Moderators (green boxes and arrows) and circular causation (red boxes and circles) align to develop physical capacity and injury resilience in athletes. From "In pursuit of the 'Unbreakable'Athlete: what is the role of moderating factors and circular causation?», by Gabbett, T. J., Nielsen, R. O., Bertelsen, M. L., Bittencourt, N. F. N., Fonseca, S. T., Malone, S., Møller, M., Oetter, E., Verhagen, E., & Windt, J., 2019, *British journal of sports medicine*, *53*(7), 394-395. Reprinted with permission (Appendix 4).

Often, many professionals are involved in an athlete's training process, and to truly understand the workload-capacity relationship, those involved need to collaborate (Gabbett et al., 2019). Effective collaboration among those involved with the athlete will result in the best-practice model for reducing injury risk and developing robust athletes (Gabbett et al., 2019).

4.7 Team Dynamics Theory

Team Dynamics Theory stems from previous theoretical and empirical work in applied psychology, aiming to explain part of team dynamics variability and predict team outcomes (Filho, 2019). The theory involves four inputs: 1) cohesion, which historically has been regarded as a vital variable when studying small group dynamics (Carron & Brawley, 2000; Golembiewski, 1962; Lott & Lott, 1965); 2) team mental models (Medeiros Filho & Tenenbaum, 2012); 3) coordination (Cienki, 2015;

Eccles & Tenenbaum, 2004; Eccles & Tran, 2012; Gorman et al., 2010; Jennings, 1993; Richards, 2001; Stout et al., 1999); and 4) collective efficacy (Bandura, 1997).

In Team Dynamics Theory, the focus is on the team, with the inter-relationship between individuals as the measurement approach. Both cohesion, team mental models, coordination, and collective efficacy are processes at the team level. Hence, the processes appear from the team as a whole and not from a single individual (e.g., an individual might perceive weak coordination within the team, but coordination is high within the team as a whole). However, it is essential to account for the influence of the individual members´ characteristics and contextual factors (Filho, 2019).

Filho (2019) put forth a nomological network where cohesion first promotes the development of team mental models, which is the basis for coordination. Simultaneously with team mental models and coordination, collective efficacy will develop. Hence, higher accuracy and quality of the team mental model will also promote higher collective efficacy and coordination, and vice versa. These four team processes will impact team outcomes together, via direct or indirect paths.

4.8 Holistic Ecological Approach

The holistic ecological approach is built around two working models: 1) the athletic talent development environment (ATDE) and the model of environmental success factors (ESF), inspired by three background theories (Henriksen, 2011). The Holistic Ecological Approach, with its two working models (the ATDE model and the model ESF), has shown its value as a lens to aid the study of a specific environment in the area of talent development (Henriksen et al., 2010a, 2010b; Kegelaers et al., 2022). The dual career development environment (DCDE) working model is based on the original ATDE working model, where the main change is a revision of the environmental domain (Henriksen et al., 2020). The ATDE model can be used to describe a particular DCDE and draw a picture of the roles and functions of the different elements and relations within such an environment (Henriksen et al., 2020). The model illustrates that student athletes are at the centre. Those closest to the student athlete, such as their study peers, family, friends, and club environment, are directly surrounding them. The DCDE's working model involves micro- and macro-levels. The micro-level refers to the environment where the student athlete spends a good deal of their daily life, whereas the macro-level refers to social settings, which affect but do not contain the student athlete. The micro level is characterised by direct communication and interactions, and elements include related teams and clubs, study programs, and residence. Elements at the macro-level include sport systems, the educational system and local authority, and various cultural contexts (e.g., national culture, sports culture and study culture). The model considers sports, studies and private life as domains in student athletes' development. The sport domain involves the part of the student athletes' environment directly connected to sport, the study domain represents elements related to their school activities, and private life refers to the other areas of the student athletes' lives. There is a permeability and interplay between the different components, which the model illustrates with dotted lines. Lastly, to emphasise the model's dynamic nature, an outer layer of the model outlines the past, present, and future of the DCDE.

4.9 Relational Coordination theory

Relational coordination is a theory for understanding the relational dynamics of coordinating work within and between organisations (Gittell & Ali, 2021, p. 16). The theory was developed from an in-depth field study of flight departures in the airline industry in the early 1990s (Bolton et al., 2021). Relational coordination, the core construct in the theory, is defined as "a mutually reinforcing process of interaction between communication and relationships carried out for the purpose of task integration" (Gittell, 2002, p. 300).

Relational coordination allows people in a work process to coordinate their work more effectively and consequently reduce the limits of production possibilities to achieve higher quality outcomes and use resources more efficiently (Gittell, 2012). Researchers have observed that relationships affect the frequency and quality of communication and that the frequency and quality of communication in succession impact the quality of relationships (Gittell & Ali, 2021, p. 22). Relationships of shared goals, shared knowledge, and mutual respect support frequent, timely, accurate and problem-solving communication and vice versa (Gittell & Ali, 2021, pp. 21-22). The dimensions of high-quality relationships and communication enable persons to coordinate their work in an effective manner (Gittell & Ali, 2021, p. 22). Conversely, low-quality relationships will undermine communication and hinder the ability to coordinate work in an effective manner (Gittell & Ali, 2021, p. 22). This implies that the mutual reinforcement that is expected to occur between the dimensions of relationship and communication of RC can occur in either a positive or negative direction, as shown in Figure 6.

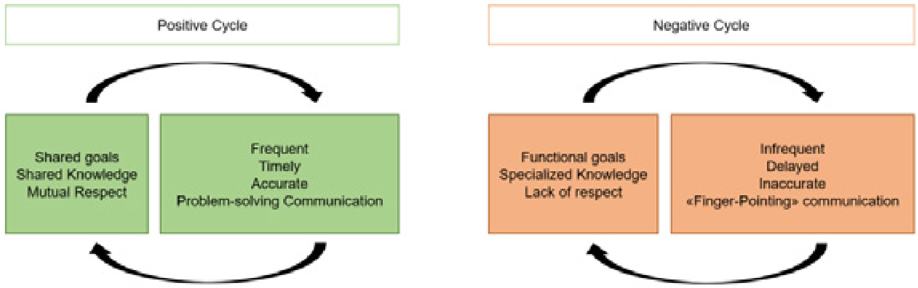

Figure 6 – Positive and negative mutually reinforcing cycles of Relational Coordination. Adapted from "Revisiting relational coordination: A systematic review", by Bolton, R., Logan, C., & Gittell, J. H., 2021, *The Journal of Applied Behavioral Science*, *57*(3), 290-322. Reprinted with permission (Appendix 5).

The theory recognises coordination as taking place through a network of communication and relationship ties *between roles* rather than *between unique individuals,* which is different from other relationship-based approaches to coordination (Gittell & Ali, 2021, p. 32). Focusing on role-based relationships rather than relationships between unique individuals has a practical advantage (Gittell & Ali, 2021, p. 18). For instance, with a high level of RC, employees are connected by the dimensions of relationships irrespective of whether they have robust personal ties. This permits for the interchangeability of employees, allowing them to come and go without it negatively impacting performance. This is a vital consideration for organizations wanting to accomplish high levels of performance while allowing employees the scheduling flexibility to meet their obligations outside of work (Gittell et al., 2010). Role-based coordination is also more robust to changes in employment over time (Gittell et al., 2010). However, research has also indicated that communication and relationship dynamics are person- and role-based, which adds nuances to the theory of RC (Tørring et al., 2019).

4.9.1 Communication dimensions

The theory consists of four communication dimensions: 1) frequent communication, 2) timely communication, 3) accurate communication, and 4) problem-solving communication.

The dimension of frequent communication refers to how often people in a work group communicate with each other (Gittell & Ali, 2021, p. 97). Frequent communication can improve relationships through the knowledge that develops from repetitive interaction between persons in a work group (Gittell & Ali, 2021, p. 19). However, according to Gittell and Ali (2021, p. 19), it is not a given that the communication is of high quality, even if it is frequent. For instance, communication can lack timeliness, which leads to the dimension of timely communication.

Timely communication refers to whether the communication between a work group's roles is timely or not. Timing can be critical in coordinating highly interdependent work. For example, delayed communication can result in errors or delays that can have negative implications for the outcomes of the work group (Gittell & Ali, 2021, p. 19).

Accurate communication involves the accuracy of the communication and is an essential dimension for effective coordination. Communication can be frequent and received on time. However, if the information is not accurate, the consequence can be errors or delays as people in the work group will try to seek more accurate information (Gittell & Ali, 2021, p. 19).

Lastly, problem-solving communication refers to what happens when a problem occurs. The roles in a work group can either blame each other or work together to solve the issue. A working group must engage in problem-solving communication for effective coordination (Gittell & Ali, 2021, p. 20).

4.9.2 Relationship dimensions

The theory consists of three relationship dimensions: 1) shared goals, 2) shared knowledge, and 3) mutual respect.

The dimension of shared goals implies that those in a work process have shared goals for their work. By having a set of shared goals for the work process, the people involved will have a more powerful bond and can come to mutual conclusions about how to respond as new information becomes available (Gittell & Ali, 2021, p. 20). Shared goals motivate employees to act to optimize the overall work process rather than focusing on individual sub-goals (Gittell & Ali, 2021, p. 22). It is suggested that the dimension of shared goals among participants in a work process can facilitate effective coordination (Gittell, 2006).

Shared knowledge indicates that people in a work process have a high degree of shared knowledge about each person's tasks. When there is a high degree of shared knowledge, people know how their tasks are related to the task of others. Hence, they know how changes can impact others and which persons need to be given what information and at what time (Gittell & Ali, 2021, p. 21). In addition, shared knowledge of how individual goals relate to the organisation's overall goal facilitates more accurate communication between persons in a work group (Gittell, 2012).

Finally, mutual respect refers to participants in a work process respecting each other. Lack of respect can lead to divisions between those with different roles in a given work process (Gittell & Ali, 2021, p. 21). Mutual respect between colleagues can help to minimize potential status barriers which might otherwise limit care and consideration for each other´s work. Mutual respect can increase the probability that roles in a work process are receptive to communication from roles with other functions in the work process, regardless of their status, consequently increasing communication quality (Gittell, 2012).

5 Methodology

A quantitative methodology was applied to answer the research questions of the thesis. This section presents how the methodology was used to reach the aims of the individual research papers.

5.1 Quantitative study design

The thesis has a quantitative approach, emphasising quantification in the data collection and using statistical procedures to analyse the data (Clark et al., 2021, p. 31). The research process involved a deductive approach, in which literature and theory-driven research questions and hypotheses guided the collection and analyses of data (Trochim et al., 2016, pp. 22-23). When analysing the collected data, there was an openness for alternative theories and literature (Clark et al., 2021, p. 20).

5.2 Research design

The thesis represents two research designs: a cross-sectional design (*Paper I*, *II* and *III*) and a randomised controlled trial (*Paper IV*). The employed design has considerable implications for the credibility and validity of the conclusions drawn (Trochim et al., 2016, p. 207). The research design will essentially affect the internal validity of the research, that is, the capability to make sound inferences about what caused any observed difference in the dependent variable (Smith, 2014). However, research design will also have implications for other forms of validity (Cook & Campbell, 1979, p. ix), such as statistical conclusion validity, construct validity and external validity (Smith, 2014). Hence, various aspects of validity are discussed in Section 7.3.

5.2.1 The cross-sectional design

A cross-sectional design involves collecting data from a population at a single point in time (Clark et al., 2021, p. 50). When the purpose of the study is descriptive, often in the form of a survey, a cross-sectional design is used (Levin, 2006). A vital feature of the cross-sectional design is its use of a sample of cases, making it possible to investigate variations among people (Clark et al., 2021, p. 51). The present thesis used a cross-sectional design in *Study I* and *II*. Both studies used a questionnaire as the research method. In *Paper I,* the cross-sectional design was used to assess the factorial validity of MTDS-N. In *Paper II*, a cross-sectional design was used to describe student athletes' weekly training volume and their responses on MTDS-N. Lastly, in *Paper III,* a cross-sectional design was used to investigate perceived RC within and between student athletes, club coaches, school coaches, schoolteachers, parents, and health personnel.

5.2.2 The experimental design

A classical experiment was performed in *Study III*, often called a randomised controlled trial (RCT) (Clark et al., 2021, p. 43). Randomised controlled trials are typically considered the gold standard for causal inference (West et al., 2014). This design involved randomly assigning participants to either an experimental[1] or control group (Clark et al., 2021, p. 44). The experiment took place in a real-life setting; thus, it was a field experiment (Clark et al., 2021, p. 43). The experimental design was used to evaluate the effectiveness of communication and coordination combined with a progressive and individualised sport-specific training program for reducing all-complaint injuries in youth female and male football and handball players transitioning to a sports academy high school.

[1] In *Paper IV,* we used the term intervention group instead of experimental group.

5.3 Sample and procedure

All the sub-studies in the present thesis used a non-probability sampling method. However, different sampling strategies were used in the sub-studies. In *Study I*, all public and private schools offering Elite Sport in Norway were considered for inclusion. In 2019, 119 sports high schools were identified as eligible for inclusion. An invitation to participate in the study was sent to the school principals and administrators. Participants were selected based on availability and willingness to participate in the study (i.e., convenience sampling strategy) (Clark et al., 2021, p. 176). The study included first, second and third-year student athletes (15-18 years) enrolled in school programs specializing in general studies and sports and physical education. In S*tudy II*, all public and private schools offering Elite Sport in Rogaland County were considered for inclusion. In addition, club coaches, school coaches and schoolteachers connected to the student athletes were considered for inclusion. Convenience sampling was also applicable in *Study II.*

In *Study III*, three schools were selected for participation. Two of the schools were private, while one was public. The three schools were placed in two geographically different counties, namely in Rogaland and Vestfold and Telemark. Football and handball players aged 15-16 years were considered for inclusion. The cohort was chosen based on previous literature indicating a high injury prevalence in this population (Bjørndal et al., 2021; Moseid et al., 2018). Hence, the included participants were selected based on predefined characteristics, using a purposive sampling strategy (Clark et al., 2021, p. 177).

Study I was conducted from March to May 2020, whereas *Study II* was conducted from February to March 2020. *Study III* was conducted from May to November 2021, including the eight-week summer holiday. Figure 7 illustrates an overview of the present thesis's sub-studies, papers, research design, and participants.

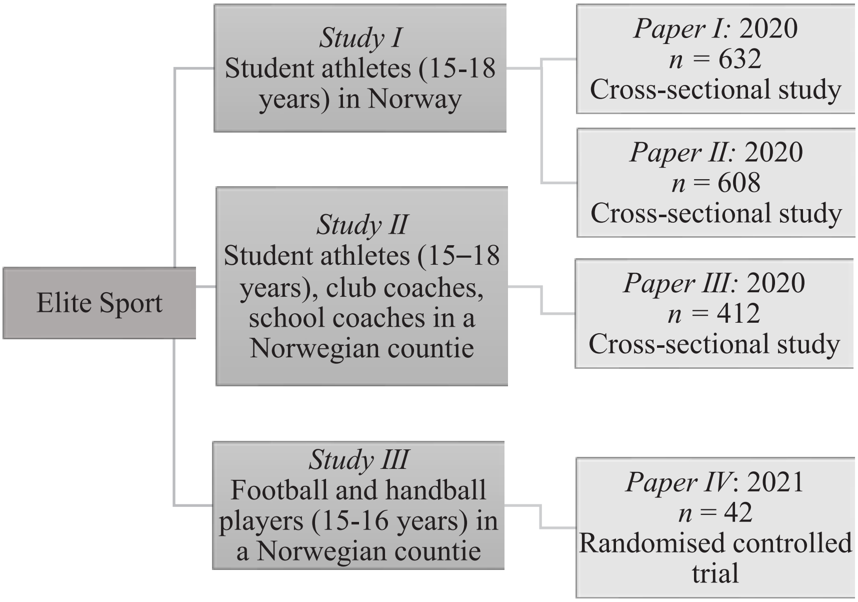

Figure 7 – Overview of the sub-studies, papers, research design and participants in the thesis

5.4 Participants

Paper I included 632 student athletes (327 males and 303 females) representing 35 different sports, all taking the optional program subject Elite Sport from 23 different Norwegian high schools. *Paper II* included the same sample as in *Paper I*. However, those with ≤4 hours of training per week or outliers with ≥30 hours of training per week were excluded (i.e., 24 participants), leaving a total sample size of 608 student athletes (308 males, 298 females). *Paper III* included 345 student athletes (198 males, 147 females), 25 school coaches (21 males, 4 females) and 42 club coaches (32 males, 10 females), giving a total sample of 412 participants. *Paper IV* included 42 football and handball players (20 males, 22 females) aged 15–16 years.

5.5 Ethical approvals

The Norwegian Centre for Research Data (NSD) reviewed and approved the three studies in 2019 (*Study I* and *II* with project number 836079, Appendix 6; *Study III* with project number 429894, Appendix 7). In addition, *Study III* was reviewed and approved by the Regional Committees for Medical and Health Research Ethics (REK) (Project number 54584, Appendix 8) before data collection in 2020. The purpose of research ethics is to promote research that is free, reliable, and responsible (NESH, 2022, p. 5). Following the Declaration of Helsinki (Association, 2013), informed consent was obtained from all participants who agreed to take part in *Study I* (Appendix 9), *Study II* (Appendix 10 and 11), and *Study III* (Appendix 12). In *Study III*, informed consent was obtained from both guardians and participants since the participants were 15–16 years old. According to the NSD guidelines for research, the participant must be at least 16 years of age before they can consent themselves if special categories of personal data (i.e., sensitive personal data) are collected (Norwegian Centre for Research Data, n.d.).

5.6 Data collection and measures

In *Study I* and *II*, questionnaires were completed electronically using Survey Xact by Ramboll, Norway. In *Study III*, the questionnaires were completed in an electronic training diary named Bestr training diary (BESTR, Norway, Lørenskog).

5.6.1 Physiological and psychological training distress

In *Paper I, II* and *IV,* the MTDS-N (Hagum & Shalfawi, 2020) was used to record perceived training distress among student athletes (Appendix 13). In *Paper I* and *II*, the student athletes answered the questionnaire delivered in Survey Xact at one given time point. In *Paper IV*, the questionnaire was delivered in the electronic training diary Bestr. The student athletes reported weekly training distress for 22 weeks.

5.6.2 Relational Coordination

Relational coordination theory presents analytical methods to evaluate coordination as a network of ties (Gittell & Ali, 2021, p. 32). In *Paper III*, the validated RCS (Gittell et al., 2010; Valentine et al., 2015) was used to collect perceived RC within and between student athletes, club coaches, schoolteachers, parents, and health personnel. Survey Xact was used to distribute the questionnaire to the participants. First, the RCS was distributed to student athletes, and then their schoolteachers received the questionnaire. Lastly, club coaches connected to the student athletes received the RCS. The respondents were asked to complete each item according to their perception of communication or relationships regarding student athletes' total training load (i.e., training load and life stress) with specific roles (i.e., student athletes, club coaches, school coaches, parents, and health personnel) on a 5-point Likert scale. Appendices 14, 15 and 16 show the versions of RCS formulated for student athletes, school coaches and club coaches, respectively.

5.6.3 Non-sports load

In *Paper IV,* we used the ASQ-N (Moksnes & Espnes, 2011) to investigate non-sports load in student athletes (Appendix 17). The questionnaire was delivered in Bestr training diary three times during the 22-week data collection (i.e., in June, August, and November 2020).

5.6.4 Training load monitoring

In *Paper I* and *II*, the participants self-reported their current weekly training volume as a part of the MTDS-N. In *Paper IV,* we used the electronic training diary Bestr to monitor the daily training load (Figure

2). Each participant was given their own user and could report daily training via their computer, smartphone, or tablet. If participants had not registered training during the week, they received a reminder on their phone. Participants were asked to log training volume (hours and minutes) for all handball or football activities, including organized training and matches, strength training, endurance, speed-training, mobility and injury prevention. In addition, participants were asked to rate how good they felt during training on a scale from 1–10, and rating of perceived exertion (RPE, 1–10). Figure 8 shows an overview of a football player's training load recording process.

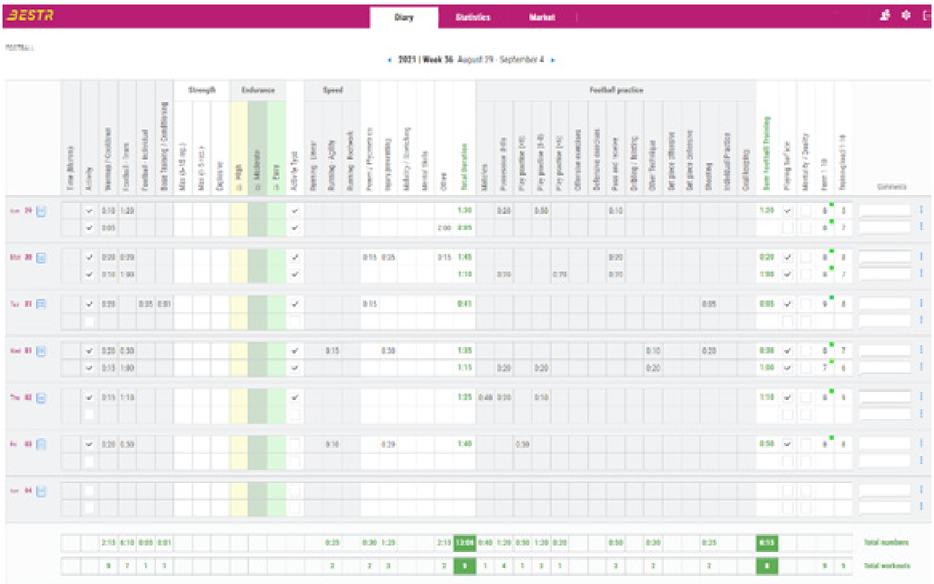

Figure 8 – An overview of the training load recording process for a football player

5.6.5 Health problem surveillance

In *Paper IV,* we used the OSTRC-H2 to record health problems (Appendix 18) (Clarsen et al., 2020). The questionnaire was implemented in Bestr training diary and available each Friday for 22 weeks. All participants responded to the questionnaire by the end of each week. They were instructed to report any health problems for the previous seven days. If a participant answered “full participation without any health problems” (the first answer option), all further questions were redundant, and a total severity score of 0 was assigned. If a participant answered “could not participate due to a health problem”, questions 2–4 were redundant, and a total severity score of 100 was assigned. Then, the participant answered additional questions regarding the reported health problem. By the end of the study, we calculated the weekly prevalence of all health problems and substantial health problems by dividing the number of participants reporting either a health problem or a substantial health problem by the total number of participants in each group (Clarsen et al., 2013).

5.6.6 Load management

In *Study III*, the intervention in the transition period (i.e., 8-week summer holiday) consisted of individualised load management of every player in the experimental group. Load management refers to the suitable prescription, monitoring, and adjustment of external and internal loads (Soligard et al., 2016). Each week, the participants in the experimental group had a phone call with the research team. Then, based on the communication with the participant regarding training from the previous week and the coming week, available facilities, and personal schedule and commitments, the research team planned a weekly individualised sport-specific training plan. If the participant had any training with the club, these were implemented in the training plan. The research team designed the whole training week if the participant´s club had weeks with no training (i.e., summer vacation). Coaches and guardians were always copied into email correspondance when the participant received their weekly training plan. Halfway through the intervention period, coaches were asked to provide input on changes to the training plan if they had any.

The following guidelines were considered when designing the individualised training plan:

1. Maintain technical and tactical training in terms of frequency, duration and intensity, adapting to the participants' available facilities and holiday plans.
2. Supplement with physical training such as strength, endurance, sprint and jumps training, and include an injury prevention program.
3. Progress the training load appropriately (i.e., frequency, duration, and intensity) to ensure that participants had a sufficient foundation to tolerate the training load when they started at the sports academy high school.
4. A polarized model of training intensity distribution (Seiler & Kjerland, 2006) with two to three days with a heavy training load and the remaining days with a lower training load (i.e., intensity and duration).
5. A form of fluctuating overload (Comfort & Abrahamson, 2010, pp. 228-229), with two weeks of high training load followed by a week of light training load consisiting of a 30% reduction in volume and intensity.

5.7 Data management and statistical analyses

All statistical procedures were performed using IBM SPSS statistics Version 27 (IBM Corporation, Armonk, NY, USA) and Mplus Version 8.4 (Muthén and Muthén, Los Angeles, CA, USA) (Muthén & Muthén, 1998-2017). Before analyses, Microsoft Excel (version 2016) was used to prepare the data. Descriptive statistics were calculated for all papers. Continuous variables are presented as mean (*M*) and standard deviation (*SD*), whereas ordinal or categorical variables are presented as percentages. McDonald’s omega (ω) with CIs was employed to assess the internal consistency of MTDS-N and the RCS. The statistical significance level was set at $p<0.05$ for all analyses.

The statistical procedures specific to each paper are outlined below.

5.7.1 Paper Ⅰ

A confirmatory factor analysis (CFA) was conducted to assess the six-factor solution proposed by Main and Grove on the data from MTDS-N. The multiple indicators and multiple causes (MIMIC) model was conducted to investigate the relationship between the covariates (i.e., gender, sport, training volume, school program and school year) and the latent variables (i.e., depression, vigour, physical symptoms, sleep disturbances, stress, and fatigue). An extended MIMIC model was conducted to investigate differential item functioning (DIF). The Pearson correlation coefficient (r) was used to measure effect size, following the guidelines from Funder and Ozer (2019).

5.7.2 Paper Ⅱ

Multiple one-way analyses of variance (ANOVA) were conducted to investigate differences in weekly training volume according to gender, type of sport, school program, and school year (independent variables). A two-way ANOVA was conducted to investigate the trend in weekly training volume across the school years and different sport types. Four factorial multivariate analyses of variance (MANOVA) were conducted to assess whether the independent variables influenced the dependent variables in MTDS-N, or if there were any interactions between training volume and the independent variables. To evaluate the MANOVA effects, a descriptive discriminant analysis (DDA) was conducted as a multivariate post-hoc analysis. A one-way ANOVA was conducted to examine the difference among the composite mean scores (i.e., mean training distress score). Given the rationale for using DDA, it might seem contradictory to use a univariate test; however, the analysis is still testing a multivariate outcome variable (Barton et al., 2016). Cohen's d effect sizes were calculated for the different one-way ANOVAs. Then, Cohen's d values were converted to Pearson's r by using Cohen's approximate conversion formula (Cohen, 2013, p. 23):

$$r = \frac{d}{\sqrt{d^2 + 4}}$$

Pearson's r was interpreted based on the guidelines from Funder and Ozer (2019). For the two-way ANOVA, partial eta squared (η_p^2) was used to determine the effect size.

5.7.3 Paper Ⅲ

An exploratory factor analysis (EFA) was conducted to examine the factor structure and evaluate the construct validity of RCS (Bowman & Goodboy, 2020). Eigenvalues, the scree plot and the parallel analysis were investigated to determine the number of factors (Costello & Osborne, 2005).

The strength of RC within and between roles was calculated, and cut-off points for weak, moderate and strong RC ties were based on norms from previously collected RC scores (Gittell & Ali, 2021, p. 124). Multiple one-way analyses of variance (ANOVAs) were conducted to investigate the difference in perceived RC between the surveyed roles (i.e., athletes, club coaches and school coaches) and to investigate the difference in athletes' perceived RC according to the type of sport (individual or team), school (public sports-friendly high school or private elite sport high school), performance level (above top 5%, top 5-25%, top 25-50% or below top 50%), sex (female or male), and school year (first, second or third year). A Bonferroni adjustment was applied to correct multiple comparisons and reduce the likelihood of Type I errors (Mood et al., 2020, p. 297; Verma, 2015, p. 203). The effect size was determined using η_p^2.

5.7.4 Paper Ⅳ

Differences in baseline characteristics, session RPE (sRPE) and training volume (hours) were assessed with independent sample t-tests. A two-way χ^2 test of independence was conducted to examine the relationship between groups and injury. Period (weeks 11–14; 15–18; 19–22) was used as a stratifying variable. Fisher's exact test was used to reduce the chance of making a Type I error (O'Donoghue, 2012, p. 290). The effect size was evaluated using the phi coefficient (φ). A value of 0.1, 0.3, and 0.5 indicated small, medium, and large associations between groups, respectively (Serdar et al., 2021). Relative risk (RR) and corresponding 95% CI were also used as an effect size measure (Uanhoro et al., 2021) and were calculated as part of the two-way χ^2 test of independence in SPSS (Gignac, 2019).

No data imputations were made for missing data. All analyses were performed according to the intention-to-treat principle. To be included in the study, the participants had to be injury-free. The final analyses did not include athletes reporting an injury the week before enrolment.

6 Results

This section presents the papers aims and summary of findings.

6.1 Training volume and perceived training distress (Paper Ⅰ and Paper Ⅱ)

6.1.1 Paper Ⅰ

The main aim of *Paper I* was to translate MTDS into Norwegian and investigate whether the Norwegian version of MTDS (MTDS-N) could be considered valid in detecting training distress among student athletes studying Elite Sport in Norwegian high schools. Another aim was to investigate the effect of covariates on the factor structure and model fit.

The results of the CFA showed that the original MTDS by Main and Grove (2009) did not fit the data well χ^2 = 814.824, *p*-value of χ^2 = <0.001, RMSEA = 0.071 (90% CI: 0.066–.076), CFI = 0.873, TLI = 0.848, and SRMR = 0.057. However, an alternative model where three error covariances were set as free parameters, resulted in a well-fitting model: χ^2 = 523.017, *p*-value of χ^2 = <0.001, RMSEA = 0.052 (90% CI: 0.047–.058), CFI = 0.932, TLI = 0.918, and SRMR = 0.050. The MTDS-N factors scale reliability was acceptable with McDonald's omega (ω) ranging from 0.725–0.862. The results of the multiple indicators multiple causes (MIMIC) model suggested that female student athletes tend to score higher on depression, physical symptoms, sleep disturbances, stress, and fatigue than male student athletes. Team sports student athletes tend to score higher on physical symptoms than those in individual sports. Those with a higher weekly training volume tend to score higher on physical symptoms than those with a lower weekly training volume. Student athletes studying sports and physical education tend to score higher on depression, physical symptoms, stress, and fatigue and lower in vigour than those taking the specialization in general studies. Second- and third-year student athletes tend to score higher on depression and vigour than first-year student athletes. Further, the extended MIMIC model testing for differential item functioning (DIF) indicated DIF for 13 of 22 items in MTDS-N. However, after incorporating the five covariates on the MIMIC model and the extended MIMIC model testing for DIF, the factor structure remained unchanged, and the model fit remained within acceptable values.

6.1.2 Paper II

The aims of *Paper II* were dual. The first aim was to describe weekly training volume in student athletes attending Elite Sport in Norwegian high schools and determine differences in training volume according to gender, type of sport, school program, and school year. The second aim was to investigate whether weekly training volume, gender, type of sport, school program, or school year influenced the responses on MTDS-N and to what extent there were interaction effects between these variables.

The one-way ANOVA results revealed no significant differences in weekly training volume for gender [F (1,589) = 1.08, p = 0.229], school program [F (1,591) = 0.20, p = 0.652], or school year [F (2,590) = 1.80, p = 0.166]. However, there was a significant difference in weekly training volume between sport types, with endurance sports, weight-bearing sport and other sports[2] having a larger weekly training volume than more technically demanding sports such as soccer[3] and other team and ball sports (Figure 9). The two-way ANOVA indicated a significant interaction between school year and sport type on weekly training volume [F (8, 578) = 1.978, p = 0.047, η_p^2 = 0.027], where student athletes in weight-bearing sports had significantly less training volume

[2] The categorisation of the different sports can be found in the supplementary connected to *Paper II* (S2 Table. The categorization of the different sports in the present study).
[3] Soccer and football indicate the same sport in the current thesis. The term soccer was used in *Paper I* and *Paper II,* whereas the term football was used in *Paper IV*.

in the third year compared to the first year (*M* difference = -4.04, p = 0.020, d = 0.81, r = 0.38) and student athletes in other sports had a significantly larger training volume in the third year compared to first and second year (*M* difference = 3.69, p = 0.16, d = 0.77, r = 0.36; *M* difference = 3.58, p = 0.03, d = 0.71, r = 0.34, respectively). The MANOVAs revealed no significant multivariate effect of weekly training volume, school year, sport type or school program on the combined characteristics of training distress. A significant multivariate effect of gender on the combined characteristics of training distress was found, irrespective of training volume per week, $\lambda = 0.899$, F (6, 580) = 10.82, $p<0.001$. The DDA indicated that female student athletes reported higher training distress than males, where stress significantly contributed to the equation. In addition, an interaction effect of weekly training volume × school year on training distress was observed $\lambda = 0.939$, F (24, 2021.10) = 1.53, p = 0.048. The two-way ANOVA indicated no significant differences among student athletes training 10–15 hours per week. Significant differences were found among student athletes training 5–10 hours per week, F (2, 584) = 4.393, p = 0.013, and student athletes training more than 15 hours per week, F (2, 584) = 6.369, p = 0.002. With 5–10 hours of weekly training, second-year student athletes perceived significantly more training distress than first-year student athletes (p = 0.003, d = 0.48, r = 0.23). Conversely, for those training ≥15 hours per week, first-year student athletes perceived significantly more training distress than second-year student athletes ($p<0.001$, d = 0.54, r = 0.26).

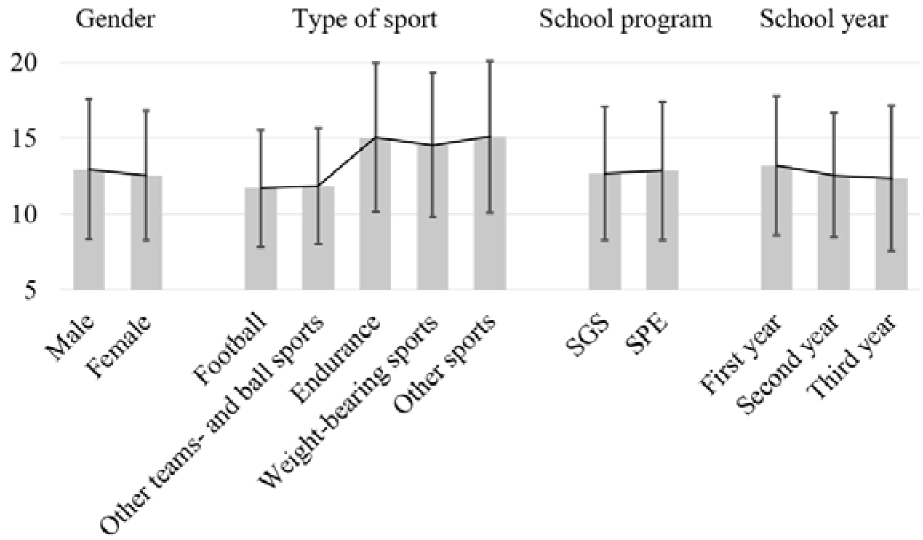

Figure 9 – Weekly training volume for gender, type of sport, school program and school year. SGS = Specialization in general studies; SPE = Sports and physical education.

6.2 Perceived communication and coordination (Paper Ⅲ)

The main aim of *Paper III* was to investigate perceived RC within and between student athletes, club coaches, school coaches, schoolteachers, parents, and health personnel. In addition, an aim was to examine differences in athletes' perceived RC with their coaches and other important roles according to the type of sport, school, performance level, sex, and school year.

The results indicated a strong RC tie from athletes to parents. Other than that, there was a predominance of moderate and weak RC ties within and between the included roles (Figure 10). Parents and club coaches received the strongest RC scores (*M* = 3.8 and 3.7, respectively), whereas schoolteachers received the weakest RC score (*M* = 2.9). The one-way ANOVAs indicated no significant difference in perceived RC with club coaches or health personnel between athletes, school coaches or club coaches. Results indicated that student athletes and school coaches perceived significantly stronger RC with school coaches and schoolteachers than club coaches. Student athletes perceive significantly stronger RC with parents than club coaches (*M* difference = 0.77, *p*<0.001) and school coaches (*M* difference = 0.77, *p*<0.001). Lastly, school and club coaches perceived significantly stronger RC with student athletes than student athletes did with their peer student athletes. Further, results indicated that individual sport athletes perceived significantly stronger RC with club coaches (*M* difference = -0.36), school coaches (*M* difference = -0.33), schoolteachers (*M* difference = -0.40), parents (*M* difference = -0.37), and health personnel (*M* difference = -0.52) than team sport athletes. No significant differences were found for the type of school, performance level, sex or school year.

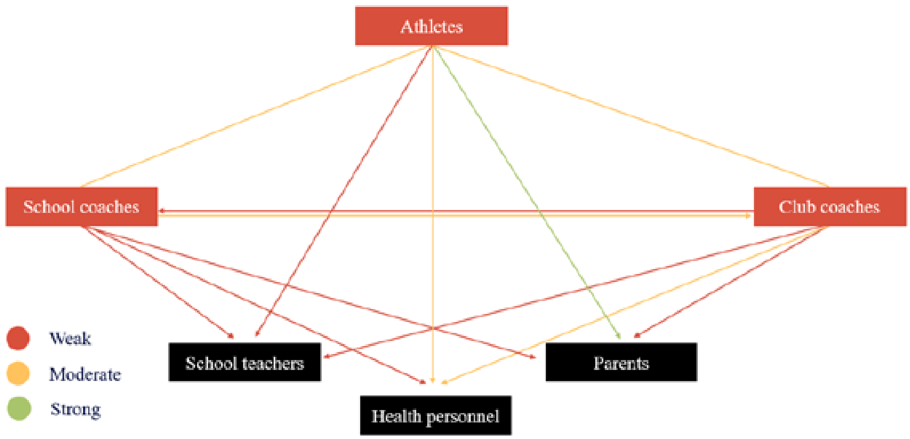

Figure 10 – The quality of relational coordination among the participants. Black boxes indicate roles that were not surveyed. Arrows from one box to another indicate the roles perceived quality of relational coordination. Lines between two boxes indicate a mutual quality of relational coordination between the roles.

6.3 The effect of communication and individualised sport-specific training on injury (Paper IV)

Paper IV aimed to evaluate the effectiveness of communication and coordination combined with a progressive and individualised sport-specific training program for reducing all-complaint injuries in youth female and male football and handball players transitioning to a sports academy high school.

The results showed an average weekly prevalence of all injuries of 11% (95% CI 8%–14%) in the experimental group and 19% (95% CI 13%–26%) in the control group. The average weekly prevalence of substantial injuries in the experimental and control groups was 7% (95% CI 3%–10%) and 10% (95% CI 6%–13%), respectively. The proportion of all-complaint injuries reported after enrolment differed significantly between the control and experimental groups: χ^2 (1, N = 375) = 4.865, p = .031, φ =.114, relative risk = 1.75 (95% CI 1.05–2.89). After stratifying the 12 weeks into three periods, results showed significant differences between the groups in weeks 11–14: χ^2 (1, N =125) = 6.904, p = .012, φ = .235 and in weeks 19–22: χ^2 (1, N = 124) = 4.402, p = .042, φ = .188. The relative risk was 3.57 (95% CI 1.26–10.17) and 2.28 (95% CI 1.02–5.10), respectively. The results showed no differences in the proportion of reported injuries in weeks 15–18. In the experimental group, 50% of the reported injuries were acute, whereas 15% and 35% were repetitive with a sudden onset and repetitive with a gradual onset, respectively. In the control group, 24% of the reported injuries were acute, 43% were repetitive with a sudden onset, and 33% were repetitive with a gradual onset. During the 12 first weeks after enrolment, 40% of the 15 athletes in the experimental group became injured, whereas ~69% became injured in the control group.

Results from *Study III*, showed that at any given time during the 22-week data collection period, 37% (95% CI 35% to 40%) of the participants from both groups reported a health problem. The distribution of injury and illness was 29% (95% CI 26% to 31%) and 9% (95% CI 6% to 12%), respectively (Figure 11).

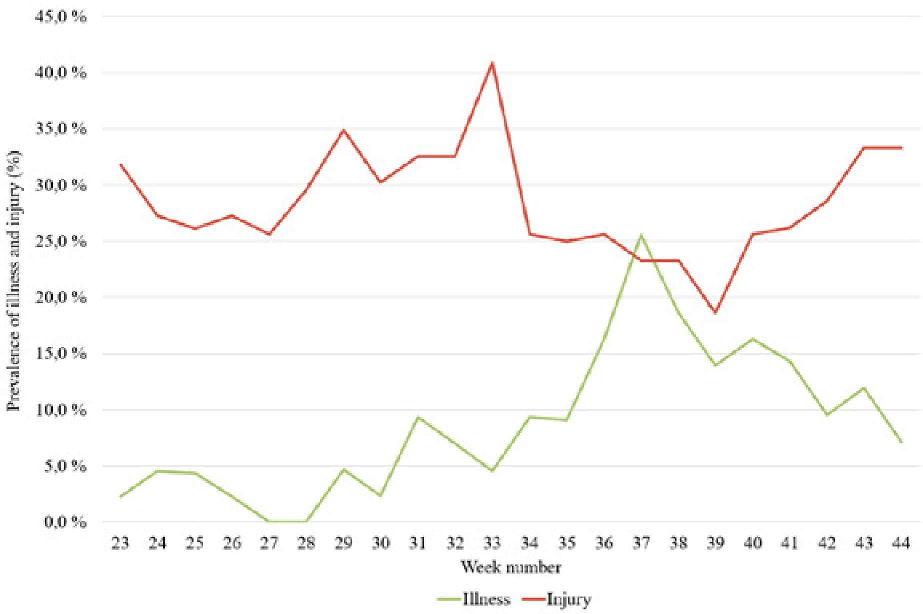

Figure 11 – The prevalence of health problems during 22 weeks. The summer holiday was from week 24 to week 31. The school started in week 32.

7 Discussion

The overall aim of the thesis was to empirically increase the knowledge about student athletes attending Norwegian sports high schools and identify possible measures to optimise the combination of sports and education in student athletes. To reach these aims, three individual sub-studies have been completed, and four papers are presented as the main content of this thesis. All of the sub-studies and research papers have aims, methodological approachs and results that contribute to increased knowledge of the research field of interest. This chapter discusses the themes relevant to the thesis's overall aim. The results obtained from the four papers will be used to discuss the presented themes, reflecting the coherence between the papers. Further, this chapter highlights methodological considerations, the validity of the thesis, and ethical considerations.

7.1 Training volume and perceived training distress

7.1.1 Training distress in student athletes

The results from *Paper I* and *Paper II* indicated that scores for the different dimensions of training distress were generally low to moderate. This finding is in accordance with previous research indicating that sport participation does not appear to be related to elevated psychological distress levels (Davis et al., 2019; Panza et al., 2020; Rosenvinge et al., 2018). Hence, the traditional assumption in sport psychology that student athletes combining both school and sports are more vulnerable to increased stress levels is not supported (Sallen et al., 2018). However, results from *Paper II* indicated that females experienced more depression, sleep disturbances, physical symptoms, stress and fatigue, and less vigour than males. These results corroborate the findings of previous studies, which have also found female student athletes to have relatively higher psychological distress levels (Sullivan et al., 2019), a higher prevalence of depressive symptoms (Wolanin et al., 2016) and greater fatigue levels with lower vigour levels (Brandt et al., 2017; Reynoso-Sánchez et al., 2020). In addition, sleep disturbances are more prevalent in adolescent females (Galland et al., 2017; Hysing et al., 2013). Considering the research to date, including the study results from *Paper I* and *Paper II*, practitioners involved with female student athletes should take this into consideration and focus on preventing adverse health outcomes and decreased performance.

As illustrated in Figure 5 by (Gabbett et al., 2019), the workload-capacity relationship is moderated by psychosocial factors in addition to historical and physical factors. Hence, in *Study III*, the data derived from the weekly report of the student athletes MTDS-N was used as a guide in planning the training for the experimental group. Other monitoring measures used were self-reported training data, RPE, daily form, general life stress by using ASQ-N and health problems using OSTRC-H2. Alongside weekly communication with the experimental group, these measures made it possible to get an overview of the participants´ total load. Contrary to *Study I*, we also measured the student athletes over time in *Study III*, allowing us to track individual changes in these measures over time. The updated workload-injury aetiology model from Windt and Gabbett (2016) shows that the multifaceted and complex occurrence of injury requires a more detailed approach than a "one size fits all" injury risk quantification, such as the ACWR (Kalkhoven et al., 2021). Monitoring should focus on objective physiological measures, subjective outcomes reported by the athlete (e.g., RPE), psychological measures (e.g., stress and coping mechanisms) and lifestyle-related factors (e.g., nutrition and sleep) (Verhagen & Gabbett, 2019). The interaction with psychological non-sports-related stress factors, such as negative life events or daily challenges, are crucial with regard to adverse development (Fry et al., 1991; Soligard et al., 2016). Hence, a holistic approach that considers physical and psychological perspectives should be used to monitor young athletes (Lloyd et al., 2015). The present thesis is based on a holistic perspective, which, together with ecological frameworks, have been the dominant theoretical lenses for understanding student athletes' development and functioning (Henriksen et al., 2010a; Henriksen et al., 2020; Kegelaers et al., 2022; Linner et al., 2022; Wylleman & Rosier, 2016). Those involved with student athletes should consider the whole picture, including physiological, psychological, biomechanical, and other life factors, for optimal student athlete management and development. Combining several types of monitoring tools make it possible to obtain more meaningful individual training data compared to interpretations based on a single monitoring tool in isolation (Gabbett et al., 2017). The aspects included in Figure 4 require continuous and prospective monitoring on each aspect to better understand the complex relationships between the components and their strength and temporality (Verhagen & Gabbett, 2019).

7.1.2 Training volume in student athletes

The results from *Paper II* demonstrated that there were no differences in weekly training volume according to the student athletes' gender, school year or school program. However, there was a statistically significant difference in weekly training volume according to the type of sport. Student athletes playing football or other team and ball sports trained fewer hours per week than student athletes in endurance sports, weight-bearing sports, and other sports (Figure 9). The present study's findings correspond with existing reference values for training volume. Elite athletes in typical endurance sports train between 800–1200 hours per year (Knechtle et al., 2015; Myakinchenko et al., 2020; Skattebo et al., 2019; Saavedra et al., 2018; Treff et al., 2017; Tønnessen et al., 2014), while elite athletes in more technically demanding sports train around 500–700 hours per year (Casado et al., 2019; Elferink-Gemser et al., 2012; Ingebrigtsen et al., 2013; Kenneally et al., 2020). However, these reference values on training volume are for senior athletes, and interestingly, the student athletes are already close to these values at the age of 15 to 18 while combining training and school, also referred to as a dual career (Stambulova et al., 2015). The combination of sports and education can be challenging as it demands the development of student athletes full potential in both areas (Christensen & Sørensen, 2009; Kristiansen, 2017). In addition to training and school loads, athletes typically encounter additional stress from other external sources such as social, work-related, lifestyle, and the athlete–coach relationship (Hamlin et al., 2019). According to GAS (Selye, 1950, 1951) and SFRA (Verkhoshansky, 1979, 1988), the balance between stress and recovery is important for adaptation and continuous high-level performance (Kellmann et al., 2018; Kraemer & Ratamess, 2004; Pearson et al., 2000; Rhea et al., 2003). Hence, those involved with student athletes should consider the whole picture, including physiological, psychological, biomechanical, and other life factors, for optimal student athlete management and development. In *Study III*, we combined several types of monitoring measures, including training load data, RPE, daily form, physiological and psychological training distress (MTDS-N), general life stress (ASQ-N) and registration of health problems (OSTRC-H2) to get an overview of the student athlete's total load. In addition, contrary to *Study I*, we measured the student athletes over time in *Study III*, which made it possible to track individual changes in the measures over time.

In *Paper II*, football student athletes had a mean weekly training volume of 11.7 ± 3.8 hours, while other team- and ball sports had a mean weekly training volume of 11.9 ± 3.8 hours. In *Paper IV*, football and handball student athletes in the experimental group had a training volume of 11.7 ± 1.8 hours during the first four weeks after starting at an elite sport high school. The control group's football and handball student athletes had a training volume of 12.3 ± 3.3 hours during the same period. Hence, reported training load in *Paper II and IV* are almost identical, despite data from *Paper II* being collected at a single point in time, while data in *Paper IV* were collected over several weeks. This increases the credibility of the training data from *Paper II* and shows the possibilities of using a cross-sectional design to collect training volume data from this population. However, to obtain the most accurate data and to examine changes in training (i.e., volume, type, intensity) and fatigue variables over time, a longitudinal design such as used in *Paper IV* is recommended (Jones et al., 2017).

More detailed training data was collected in *Paper IV* compared to *Paper II*. Results from *Paper IV* showed that the average volume of sport-specific training for handball players was 1.9 hours per week during the summer holiday in the control group. During the first four weeks after enrolment, the average volume of sport-specific training was 6.3 hours per week, corresponding to a 232% increase. In the experimental group, the increase was 100% (from 2.7 hours to 5.4 hours of weekly sport-specific training). This finding illustrates the large gap between the athlete's capacity and the required capacity after enrolment. According to Gabbett (2020b), the only way to progress from the floor to the ceiling with a large gap is to rapidly increase the training load to ensure the student athletes are prepared when starting at an elite sports academy high school (Gabbett, 2020b). Rapid increases in training load are associated with an increased risk of injury (Gabbett, 2016). For instance, research has indicated that a large increase in weekly handball load is associated with increased shoulder injuries in youth handball players (Møller et al., 2017). Those with scapular dyskinesis and reduced strength may be more vulnerable to shoulder injury with only a moderate increase in handball load (Møller et al., 2017). Research has also indicated that elite football players with poorer physical capacities (Malone et al., 2019; Malone et al., 2018; Windt et al., 2017) and musculoskeletal dysfunction (Møller et al., 2017) are at increased risk of injury. Thus, the increase in handball load that emerges from *Paper IV* is cause for concern.

According to Møller et al. (2017), concerted efforts should be made to avoid rapid increases in handball load. To achieve this, there is a need for available facilities (i.e., open handball halls) during the summer, especially for those participating in cups and tournaments in the weeks before enrollment. Sport-specific training volume during the summer was significantly different between groups; however, the difference was not significantly different after high school enrollment. The handball season starts in mid-September, but several clubs host cups and tournaments before the season (e.g., there were several participants in a tournament that started in mid-August, just before school started). It is not unusual for some teams to play up to four matches over four days. With several studies indicating a higher risk of injury during matches (Raya-González et al., 2020; Robles-Palazón et al., 2021), as well as our findings indicating a 232% increase in handball training volume during this period, athletes might be at a higher risk of overload and injury (Cook & Docking, 2015).

To make it more challenging, many student athletes reduce their training load during the summer holiday before high school enrolment due to travel, limited facilities, and fewer club training sessions. According to Gabbett (2020b), athletes might be at risk of being underprepared, underperforming or sustaining an injury if an inadequate training stimulus is applied to them. Hence, coaches and school coaches should monitor student athletes training load and fatigue on an individual level and modify appropriately during periods where there can be an intensification of training or increases in acute and/or accumulated training load (Jones et al., 2017; Møller et al., 2017). If this is not prioritized, there is a considerable risk of injury (Jones et al., 2017).

Contrary to the handball players in *Paper IV*, football players had more frequent organized club training during the summer and participated in several cups. This was not unexpected as the football season started in May. We did not identify any differences in sport-specific training volume between the experimental and control groups during the summer. However, the total training volume was significantly different, where the average weekly training volume was 11.1 hours in the experimental group and 7.7 hours in the control group. In addition, the experimental group had more physical training than the control group (i.e., strength training, endurance, sprints). This finding underlines the effectiveness of close follow-up during longer breaks from school. Via weekly follow-up in the experimental group, a progressive training load with an appropriate distribution of sport-specific and physical training was ensured. As highlighted in the updated workload-injury aetiology model from Figure 3, careful planning of training may have contributed to increased fitness in the experimental group, representing positive physiological adaptations that positively change the internal risk factors for injury (Windt & Gabbett, 2016). If so, one could argue that the participants from the experimental group would be more resilient and robust (Gabbett, 2020b), and better able to tolerate the high training loads after enrolment into a sports academy high schools.

According to Gabbett (2020b), it is not a realistic option to lower the ceiling to help athletes avoid injury and perform well – especially not when considering that elite performance demands are constantly evolving in complexity and physicality (Barnes et al., 2014). Thus, Gabbett (2020b) proposes two options. First, one could take more time to bridge the gap between the floor and the ceiling. This would mean that the requirement after enrolment regarding load should be delayed, for example, with a softer start after enrolment into elite sport high schools. However, this is problematic for handball athletes, as their season starts in September, just a month after school starts after the summer holiday. In addition, many participate in tournaments the weeks before school start as these tournaments must be outside the season (i.e., from 15th April to 15th September). The second suggestion is to buy more time prior to the official start of the preseason by increasing the floor before an extended break (Gabbett, 2020b). This would mean that student athletes should train more before the summer holidays. In recent years, elite sport middle schools have been introduced. One of the ideas behind this is to prepare athletes to withstand the load they will face in elite sport high schools. This idea might be good; however, one could argue that this may move injury and illness problems to an earlier stage.

7.2 Perceived communication on coordination

The results from *Paper III* demonstrate a potential for enhancing relationships and communication regarding student athletes' total load, both within and between significant roles involved with the student athletes. The importance of effective communication between student athletes and their teachers and coaches should not be undervalued when it comes to understanding the effect that the training has on them (Murphy et al., 2021). As illustrated in Figure 4 by Verhagen and Gabbett (2019), temporal factors such as context and environment can severely impact the balance between load capacity and load. For instance, fluctuations in motivation, mental state, or fatigue can influence how the body responds to a given daily load. This emphasizes the importance of frequent communication for optimal training prescription. In addition, many roles within a sports context are involved in the components shown in Figure 4, making communication and coordination of information necessary (Verhagen & Gabbett, 2019).

Result from *Paper III* also demonstrated that student athletes from individual sports perceived markedly higher RC with all roles compared to student athletes from team sports. These findings correspond with research from Rhind and Jowett (2012), indicating that athletes from individual sports report being closer and more committed to their coach. Hence, the results from *Paper III* suggest that those working with team sport student athletes should especially focus on developing high-quality relationships and communication. Research has shown that athletes in individual sports perceive that their coach feels more respect, trust, and appreciation for them than team student athletes, likely due to interacting more frequently on a one-to-one basis (Rhind & Jowett, 2012). A challenge for club coaches and school coaches working with student athletes in team sport is the limited time available. In individual sports, coaches can focus more on managing and optimising load for a single athlete, rather than having a whole team of players to consider. It would therefore be beneficial for Norwegian schools and clubs to invest more resources and free up more time to foster coach-athlete relationships in team sports. According to the RC theory, high-quality relationships of shared knowledge, goals, and mutual respect reinforces and are reinforced by frequent, timely, accurate, and problem-solving communication, resulting in effective coordination (Bolton et al., 2021). Conversely, the consequence of not focusing on building relationships is a potential negative effect on the student athlete's academic and sporting development, since relationships of low quality undermine effective communication, hindering successful coordination (Bolton et al., 2021).

In the context of injury-prevention in student athletes, communication between the athlete and the coach is important (Bolling et al., 2019). Several studies have emphasized collaboration and effective communication between coaches, management, medical staff, support staff and the players themselves as important components of the successful implementation of sports injury prevention strategies (Coles, 2018; Dijkstra et al., 2014; Speed & Jaques, 2011). A trusting relationship where the athlete has an active voice and the coach is open to listening will contribute to an open communication channel in the team and a shared responsibility concerning the athletes' health and performance (Bolling et al., 2019). It is reasonable to assume that this is especially important with younger athletes, as they might hold back information for fear of missing out on training or competition. Regular and personal conversations with the student athlete can improve effective communication and social support, which fits well with a holistic approach to rehabilitation in injured athletes (van de Wouw, 2023). In addition to regular communication, it is important to monitor athletes and be conscious that alterations in performance can be due to a potential injury (Bolling et al., 2019). In *Study III*, the electronic training diary and regular communication made it possible to evaluate the student athletes´

health and readiness to train. Load management is a constant process that depends on effective communication and teamwork, where all roles working with the athlete need to establish frequent and open communication (Bolling et al., 2019). It is suggested that the better the systems are, and the more integrated all the roles across a club (and other arenas, such as the school) are in the implementation of these systems, the more success and the fewer injuries there will be (Coles, 2018).

in *Study III*, an electronic training diary was used to guide the researchers in managing the training load. However, it was also used to involve and educate the student athletes. All participants had access to their training load data in *Study III*. In the online training diary, they could get an overview of the type of training they did, the training volume (hours and minutes) and their RPE over time. According to Bourdon et al. (2017), logging training can increase student athletes´ understanding of training load and the implications on attendance, performance and health. Hence, teachers and coaches in schools and clubs should emphasize the value of regular training registration. In addition, including student athletes in their training schedule can provide meaningful developmental and educational opportunities (Scantlebury et al., 2020). One would have a good argument for including education about self-reported training in theoretical sessions during school hours, which can further reduce the additional burden on student athletes (Murphy et al., 2021).

7.3 The effect of communication and individualised sport-specific training on injury

The proportion of athletes reporting an injury after sport academy high school enrolment differed between groups. The control group had 1.8 times higher injury risk than the experimental group during the first 12 weeks after enrolment. When dividing the first 12 weeks into three periods, the control group had a 3.5 and 2.3 times higher risk of becoming injured in the first and last four weeks after enrolment, respectively. Hence, it appears that a gradual and systematic increase in training load during the summer in combination with regular communication with coaches contributes to a safe progression in training load, improving players' tolerance to training towards the end of the summer. This in turn can reduce injury risk and enhance performance (Gabbett, 2020b; Verhagen & Gabbett, 2019).

7.3.1 Injury location

The most frequently reported injury location in handball players in the experimental group was the wrist, whereas shoulder/collarbone injuries were the most commonly reported injuries in the control group. The second most frequently reported injury in the control group was the knee. Repetitive throwing motions in handball (Raya-González et al., 2020) can potentially result in gradual onset injuries in the wrist and shoulder/collarbone. However, 100% of the wrist injuries in the experimental group were categorised as acute. For the shoulder/collarbone injuries in the control group, 75% of the injuries were categorised as repetitive with a sudden onset, while 15% were categorised as repetitive with a gradual onset. No shoulder or knee injuries were observed in the experimental group after high school enrolment. The individualised training program they received during the summer involved strength training, throwing with medicine and tennis balls, handball drills, sprints, agility and jump exercises and might have been effective in preventing injuries in these locations. As illustrated in the model from Gabbett et al. (2019) in Figure 5, structure-specific load capacity is related to a degree of physical capacity (e.g., speed, strength, and aerobic fitness), allowing athletes to better tolerate training. Appropriate training load further improves these physical qualities, ultimately generating sport-specific load capacity (T. J. Gabbett, 2020). The control group lacked sport-specific training during the summer, which might result in greater injury risk when performing technically demanding skills after enrolment.

The most frequently reported injury in football players in the experimental group was the shin/calf, followed by the lower back and ribs/upper back. No knee injuries occurred in the experimental group. The injury pattern in the experimental group differs from other studies of similar groups (Wik et al., 2021). A possible explanation is the low number of athletes and injuries in the current study. In the control group, injuries of the hip/groin and knee were the most frequent, followed by the thigh. This finding corresponds with previous research reporting that the thigh, knee, ankle, and hip/groin are the most frequently injured locations in youth elite football players (Le Gall et al., 2006; Light et al., 2021; Read et al., 2018; Renshaw & Goodwin, 2016; Tears et al., 2018).

Participating in sports involves the possibility of sustaining an injury (van de Wouw, 2023). Regardless, it is vital to implement measures to reduce the injury risk. This is considered particularly important for the age group investigated in this thesis since injury can affect both physical and psycho-social well-being (van de Wouw, 2023), which in the worst case can lead to student athletes dropping out of sport. Sustaining an injury also increases the risk of recurrence of both the original injury as well as subsequent injuries of any type (Toohey et al., 2017; Toohey et al., 2019), since alterations resulting from previous injuries may overload other structures not involved in the initial injury (Impellizzeri et al., 2020). Hence, preventive actions should be the focus for those involved with student athletes. According to van de Wouw (2023), building stronger athletes by providing them with different tools to reduce injury risk factors is better than waiting until the athlete “breaks” and gets injured. Employees in Norwegian schools and clubs should focus on lifelong enjoyment and physical activity as important goals of doing sports. Unfortunately, very few young athletes achieve their dream of becoming elite athletes. However, good experiences, few injuries and a good network around the student athletes can contribute to a lifelong enjoyment of physical activity, regardless of their performance level.

Results from *Study III* showed that at any given timepoint during the 22-week data collection, 37% (95% CI 35% to 40%) of the participants from both groups (n = 42) reported a health problem. The distribution of injury[4] and illness was 29% (95% CI 26% to 31%) and 9% (95% CI 6% to 12%), respectively (Figure 11). Overloading is a process described as a factor leading to injury (Bertelsen et al., 2017; Malisoux et al., 2015; Verhagen et al., 2021). Overloading can occur in two ways – either due to wanting to train too much, too fast and for too long without proper recovery, or due to insufficient or reduced load capacity, as illustrated in Figure 4 by Verhagen and Gabbett (2019). The increased training volume after high school enrolment could explain the high injury prevalence. However, as illustrated in the workload-injury aetiology model from Windt and Gabbett (2016) (Figure 3), injuries are multifactorial and, as such, multiple factors likely contribute towards the high prevalence of injuries. A recent study from Verhagen et al. (2021) found that recreational runners mentioned only load-related factors as causing overloading, while factors related to load capacity did not seem to be considered to cause overloading. Psychological/ lifestyle subjective health complaints (e.g., extra heartbeats and anxiety) and a lack of sleep (i.e., <7 hours/day over the past two weeks) have been associated with new injury risk for those participating in endurance sports (Johnston et al., 2020). This highlight the importance of sleep for optimal athlete recovery, well-being, and sports performance (Biggins et al., 2018; Charest & Grandner, 2020; Samuels, 2008). A love of exercising and/or wanting to achieve a specific goal can make athletes unwilling to rest, resulting in overloading (Verhagen et al., 2021). This might be linked to the athletes' intrinsic motivation, as research has found that high intrinsic motivation increases the number of injuries in recreational runners (León-Guereño et al., 2020). Coaches and other relevant people around

[4] These include all injuries, also accidents happening outside of sports (e.g., a fall on a bicycle or an ankle sprain during a walk in the city). *Paper IV* included only injuries resulting directly from participation in a competition or training in the sport's fundamental skills.

the athlete should be aware of the student athletes' intrinsic motivation and their desire to train and play as much as possible. If an athlete is offered to host another team or play an extra match, they probably will not say no to the opportunity. Some might also be willing to participate despite having a health problem. For this reason, monitoring the total load of student athletes is important (*Study III),* as well as effective communication between the coaches and other relevant roles (*Study II*).

The prevalence of health problems from *Study III* corresponds with previous research on similar populations. For instance, Moseid et al. (2018) reported a 37% average weekly injury prevalence after enrolment into a specialized sports academic high school in elite youth athletes in technical and team sports. Further, Bjørndal et al. (2021) reported an average weekly injury prevalence of 42%, of which 29% were categorized as substantial injuries in youth elite handball players. Similarly, high levels of injuries have been reported in Swedish elite adolescent handball players (von Rosen, Heijne, et al., 2018). It seems as though the term *training load* has become a “loaded” expression due to the increased rates of injury among youth athletes (Bjørndal et al., 2021; Dalen-Lorentsen et al., 2021; Jones et al., 2019; Moseid et al., 2018; Møller et al., 2017; Wik et al., 2021). For instance, the incidence of shoulder injuries is more than twice as high as previously reported in youth handball (Møller et al., 2017). To improve performance, the load must exceed the athlete's capacity (Gabbett, 2020b). Training that is appropriate to the individual athlete and physically demanding will develop physical qualities, which can reduce the risk of injury (Gabbett, 2016). Regarding Figure 3 from Windt and Gabbett (2016), when a tissue’s capacity to tolerate load is exceeded, it can result in injury. However, a reasonable and tolerable training dose can promote resilience and decrease the chance of fatigue leading to injury (Windt & Gabbett, 2016). In addition, a fundamental principle from the figure is that when athletes experience an injury, their bodies must undergo some loading to recover and ultimately be healthy again.

During the intervention period in *Study III,* student athletes in the experimental and control groups experienced illness and injury. According to Gabbett (2020b), one will likely meet individualds with a deconditioned state or injury when training athletes, making the athletes' current capacity inadequate to sustain normal training loads. In such a situation, the athletes' capacity is not at the floor level but more like “the basement” level (Figure 2, panel E) (Gabbett, 2020b). During the intervention period, it became vital to communicate more regularly than once a week with those athletes in the experimental group who experienced injuries or illness. They were asked to inform the research team about how the training went and how their body felt after each prescribed training. Athletes who experience health problems before enrolment into a sport academy high school will experience an even larger gap between their current capacity and the expected capacity. Hence, schoolteachers should communicate closely with club coaches and the student athletes themselves to get information about their readiness to train after enrolment.

The results in *Paper III* showed that student athletes from individual sports perceived significantly higher RC with all roles (i.e., club coaches, school coaches, schoolteachers, parents, and health personnel) compared to team student athletes. This finding implies that school coaches and club coaches should be extra aware of athletes who participate in team sports. A possible solution for optimal training after enrolment could be to map injury history, maturation, and physical capacity. This should be done individually as athletes of the same age can differ substantially with regards to maturation and psychological and physiological characteristics (Gabbett, 2022). In addition, injured athletes must be prioritised and looked after in this transition to maintain the athletes' motivation and mental health (Putukian, 2016).

7.4 Methodological considerations

Several methodological considerations must be acknowledged, which are elaborated on in the following section.

7.4.1 General strengths and limitations

A strength of this thesis is that it consists of an RCT (*Study III*) that builds on the themes and knowledge from *Study I* and *II*. To my knowledge, this is the first study where student athletes have been followed by a research team from the end of middle school, during the summer holiday, and for a further three months after starting at a sports academy high school. Thus, this thesis contributes new insight and knowledge in a critical transition period for adolescents in general and student athletes in particular.

However, all studies involved collecting self-reported data from the participants. Self-reported data is relatively easy to obtain, inexpensive, and can be collected from a large population. However, they are also subject to biases and limitations, such as response bias, sampling bias and social desirability bias (Heppner et al., 2015, p. 467).

7.4.2 Study design

A strength of a cross-sectional study design as used in *Study I* and *II* is that these types of studies are relatively inexpensive and take little time to conduct (Levin, 2006). In addition, the design can yield correlational indications about the directions and magnitudes of associations between the investigated variables (Krosnick et al., 2014). We cannot give evidence of causality, but the cross-sectional analysis is valuable because it can give information about the plausibility of a causal hypothesis (Krosnick et al., 2014).

Questionnaires can result in low response rates (Wang & Cheng, 2020). To facilitate a higher response rate, we were present during data collection in *Study II.* In *Study I*, schoolteachers were present during the completion of the questionnaire. Data collection occurred during school hours, presumably significantly impacting the response rate. Another limitation of the cross-sectional design is that it only provides a snapshot from one period in time; consequently, another timepoint might have yielded a different result (Levin, 2006). For example, in *Paper II*, student athletes' weekly training volume is discussed. Due to seasonal differences in a sport, the training volume might have differed if the data was collected from another period. Since cross-sectional studies are carried out at one time, they cannot indicate the sequence of events, making it difficult to infer causality (Levin, 2006; Wang & Cheng, 2020). However, they can indicate possible associations and help generate hypotheses for future research (Levin, 2006).

7.4.3 Participants and sample size

A low participation rate was present for *Study I.* A total of 119 schools in Norway were invited to the study. Of the 119 invited schools, 34 agreed to participate (28.6%), and 23 implemented the survey (19.3%), which might threaten the external validity of the results from *Paper I* and *II*. It is difficult to tell why some schools accepted participation and others did not. One possible explanation is if the headteacher of the school viewed the subject as valuable and important. In *Study II*, few club coaches and schoolteachers were included in the study, compared to student athletes. This was not unexpected since there will naturally be more student athletes than teachers in a sports high school. The same applies to club coaches. In *Study III*, 84 student athletes were eligible for inclusion. However, only 49 agreed to participate (58% of eligible players), and only 42 completed the study (50% of 84 eligible players). This is a limitation as it reduces the sample size and statistical power and increases the risk of selection bias (Heijmans et al., 2015). The probability sampling method is generally preferred as it is considered more accurate and rigorous than a non-probability sampling method

(Wang & Cheng, 2020). However, in this thesis, performing random sampling was not feasible or practical, so nonprobability sampling was applied.

7.4.4 Attrition and missing data

In long-running studies, sample attrition is inevitable and can occur because of participant withdrawal (Clark et al., 2021, p. 57). The main issue with attrition is the concern that participants leaving the study may differ from those who remain, resulting in a non-representative group (Clark et al., 2021, p. 57). In *Study III*, five participants withdrew after randomisation, resulting in an attrition rate of 2.4% (0.5% in the experimental group and 1.9% in the control group). In addition, one participant stopped responding during the project and could not be included in the final analysis. The final analyses also excluded participants reporting an injury the week before starting at the sports academy high school, which applied to eight participants in the experimental group and three in the control group. Hence, the overall participant attrition was 35.4%, which can pose severe threats to validity (Schulz & Grimes, 2002) and undermine the statistical power (Donkin et al., 2011).

Concerning missing data, a response to each question was required to complete the questionnaires in the three sub-studies. Thus, due to the electronic survey format, there were no missing data at the item level. However, there were missing data at the unit level, in which respondents did not respond to the questionnaires (Dong & Peng, 2013). Missing data at the unit level mainly applied to *Study III*, where participants did not respond to the questionnaires in certain weeks. For the OSTRC-H2, the response rate was 79% over the study duration of 22 weeks. The response rate was 74% in the experimental group and 84% in the control group. To increase the response rate, missing data were collected retrospectively by performing supplemental interviews at the end of the study, resulting in a response rate of 100%. The supplemental in-person interviews were also completed to verify the collected training data's accuracy.

In *Study III,* no data imputations were made for missing data. All analyses were performed according to the intention-to-treat principle. This principle involves comparing outcomes between the study groups with every participant analysed according to the randomised group assignment, regardless of whether the participant adhered to the assigned intervention (Hulley et al., 2013, p. 164). This type of analysis may underestimate the full effect of the treatment received. However, it protects against the more important problem of biased results by controlling for confounding resulting from the randomisation (Hulley et al., 2013, pp. 164-166). The alternative to the intention-to-treat approach is per-protocol analyses, where only those who comply with the intervention are included (Hulley et al., 2013, p. 165). To be included in the study, the participants had to be injury-free. Participants injured before school started were not included in the final analysie. Otherwise, the intention-to-treat approach was followed.

7.4.5 Specific for Study III

The main limitation of *Study III* is the limited sample size. With a larger sample size, it would have been possible to complete sub-group analyses of gender and sport (i.e., female, male, handball, and football). However, with a larger sample size, the research team would not have been able to give such close follow-up with weekly training programming on an individual level.

Previous research on injury prevalence and incidence over time has used Generalized Estimating Equations (GEE) as the statistical procedure to analyse the data (Al Attar et al., 2017; Andersson et al., 2017; Bjørneboe et al., 2014; Finch et al., 2016; Pas et al., 2020). We performed a two-way χ^2 test of independence due to the low sample size, as it requires a large sample size to execute GEEs (Liu, 2016). When the sample size is small, GEEs can have reduced efficiency due to incomplete, occasionally incorrect model specifications (Fitzmaurice, 1995; Lipsitz et al., 1994).

We did not collect injury history for the participants in the control group. Prior injury is one of the strongest predictors of subsequent re-injury (Gabbett et al., 2021). Therefore, the injury history should have been collected and controlled for in the statistical analysis.

7.5 Validity

In a broad sense, validity refers to an inference's approximate truth or falsity (Cook & Campbell, 1979, p. 37). Judgements about validity in research are not absolute, and various degrees of validity can be invoked (Shadish et al., 2002, p. 34). Campbell and Stanley (Campbell & Stanley, 1963) presented threats to validity nearly 50 years ago. Their work and subsequent revisions (Cook & Campbell, 1979; Shadish et al., 2002) have resulted in a framework where four types of validity are set forth: internal validity, statistical conclusion validity, construct validity and external validity. These types of validity will guide the following consideration of validity in the thesis. Since reliability is an important aspect of measurement quality (Trochim et al., 2016, p. 115), it will be discussed in the section on construct validity.

7.5.1 Internal validity

Internal validity refers to the approximate validity with which we infer that a relationship between two variables is causal or that the absence of a relationship implies the absence of cause (Cook & Campbell, 1979, p. 37).

Concerning *Study III*, a relevant question would be if it was the communication and coordination in combination with the individualised and progressive sport-specific training program that was the reason for the reduced risk of injury in the experimental group after enrolment. In addition to control over the variation in the independent variable (the manipulation), the random assignment of the participants to an experimental group and control group serves to rule out many potential third-variable threats to causal inference, particularly self-selection (Reis & Judd, 2014, p. 14). Randomisation allows the assumption that the experimental and control groups are not different at the beginning of the experiment (Thomas et al., 2015). In *Study III,* the randomisation was stratified by gender[5], sport, and performance level (i.e., physical fitness, motor performance, sport-specific and skills). Since we did not randomise participants according to their teams, there is a possibility of contamination, for example by participants sharing their experiences of the intervention during club training. According to Trochim et al. (2016, p. 216), this threat to validity tends to equalise the outcomes between the included groups, reducing the chance of seeing an effect even if there is one. However, all the players did the same training during club training, and the research team only prescribed training outside of club training. In addition, the treatment was given in the summer holiday, when many participants had a reduced number of club training sessions.

We did not adjust for previous injuries in *Study III*, which is a limitation and could potentially threaten the internal validity. Although only players who were injury-free before enrolment were included in the statistical analyses, there is a chance that a number of them have had previous injuries. The process of randomisation controls for history up to the point of the experiment (Thomas et al., 2015), meaning that we could assume that past injuries were equally distributed among the groups. However, because of the small sample size in *Study III*, there may be a chance that the proportion of players with previous injuries could differ due to random bias, which could potentially have a significant effect on the results in *Paper IV*. Previous injury represents a leading intrinsic risk factor for sustaining a new injury (DiFiori et al., 2014; Meeuwisse et al., 2007). The increased risk may be related to

[5] In *Paper IV*, we used the term sex instead of gender.

continuing symptoms, insufficient rehabilitation or underlying physiological weaknesses resulting from the original injury (e.g., ligament laxity, endurance, muscle strength, or kinaesthesia) (Emery, 2003).

Another threat to the study's internal validity is that we did not control for sleep or diet, which are possible mediators of the relationship between athlete management (i.e., progressive, individualised training) and injury. Diet and sleep may be relevant multifactorial determinants of performance and injury (Gabbett, 2020a; von Rosen, Frohm, Kottorp, Friden, et al., 2017; Watson & Brickson, 2018). For instance, increased training volume has been shown to reduce the quality of sleep, as well as increasing the need for a high calorie intake. von Rosen, Frohm, Kottorp, Friden, et al. (2017) found that athletes sleeping more than 8 hours during weekdays or reaching the recommended nutritional intake reduced the odds of injury by 61% and 64%, respectively. Conversely, chronic lack of sleep has been shown to increase the risk of injury in youth athletes (Milewski et al., 2014). In addition, an athlete's diet can impact their sleep (Barnard et al., 2022). To achieve overall health and recovery, optimising exercise, sleep, and diet is important (Vitale et al., 2019). Consequently, these factors, along with psychological stress and general life stress, should be considered when planning and prescribing training for student athletes.

Lastly, we did not perform blinding, which could limit the internal validity of *Study III*. However, blinding was not possible due to the nature of the study and the involvement of the researchers. The researchers were engaged in all parts of the study, including the development of the intervention, the design, the delivery of the intervention, the writing of papers and the statistical analyses.

7.5.2 External validity

External validity refers to the generalisability of the causal finding (Trochim et al., 2016, pp. 394-395). In other words – to what extent can the conclusions from a study be obtained in other settings, at different times, with different persons, and across different persons and research procedures (Brewer & Crano, 2014)?

The target population in the present thesis was primarilly Norwegian student-athletes in high schools. For this reason, the results of the sub-studies cannot be generalised to the larger population. It is a strength that the non-probability sample was from two geographically different counties in *Study III*. However, to increase the robustness of the sub-studies included in the present thesis, they should be replicated with student athletes in different Norwegian counties.

Study III was a field experiment in a real-life setting (Clark et al., 2021, p. 43). Field experiments are a proven way to improve external validity as the participants' behaviour is often more typical of their usual behaviour and thus less artificial (Eysenck, 2005, p. 281). However, field experiments do not allow for the same level of control, threatening the internal validity (Eysenck, 2009, p. 544). Therefore, to ensure as much control as possible, we chose to include a lower number of participants in the study to make it possible for investigators to carry out individual meetings with each participant once a week to control for interactions with other participants, the completed exercises, training volume and intensity, etc. In addition, many participants contacted the investigators several times during the week with questions related to training and life in general.

It should be noted that external validity is relative. Although a field experiment is associated with greater external validity, the experiment was conducted in a population from three different high schools in Norway. Elite sport high schools vary regarding coordination, communication, and prescribed training. Hence, it is not possible to know the extent to which our findings can be generalised to student athletes attending other elite sport high schools or those of a similar age who play handball and football but choose not to attend this type of school. Consequently, generalisation of the findings from *Study III* should be made with caution.

In *Study III*, the sample was derived from a single cohort: first-year student athletes in the academic year 2020-2021. Hence, the findings from the study may have been related to specific events in this specific cohort, which can limit the generalisation to other cohorts (Little, 2013, p. 40). That the participants were student athletes during COVID-19 could be such an influential event. Consequently, this can be relevant for comparisons with future studies.

In *Study I*, all student athletes on the Elite Sport program were offered an equal opportunity to participate. The participation rate was low; however, data were derived from four different regions in Norway (i.e., West, East, Mid and Northern Norway). Hence, the results might be valid across the student athletes' peers but limited to those studying Elite Sport in Norwegian high schools.

7.5.3 Construct validity and statistical conclusion validity

Construct validity is seen as the overarching category that contributes, together with reliability, to measurement quality (Trochim et al., 2016, p. 128). It refers to the extent to which a measure or instrument measures what it is theoretically supposed to measure (Trochim et al., 2016, p. 128).

In *Study I*, we measured training distress. The study aimed to translate MTDS to Norwegian and test the instrument´s factorial validity. Factorial validity is a type of construct validity as evaluated using factor analysis (Gunzler et al., 2021, p. 137). We conducted a CFA, which can provide compelling evidence of theoretical constructs' convergent and discriminant validity (Brown, 2015, p. 2). Convergent and discriminant validity are considered subcategories of construct validity, and if support for both is demonstrated, this is regarded as evidence of construct validity (Gunzler et al., 2021, p. 137). According to Fornell and Larcker (1981), convergent validity can be evaluated by calculating each construct's average variance extracted (AVE). This was not done in *Paper I*; however, later calculations of AVE following the procedure described by Collier (2020, p. 83) showed that three of six indicators had AVE >.50, which is the criteria to denote that the indicators have convergent validity on the construct (i.e., training distress in *Study I*). The discriminant validity was assessed by investigating the factor intercorrelations in *Paper I*. Following the criteria of Brown (2015, p. 28), we assumed that the discriminant validity was acceptable as none of the factor intercorrelations was above 0.80 or 0.85, which can imply poor discriminant validity.

Reliability is an integral part of construct validity and pertains to a measure's consistency or repeatability (Taber, 2018; Thomas et al., 2011, p. 197). Hence, we evaluated the internal consistency of MTDS-N and RCS in *Study I* and *Study II* by McDonald's ω as an additional measure to evaluate the quality of the measurement. In *Study I*, the MTDS-N factors constituted high scale reliability with McDonald's ω ranging from 0.725–0.862. In *Study II*, the factor also constituted high reliability with McDonald's ω of 0.892. The acceptable internal consistency of the measures can increase statistical power, effect sizes and gain the value of the observed correlations between two variables (Kline, 2016, p. 92). Thus, we can consider reliability an aspect of statistical conclusion validity (Sallis et al., 2021, p. 6; Shadish et al., 2002, p. 112).

7.6 Ethical considerations

The following sections presents some ethical considerations arising before, during and after the project.

Considering the length and scope of *Study III* (i.e., 22 weeks) an information meeting was conducted with the student athletes, their guardians, and the schools prior to the start of the study. To avoid coercing potential participants into taking part in the studies, the informed consent did not include any promises of rewards. However, during the meeting, we informed participants that the four athletes with the highest response rate on the questionnaires and training diary would receive a gift card of 500 NOK. It was clearly stated that participation was *voluntary*, and that participants could withdraw from the study at any time without providing a reason or facing negative consequences (NESH, 2022, pp. 18-19). During the data collection, participants that did not respond to the questionnaire or report their training would receive up to three reminders on their mobile phone. It is possible that this caused some participants to feel pressure to continue with the study. The involvement of coaches and teachers may also have led to pressure to participate. In addition, the survey format may have provoked some pressure to answer. To ensure anonymity and confidentiality, ID numbers were used rather than the participants' names to record data and the results were presented as group data. Only the research team had access to the raw data.

In *Study III*, participants were randomly assigned to an experimental or control group. The control group received a general injury prevention program during the summer (intervention period). The aim was to offer all the participants something and to increase their motivation to complete the project. Further, during data collection, three physical test batteries were performed. We collected body weight measurements, which might have made some participants uncomfortable. The participant could choose whether they wanted to see the weight results. The results were not said aloud to avoid any potential discomfort.

The necessity of each questionnaire was critically judged to avoid an additional demand on the participants and reduce the risk of survey fatigue. This was especially relevant in *Study III,* with a duration of 22 weeks. It was stated in the informed consent that one disadvantage of participating in the study was the possible burden of answering a number of questionnaires over an extended period. To make it more practical for the student athletes and reduce the burden, all questionnaires (i.e., MTDS-N, ASQ-N and OSTRC-H2) were implemented into the electronic training diary Bestr. The electronic diary only processes information whith the individual´s consent, and in line with the Personal Data Act and the General Data Protection Regulation (GDPR). In retrospect, we could also have stated to participants that the negatively worded items in MTDS-N could make the student athletes more aware of negative feelings.

8 Conclusion and implications

The overall aim of the thesis was to empirically increase the knowledge about student athletes attending Norwegian sports high schools and identify possible measures that can be implemented to optimise the combination of sports and education in student athletes.

Based on the findings in the present thesis, it is suggested that the following three measures be implemented in Norwegian sports high schools to optimise the combination of sports and education in student athletes. The first is to monitor student athletes over time using a holistic approach considering the whole picture, including physiological, psychological, biomechanical, and other life factors. A baseline measure should always be established before decision-making, and ideally, multiple monitoring tools should be used in parallel for a greater understanding of the student athlete's total load and overall state. This could include MTDS-N, an electronic training diary and ASQ-N. The second measure is to improve relationships and communication between the student athletes and the roles involved with the student athletes (i.e., school coaches, club coaches, guardians, schoolteachers and health personnel). This can be accomplished through regular informal and formal meetings, education to enhance competence, and by using electronic diaries available for the roles involved with the student athletes. The third suggested measure is to follow-up student athletes closely in periods when they are left more to themselves, such as during school breaks (e.g., the summer vacation) or in periods when there are fewer organised club training sessions. Together, these suggested measures can contribute to optimal student athlete management and development.

8.1 Practical implications and future research

More resources in clubs and schools are necessary to facilitate high-quality communication and coordination regarding the individual student athlete's total load. Extra resources should also be given to facilitate close supervision and individualised training programs during the transition into a sports academy high school (i.e., the summer holiday). In addition, there is a need for available facilities during the summer, making it possible for student athletes to maintain sport-specific training. For example, most handball halls are closed in July, and there are several cups and tournaments before school starts in the middle of August. It is easier for football players to maintain sport-specific training because there are more available facilites to play on during the summer holiday. In addition, the results from *Paper I* and *Paper II* indicate a need for additional focus on the female student athlete to preserve physiological and psychological well-being and ensure a progressive training overload leading to positive performance development.

Future research should investigate the validity of the MTDS-N. Furthermore, the three sub-studies in the thesis could be duplicated, especially *Study III*, which should include a larger sample size and consider confounders such as injury history, diet and sleep. Interventions seeking to increase relational coordination in schools and clubs could also be conducted.

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Part 2

The papers

Paper I

International Journal of
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MDPI

Article

The Factorial Validity of the Norwegian Version of the Multicomponent Training Distress Scale (MTDS-N)

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Abstract: Background: Athlete self-report measures (ASRM) are methods of athlete monitoring, which have gained considerable popularity in recent years. The Multicomponent Training Distress Scale (MTDS), consisting of 22 items, is a promising self-report measure to assess training distress among athletes. The present study aimed to investigate the factorial validity of the Norwegian version of MTDS (MTDS-N) among student-athletes ($n = 632$) attending the optional program subject "Top-Level Sports" in upper secondary schools in Norway. Methods: A confirmatory factor analysis (CFA) was conducted to assess the six-factor model proposed by Main and Grove (2009). McDonald's omega (ω) along with confidence intervals (CIs) were used to estimate scale reliability. After examining the fit of the CFA model in the total sample, covariates were included to investigate group differences in latent variables of MTDS-N, resulting in the multiple indicators multiple causes (MIMIC) model. Further, direct paths between the covariates and the factor indicators were included in an extended MIMIC model to investigate whether responses to items differed between groups, resulting in differential item functioning (DIF). Results: When modification indices (MIs) were taken into consideration, the alternative CFA model revealed that MTDS-N is an acceptable psychometric tool with a good fit index. The factors in MTDS-N all constituted high scale reliability with McDonald's ω ranging from 0.725–0.862. The results indicated statistically significant group differences in factor scores for gender, type of sport, hours of training per week, school program, and school level. Further, results showed that DIF occurred in 13 of the MTDS-N items. However, after assessing the MIMIC model and the extended MIMIC model, the factor structure remained unchanged, and the model fit remained within acceptable values. The student-athletes' reports of training distress were moderate. Conclusion: The MTDS-N was found to be suitable for use in a Norwegian population to assess student-athletes' training distress in a reliable manner. The indications of group effects suggest that caution should be used if one is interested in making group comparisons when the MTDS-N is used among student-athletes in Norway until further research is conducted.

Keywords: confirmatory factor analysis; multiple indicators multiple causes; differential item functioning; athlete monitoring; student-athletes

1. Introduction

The combination of sport and education, also referred to as "dual-career" [1] can be challenging for young athletes between the ages of 10 and 18 years old [2] as it demands the development of their full potential in both areas [3]. In addition to training and school loads, athletes typically encounter additional stress from other external sources such as social, work-related, lifestyle, and the athlete–coach relationship [4]. Consequently, there is a unique interaction between physical and psychological stresses [5]. Increased stresses can potentially lead to fatigue and increase the risk of illness and injury [6,7]. Hence, the balance between stress and recovery is a key factor for continuous high-level of performance [8]. Therefore, without a sufficient balance between training load and recovery, non-functional overreaching (NFOR) can occur [9]. At this stage, the first signs and symptoms of extended training distress such as performance decrements, psychological disturbance, and hormonal disturbances could occur and require weeks or months for the athlete to recover [9].

Periods of accumulated training load and changes in acute training load have also been reported to increase the risk of injury and illness [6]. Research showed that training and competition load resulted in temporary decrements in physical performance and significant levels of post-competition fatigue [10]. These decrements have been explained by increased muscle damage [11], reduction in the effectiveness of the immune system [12], an imbalance in anabolic and catabolic processes in the body [13], athlete mood disturbance [14], and a reduction in the neuromuscular effectiveness [15]. Besides training load, non-sport events can impose further stress on athletes, which shifts their physical and psychological well-being along a continuum that starts with homeostasis and progress through the stages of acute fatigue, functional overreaching, NFOR, overtraining syndrome, subclinical tissue damage, clinical symptoms, and time-loss injury or illness [16]. In normal circumstances, it can take up to five days to return to a balanced physical state (homeostasis) [13], and with increased training load and non-training stressors, it might take up to several weeks to recover [9,17]. The additional stress is not only evident in athletes playing sport at a high-performance level but also in athletes at the lower representative standards, where external pressure from schoolwork, relationship tensions, and pressure from parents and coaches has been reported [18]. Hence, there can be a risk of NFOR and overtraining (OT) for all young athletes. Consequently, this is not only an important issue for those adults that are involved in sport but also for coaches and teachers [18].

One of the challenges for those involved with athletes is to carefully monitor and manage the stresses and recovery to be able to optimize their performance capacity and to avoid harmful outcomes [19–24]. Athlete self-report measures (ASRMs) are methods of athlete monitoring, which have gained considerable popularity in recent years [25] and will likely continue growing in popularity as a monitoring strategy [26]. The utility of ASRMs as a monitoring tool is well supported and has been reported to be useful [10,23,24,27]. Their popularity stems from their low cost, easy to use, and the growing body of literature which have emphasized ASRMs to be sensitive to the risk of illness and injury, compared to physiological biomarkers [28]. An ASRM that has been considered to be promising in monitoring athletes [28] is the Multicomponent Training Distress Scale (MTDS) [29]. The instrument has been used in different sports, including swimming [30], rowing [31], soccer [32,33], cycling [34], alpine skiing [35], and tennis [36]. The instrument combines measures of mood disturbances, perceived stress, and symptoms of acute overtraining over a small number of items (22 questions) [29], and provides an insight into the intensity and frequency of psycho-behavioral responses [37]. Thus, the purpose of the present study was to translate MTDS into Norwegian (MTDS-N) and investigate whether the Norwegian version of the questionnaire can be considered a valid measure in detecting training distress among young athletes attending the optional program subject "Top-Level Sports" in upper secondary schools in Norway. Further, the study aimed to investigate the effect of covariates on the factor structure and model fit.

2. Materials and Methods

2.1. Sample Size Estimation

For the validity of the MTDS-N, the sample size was estimated using the point of stability approach, which is described in Kretzschmar and Gignac [38], Schönbrodt and Perugini [39], and the study of Hirschfeld, et al. [40]. The latter gave a direction to estimate the sample size needed for the Big Five Inventory and the International Personality Item Pool Big Five measure. The point of stability ensures that the deviation between the estimated sample and the population parameter is stable (small) and is expected to remain small at a stable statistical power = 80% [38,39]. To ensure that the stability is small, Schönbrodt and Perugini [39] indicated that, according to Cohen [41], the corridor of stability should not exceed a small correlation of 0.10. The study of Schönbrodt and Perugini [39] suggested that 240–250 participants would be the minimum number needed to reach the point of stability. Kretzschmar and Gignac [38] continued the work of Schönbrodt and Perugini [39] and reported that with perfect reliability (omega, $\omega = 1.0$) of both latent factors and a population correlation of $p = 0.20$, the point-estimates of the correlation was stabilized at a sample size of 220 [38]. Since perfect reliability is almost never achieved, the authors suggested that the required sample at a population correlation of $p = 0.20$ and reliability of $\omega = 0.7$ would be ≥490 participants [38]. Similar results have been reported by Hirschfeld, Brachel and Thielsch [40], and the recommended sample size to reach a point of stability was > 500 participants [40]. Therefore, the total number of participants that was required in this study was to be more or equal to the recommendations from similar studies (i.e., $n \geq 500$).

2.2. Participants

The participants in the present study were 632 student-athletes attending the optional program subject Top-Level Sport from 23 different upper secondary schools in Norway. Seven covariates that characterize the profile of the respondents are presented in Table 1. The participants reported 35 different sports, which are shown in Table 2. This study was carried out according to the World Medical Association Declaration of Helsinki. Informed consent was obtained from all participants who agreed to take part in this study in accordance to the ethical approval from the Norwegian Social Science Data Services (NSD) (Project number 836079) and the Regional Committees for Medical and Health Research Ethics (REK) (Project number 54584).

Table 1. The profile of the 632 student-athletes in the present study.

Characteristics (Total) [1]	Modalities	Frequency or M ± SD	%
Gender (630)	Male	327	51.9
	Female	303	48.1
Type of sport (630)	Individual	207	32.9
	Team sport	423	67.1
Region (632)	West Norway	344	54.4
	East Norway	148	23.4
	Mid Norway	160	16.8
	Northern Norway	34	5.4
Age in years (631)	Male	17.37 ± 0.06	
	Female	17.23 ± 0.05	
Training hours (617)	Total	12.54 ± 4.99	
	Specialization in general studies	12.60 ± 4.95	
	Sports and physical education	12.45 ± 5.06	
School program [2] (632)	Specialization in general studies	369	58.4
	Sports and physical education	263	41.6
School level [3] (632)	First grade	232	36.7
	Second grade	239	37.8
	Third grade	161	25.5

Notes. M = mean; SD = standard deviation; % = percentage. [1] Values in brackets indicate total responses from the participants. There were 20 missing values, but the number of cases with missing values on the characteristics was 18. [2] In the education program specialization in general studies with Top-Level Sports, the student-athletes are attending regular specialization in general studies with Top-Level sports as an optional program subject. Thus, they have only theoretical subjects in addition to the physical Top-Level sports subject. In the education program sports and physical education, the student-athletes have many subjects that are related to sports, both theoretical and practical. The subjects are activity theory, theory of training, training management, sports and society, and the optional program subject Top-Level Sports. Hence, student-athletes connected to the program sports and physical education have more hours of training per week at school, compared to those connected to the program specialization in general studies. [3] In Norway, the ages of the students are 15–16 years in first grade, 16–17 years in second grade, and 17–18 years in third grade. These ages can be compared to sophomores, juniors, and seniors, respectively, in high schools in the United States.

Table 2. The different sports reported by the 630 participants (two missing).

Descriptive Statistics					
Type of Sport	**Frequency**	**%**	**Type of Sport**	**Frequency**	**%**
Soccer	306	48.6	Sailing	6	1.0
Handball	91	14.4	Martial art	9	1.4
Swimming	24	3.8	Badminton	5	0.8
Track field	21	3.3	Cheerleading	1	0.2
Gymnastics	11	1.7	Strength training	4	0.6
Ice hockey	19	3.0	Sky jumping	1	0.2
Cross-country skiing	34	5.4	Diving	1	0.2
Orienteering	8	1.3	Sports drill	4	0.6
Alpine skiing	15	2.4	Shooting	1	0.2
Cycling	12	1.9	Snowboard	1	0.2
Golf	5	0.8	Jet ski	1	0.2
Floorball	2	0.3	Dance	1	0.2
Volleyball	5	0.8	Motocross	2	0.3
Rowing	3	0.5	Triathlon	2	0.3
Biathlon	12	1.9	Freeski	1	0.2
Show jumping	12	1.9	Climbing	1	0.2
Ice skate	4	0.6	Figure skating	1	0.2
Tennis	4	0.6			

2.3. Instrument

The MTDS was developed by Main and Grove [29] using three different instruments; the 10-item version of the Perceived Stress Scale (PSS) [42], the 24-item Brunel Mood State Scale (BRUMS) [43], and a checklist of 19 symptoms of acute overtraining [44]. The initial validation conducted by Main and Grove [29] concluded 22 items, addressing six factors. Four factors (depression, vigor, stress, and fatigue) are measured in terms of their frequency and scored on a five-point Likert scale ranging from "never" (0)–"very often" (4). The factor vigor is reversed scored, indicating that higher scores reflect the greater frequency of experiencing higher levels of energy. Further, two factors (physical symptoms and sleep disturbances) are measured in terms of their intensity and scored on a five-point Likert scale ranging from "not at all" (0) –"an extreme amount" (4). From a psychometric standpoint, the questionnaire exhibited a theoretically relevant relationship with a similar distinct construct, namely; the risk of burnout using the Athlete Burnout Questionnaire (ABQ) [29,45]. The results indicated that low scores on the ABQ resulted in low scores on the five negative training distress factors (depression, perceived stress, fatigue, sleep disturbances, and physical symptoms) and a high score on the positive factor (vigor). Conversely, high scores on ABQ resulted in high scores on the five negative training distress factors and a low score on the positive factor [29].

2.4. Procedures

Translation of the MTDS from English to Norwegian

Figure 1 illustrates the process of translating MTDS to the Norwegian context. The translation of the original English version to Norwegian was accomplished with reference to Guillemin, Bombardier, and Beaton [46] four-step translation procedure. Further, the International Test Commission (ITC) Guidelines for Translating and Adapting Tests were taken into consideration during the translation process [47].

Int. J. Environ. Res. Public Health **2020**, *17*, 7603

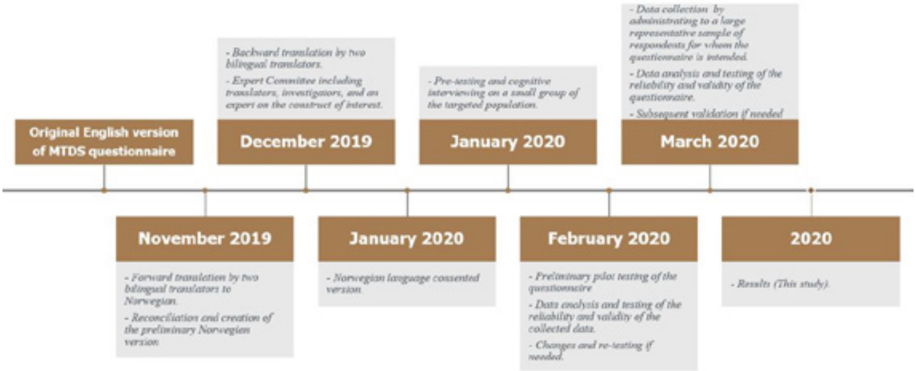

Figure 1. The process of translating Multicomponent Training Distress Scale (MTDS) to the Norwegian context.

In the first step, two independent bilingual, native Norwegian speakers forward translated the questionnaire from English to Norwegian. One of the translators was aware of the concepts the questionnaire intended to measure where the other was not aware of the objective of the questionnaire to offer more reliable restitution of the intended measurement [48]. A third translator compared the two versions and corrected differences to find the most appropriate words, expressions, and sentence structures to capture the meaning of the items.

In the second step, two different independent translators conducted the backward translation from Norwegian to English. To avoid bias, the translators were not familiar with the original version of the questionnaire. Both were bilingual and native English speakers. The original and backward translated versions of the questionnaire were then compared to ensure that the forward translation was precise and as complete as possible.

In the third step, an expert committee (consisting of one expert who was familiar with the construct of interest, a methodologist, one of the forward translators, and two which were not involved in the process of translations) were consulted to produce the final version of the Norwegian translation. All translated versions were reviewed with reference to achieve semantic, idiomatic, experiential, and conceptual equivalence, and any discrepancies were resolved [46].

In the fourth step, before conducting the pilot data collection of the final version of the MTDS-N, the items were tested on a small intended sample of respondents, following a probe technique [46]. Eight respondents completed the translated questionnaire and were asked verbally to elaborate on what they thought each item and their corresponding response meant. This was done in order to ensure that the final item was understood as having a meaning equivalent to that of the source item.

In the fifth step, a preliminary pilot testing of the questionnaire was carried out by distributing the questionnaire to a small group of the targeted population (n = 162) to measure its reliability and validity prior to the major data collection [47]. The results from the preliminary pilot testing demonstrated that the MTDS was successfully translated, culturally adapted, and reproduced the original reported psychometric properties (results of the preliminary pilot testing are attached in the Supplementary Materials). Therefore, a data collection to a larger group representing the targeted population was carried out (this study).

2.5. Data Collection

Invitations to participate were sent to all upper secondary schools that offer the optional program subject Top-Level Sports in Norway (n = 119). The final version of MTDS-N was then distributed electronically using SurveyXact version 8.0 [49] to all school management who agreed to participate in this study (n = 34, 28.6%). After that, the school management distributed the questionnaire electronically to the student-athletes at their respective schools (n = 23, 19.3%). In addition to completing the questionnaire, all participants completed questions regarding their age, gender, type of sport, hours of training per week, county, name of the school, study program, and grade level. The data collection started in March 2020 and ended in May 2020 (see Section 2.2).

2.6. Statistical Analysis

Prior to analyses, Microsoft Excel (version 2016) was used to prepare the data (source data are attached in the Supplementary Materials). Then, the factor vigor, with positive scores, was reversed. Demographic and descriptive data were analyzed using Statistical Package for the Social Sciences (SPSS) Version 25 (IBM Corporation, Armonk, NY, USA). Preliminary analyses investigating the normal distribution of the data were conducted using Mplus Version 8.4 (Muthén and Muthén, Los Angeles, CA, USA) [50]. The normality was examined using skewness and kurtosis (Table 3). Skewness and kurtosis values between ±1.0 were considered excellent, while values between ±1.0–2.0 were considered acceptable [51]. A non-normality test due to skewness and kurtosis was conducted to investigate if the data violated the multivariate normality assumption [52]. If the data were found not to violate the multivariate normality assumption, a Kolmogorov–Smirnov test (KS) and the Shapiro–Wilk test (SW) were further assessed to confirm that the data was normally distributed. A non-statistically significant ($p > 0.05$) Kolmogorov–Smirnov test (KS) and Shapiro–Wilk test (SW) would indicate normally distributed data [53].

Table 3. Descriptive statistics for 632 participants on the items of MTDS-N.

Items	Descriptive Statistics			
	M	SD	Skewness	Kurtosis
Depression (dep1–dep5)				
Miserable (dep1)	1.47	0.82	1.95	3.44
Unhappy (dep2)	1.75	0.94	1.27	1.09
Bitter (dep3)	1.64	0.86	1.49	2.16
Downhearted (dep4)	2.03	1.06	0.92	0.11
Depressed (dep5)	1.49	0.90	2.09	3.97
Vigor (vig1–vig4)				
Energetic (vig1)	2.70	0.99	0.38	−0.08
Lively (vig2)	2.61	0.95	0.54	0.03
Active (vig3)	2.52	0.90	0.32	−0.24
Alert (vig4)	2.87	0.94	0.30	−0.21
Physical symptoms (sym1–sym3)				
Muscle soreness (sym1)	2.52	1.03	0.18	−0.68
Heavy arms or legs (sym2)	2.43	0.98	0.38	−0.44
Stiff/sore joints (sym3)	2.11	1.03	0.73	−0.19
Sleep disturbances (sle1–sle3)				
Difficulties falling asleep (sle1)	2.15	1.18	0.84	−0.32
Restless sleep (sle2)	2.06	1.16	0.90	−0.21
Insomnia (sle3)	1.83	1.11	1.22	0.51
Stress (str1–str4)				
Stressed (str1)	3.06	1.11	−0.02	−0.65
Could not cope (str2)	2.76	1.02	0.10	−0.46
Difficulties piling up (str3)	2.12	0.96	0.68	0.08
Nervous (str4)	2.78	1.09	0.15	−0.56
Fatigue (fat1–fat3)				
Tired (fat1)	2.69	0.98	0.28	−0.42
Sleepy (fat2)	2.54	1.09	0.43	−0.55
Worn-out (fat3)	2.46	1.07	0.41	−0.59

Notes. M = mean; SD = standard deviation; Dep = depression; Vig = vigor; Sym = physical symptoms; Sle = sleep disturbances; Str = stress; Fat = fatigue.

All further analyses were carried out using Mplus [50]. To investigate the six-factor solution of the MTDS questionnaire proposed by Main and Grove [29], confirmatory factor analysis (CFA) was assessed. Considering a multivariate non-normality in the measures (Table 3), a maximum likelihood estimator (MLR) with robust standard errors using a numerical integration algorithm was used (Mplus codes used are attached in the Supplementary Materials).

The goodness of fit was assessed using χ^2, root mean square error of approximation (RMSEA), comparative fit index (CFI), Tucker-Lewis index (TLI), and the standardized root mean square residual (SRMR). A good fit was indicated if the corresponding *p*-value of $\chi^2 > 0.05$ [54], a RMSEA value close to 0.06 [55], or a stringent upper limit of 0.07 [56], CFI and TLI ≥ 0.90 [55,57], and SRMR of ≤ 0.07 to indicate a good model [58], and ≤ 0.08 to indicate an acceptable model [55]. The model fit was further examined based on factor loadings and the estimated squared standardized factor loading (R-squared, R^2). A factor loading of ≥ 0.30 was considered as the cut-off point [59,60]. To capture model misspecification, the model fit modification indices (MIs) were also taken into consideration, as CFA models with many indicators often do not fit the data [52]. High MI values would suggest freeing the corresponding parameter in the analysis if it were theoretically meaningful to do so. Together with MIs, also expected parameter change (EPC) provided information on model respecification [52]. Since the chi-square (χ^2) statistic of the MLR cannot be used for χ^2 difference tests, the Satorra–Bentler scaled χ^2 difference test was used for the comparison of nested models. Further details of this procedure are given in the Mplus Web site [61]. The interpretation of effect sizes was based on the guidelines proposed by Funder and Ozer [62], where an effect size *r* of 0.05 indicated a very small effect; an effect size *r* of 0.10 indicated a small effect; an effect size *r* of 0.20 indicated a medium effect; an effect size *r* of 0.30 indicated a large effect; an effect size *r* of ≥ 0.40 indicated a very large effect.

A popular measure that has been widely used in social sciences to investigate internal consistency is Cronbach's alpha (α). However, it does not provide a dependable estimate of scale reliability as it has been found to underestimate or overestimate the scale reliability depending on measurement parameters [63]. To overcome the disadvantage of Cronbach's α, the McDonald's omega (ω) with confidence intervals (CIs) has been recommended and applied in this study to estimate scale reliability based on the results of CFA [52,64–66]. The calculation of ω alongside a CI reflects the variability in the estimation process, which provides a more accurate degree of confidence in the consistency of the administration of a scale [67]. There are different reports about the acceptable values of reliability estimates, but a rule of thumb has been that it should reach 0.70 for an instrument to be acceptable [68,69]. However, very high values of α may suggest that some items are redundant as they are testing the same question but in a different way. Hence, a maximum value of reliability estimate <0.90 has been recommended [51,70] and was used as a guide in the interpretation of the ω in the preset study.

After establishing a well fitted CFA model for the total sample, covariates were included to investigate group differences in the factors from MTDS-N [71]. Such a model is referred to as multiple indicators and multiple causes (MIMIC) model [72]. The MIMIC model consists of two parts: (i) the measurement model, in which observed indicators (i.e., 22 items) measure six underlying latent factors (i.e., depression, vigor, physical symptoms, sleep disturbances, stress, and fatigue); (ii) structural equations, in which observed variables predict the six latent factors. Five covariates were included in the MIMIC model to estimate group differences on the factors, such as gender (1 = male; 2 = female), sport (1 = individual sport; 2 = team sport), hours of training per week (continuous), program (1 = specialization in general studies with Top-Level Sports; 2 = sports and physical education with Top-Level Sports), and school level (1 = first grade; 2 = second grade; 3 = third grade). Covariates labeled with the value one were considered as the reference group. Further, the MIMIC model was extended, which involved regressing the indicators and factors on the exogenous variables [73]. The purpose of the extended MIMIC model was to determine if there were any group differences in specific items, over and above differences in the latent variables [71]. Such a model is linked to differential item functioning (DIF). Differential item functioning occurs when an item has different measurement properties for one group versus another, irrespective of mean difference on the factor [74].

Detecting DIF is important since it can lead to an inaccurate conclusion about differences in groups and invalidate procedures for making decisions about individuals [75]. The factors (depression, vigor, physical symptoms, sleep disturbances, stress, and fatigue) and all endogenous indicators, except one of each latent variable, were regressed on the five covariates. This was done for the purpose of model identification [71,73]. If all direct effects between the covariates and indicators had been freely estimated at the same time, the model would be under-identified [60]. In the MIMIC models, the covariates served as grouping variables, and a significant direct effect of a covariate on a factor or item would indicate measurement non-invariance or measurement heterogeneity across the groups of the covariate (e.g., males and females).

3. Results

3.1. Item Analysis of MTDS-N

The statistical tests KS and SW yielded statistically significant ($p < 0.001$) results for all items, indicating not normally distributed data. However, in large samples, these tests can be statistically significant even when the scores are only slightly different from a normal distribution [53,76,77]. Hence, the KS and SW were interpreted in conjunction with the values of skewness (−0.02–2.09) and kurtosis (−0.08–3.97) which showed that the data were a little skewed and kurtotic. The items miserable, bitter, and depressed did not meet the criteria of ±2.0, showing kurtosis values of 3.44, 2.16, and 3.97, respectively. Furthermore, when testing for both multivariate skewness and kurtosis, the results indicate statistically significant ($p < 0.001$) results, indicating a violation of the multivariate normality assumption in the data under study.

3.2. Confirmatory Factor Analysis

In the first step, a CFA of the hypothesized six-factor model proposed by Main and Grove (2009) was run. The model did not fit the data well: χ^2 = 814.824, p-value of χ^2 = <0.001, RMSEA = 0.071 (90% CI: 0.066–.076), CFI = 0.873, TLI = 0.848, and SRMR = 0.057. As the hypothesized model yielded a poor fit, MIs was examined as a guide in search of model misspecification. A couple of high error covariances were specified in the model. Hence, a new alternative model was run where three error covariances (str4 with str1, MI = 147.57, EPC = 0.48; vig4 with vig3, MI = 84.13, EPC = 0.27; and fat2 with fat1, MI = 53.97, EPC = 0.33) were set as free parameters in model estimation. It appeared that the correlated items' measurement errors in the hypothesized model were due to somewhat similar wording in the corresponding questions of the MTDS-N. After the residual covariances were set as free parameters, factor loadings were basically unchanged. Still, all the fit indices were improved with higher CFI and TLI, as well as smaller RMSEA and SRMR. The fit indices from the two CFA models are presented in Table 4.

Table 4. The test of model fit from the six-factor solution proposed by Main and Grove (2009) and the alternative model taking three measurement errors into consideration.

Fit Indices	The Hypothesized Model	The Alternative Model
χ^2	814.824	523.017
df	194	191
p	<0.001	<0.001
RMSEA	0.071	0.052
CI	0.066–0.076	0.047–0.058
CFI	0.873	0.932
TLI	0.848	0.918
SRMR	0.057	0.050

Notes. χ^2 = chi-square value; Df = degree of freedom; p = probability value of χ^2; RMSEA = root mean square error of approximation; CI = confidence interval; CFI = comparative fit Index; TLI = Tucker–Lewis index; SRMR = standardized root mean square residual.

Using the robust estimator MLR for model estimation, a scaled difference in χ^2 was computed for nested model comparison (Table 5). The hypothesized CFA model was re-run with equality restrictions on the factor loadings to each factor, and a likelihood ratio (LR) test was conducted to test whether the indicators of each factor were equally loaded to the underlying factors. With these restrictions, the number of free parameters was reduced, the degrees of freedom of the model increased, as well as the MLR χ^2 statistics. To compare the restricted model with the alternative model, the following formula was used for calculating the scaled difference in χ^2 for model comparison [52]:

$$TRd = (T_0 \times c_0 - T_1 \times c_1)/c_d$$

where T_0 and T_1 are MLR χ^2 statistics, and c_0 and c_1 were the scaling correction factors for the restricted model and alternative model, respectively. For MLR, the products $T_0 * c_0$ and $T_1 * c_1$ were the same as the corresponding maximum likelihood (ML) χ^2 statistics. The denominator C_d in the equation was the difference test scaling correction, defined as:

$$C_d = [(d_0 \times c_0) - (d_1 \times c_1)]/(d_0 - d_1)$$

where d_0 and d_1 were the degrees of freedoms for the restricted model and the alternative model. Substituting the corresponding values, the following formula was:

$$\begin{aligned} TR_d &= (T_0 \times c_0 - T_1 \times c_1)(d_0 - d_1)/[(d_0 \times c_0) - (d_1 \times c_1)] \\ &= (1035.880 - 604.085)(204 - 191)/[204 \times 1.169) - (191 \times 1.155)] \\ &= 314.02 \end{aligned} \quad (1)$$

Table 5. Calculating the scaled difference in chi-square for nested model comparison using the robust estimator MLR.

MLR			ML	
Alternative model				
T_1	d_1	c_1	$T_1 \times c_1$	d_1
523.017	191	1.155	604.085	191
Restricted model				
T_0	d_0	c_0	$T_0 \times c_0$	d_0
886.125	204	1.169	1035.880	204

Note. MLR: robust maximum likelihood; ML: maximum likelihood; Alternative model: modified six-factor CFA of the MTDS-N; T_1: MLR chi-square statistic for the alternative model; d_1: the degree of freedom (df) for the alternative model; c_1: scaling correction factor for the alternative model. Restricted model: six-factor CFA with restricted factor loadings; T_0: MLR chi-square statistic for the restricted model; d_0: df for the restricted model; c_0: scaling correction factor for the restricted model.

Change in the model χ^2 statistics between the restricted model and the alternative model followed a χ^2 distribution: χ^2 = (886.125 − 523.017) = 363.108 with the degree of freedom (df) of (204 − 191) = 13. The χ^2 test was statistically significant ($p < 0.001$). The result indicated that restricting factor loadings equal made the model fit significantly worse than otherwise. Hence, the alternative model was preferred and retained. Standardized factor loadings and standardized R^2 values for the two models are presented in Table 6, while inter-factor correlations from the alternative model are shown in Table 7. All factors were highly correlated ($p < 0.001$), except for the correlation between vigor and physical symptoms ($r = 0.035$, $p = 0.535$).

Table 6. Standardized factor loadings and R^2 values for each item in the questionnaire for the hypothesized model and the alternative model.

Item	Hypothesized	R^2	Alternative	R^2
Miserable (dep1)	0.768	0.590	0.773	0.598
Unhappy (dep2)	0.782	0.611	0.777	0.604
Bitter (dep3)	0.632	0.400	0.631	0.399
Downhearted (dep4)	0.715	0.512	0.713	0.508
Depressed (dep5)	0.773	0.598	0.775	0.601
Energetic (vig1)	0.830	0.689	0.864	0.716
Lively (vig2)	0.798	0.637	0.805	0.648
Active (vig3)	0.498	0.248	0.451	0.204
Alert (vig4)	0.455	0.207	0.404	0.163
Muscle soreness (sym1)	0.614	0.377	0.613	0.376
Heavy arms or legs (sym2)	0.789	0.623	0.790	0.625
Stiff/sore joints (sym3)	0.650	0.423	0.650	0.422
Difficulty falling asleep (sle1)	0.803	0.645	0.805	0.649
Restless sleep (sle2)	0.855	0.732	0.856	0.732
Insomnia (sle3)	0.806	0.649	0.804	0.646
Stressed (str1)	0.627	0.393	0.534	0.285
Could not cope (str2)	0.699	0.489	0.726	0.527
Difficulties piling up (str3)	0.809	0.654	0.855	0.731
Nervous (str4)	0.601	0.361	0.507	0.257
Tired (fat1)	0.797	0.635	0.650	0.422
Sleepy (fat2)	0.809	0.655	0.664	0.440
Worn-out (fat3)	0.700	0.490	0.806	0.649

Note. R^2 = coefficient of determination.

Table 7. Standardized inter-factor correlations from the alternative model above the diagonal and inter-correlations from the initial study of MTDS are presented below the diagonal.

Factor	Depression	Vigor	Physical Symptoms	Sleep Disturbances	Stress	Fatigue
DEP	1	0.304 **	0.292 **	0.460 **	0.668 **	0.634 **
VIG	−0.194	1	0.035	0.207 **	0.269 **	0.207 **
SYM	−0.228	0.041	1	0.331 **	0.305 **	0.502 **
SLE	−0.394	0.110	0.247	1	0.441 **	0.541 **
STR	0.437	−0.259	−0.181	−0.273	1	0.667 **
FAT	−0.208	0.182	0.321	0.207	−0.311	1

Notes. ** = $p < 0.001$.

As presented in Figure 2 and Table 6, standardized factor loadings ranged from 0.404–0.864, and all factor loadings were statistically significant ($p < 0.001$) and in the expected direction. The high loadings in the measurement model indicate a strong association between each of the latent factors and their respective items. The estimated R^2 provides information about how much variance of each observed indicator variable is accounted for by its underlying factors. These values can be considered as a model estimated item reliability [52]. In the present study, sle2 has the highest R^2 (0.732), while vig4 has the lowest (0.163).

Scale Reliability

The McDonald's ω, along with CIs for the factors in MTDS-N, are presented in Table 8. The scale reliability estimate for depression and sleep disturbances was >0.80. The scale reliability for vigor, physical symptoms, stress, and fatigue ranged from 0.73–0.75. No estimations were above the maximum value of reliability estimate >0.90 [51,70].

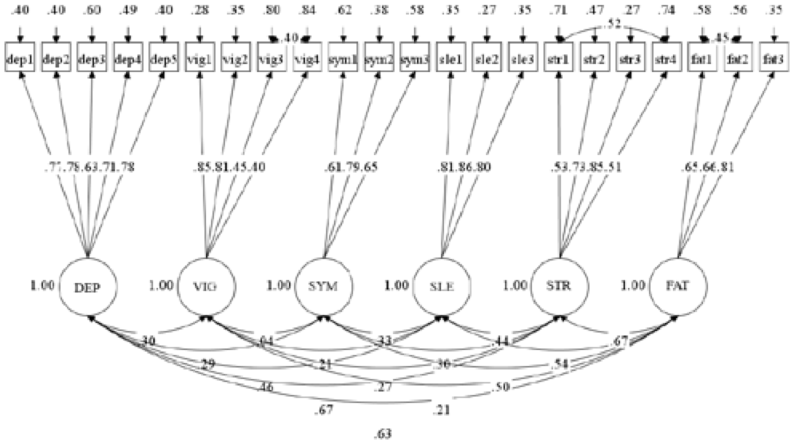

Figure 2. Standardized factor loadings, covariance estimates, and residual variances from the alternative model with three specified error covariances (vig3 with vig4; str1 with str4; fat1 with fat2).

Table 8. Calculated McDonald's ω along with confidence intervals (CIs) to estimate scale reliability.

Factor	Estimate	Lower 5% CI	Upper 5% CI
Depression	0.853	0.831	0.887
Vigor	0.747	0.714	0.799
Physical symptoms	0.725	0.690	0.779
Sleep disturbances	0.862	0.841	0.895
Stress	0.745	0.715	0.739
Fatigue	0.753	0.717	0.809

Note. CI = confidence interval.

To examine the extent to which athletes reported symptoms of psychophysiological stress related to training, scores from the MTDS-N were investigated. Taken collectively, as shown in Table 9, the student-athletes' reports of training distress were moderate. Most of the factors (i.e., vigor, physical symptoms, sleep disturbances, stress, and fatigue) mean scores were between the range of "moderate amount" and "quite a bit" from the Likert-scale. The only exception was depression (M = 1.67; SD = 0.92), scoring between "a little bit" and "moderate amount." The total score of the six factors was 13.96 (SD = 6.11).

Table 9. Mean scale scores for the six factors in MTDS-N.

Factor	Descriptive Statistics	
	M	SD
1. Depression (dep)	1.67	0.92
2. Vigor (vig)	2.67	0.94
3. Physical symptoms (sym)	2.35	1.01
4. Sleep disturbances (sle)	2.01	1.15
5. Stress (str)	2.68	1.05
6. Fatigue (fat)	2.56	1.05
Total score [a]	13.96	6.11

[a] Total score represents the sum of the six MTDS factors.

3.3. Estimating Group Differences in Latent Variables

In order to assess the effect of covariates on the factor structure, the MIMIC model was used. By conducting this model, the aim was to describe the relationship between the covariates and the training distress factors. Five covariates were included in the MIMIC model, such as gender (1 = male; 2 = female), type of sport (1 = individual sport; 2 = team sport), hours of training per week (continuous), school program (1 = specialization in general studies; 2 = sports and physical education), and school level (1 = first grade; 2 = second grade; 3 = third grade) were used to predict the latent variables. The same three error covariances specified in the alternative CFA model, were set as free parameters in model estimation (str4 with str1, MI = 133.12, EPC = 0.45; vig4 with vig3, MI = 94.10, EPC = 0.29; and fat2 with fat1, MI = 45.33, EPC = 0.30). Considering the multivariate non-normality in the measures, the MLR estimator was used for model estimation. Taken together, the covariates had 18 missing values (Table 1). Hence, the MIMIC model was based on a sample size of 614 participants. The model is specified in Figure 3.

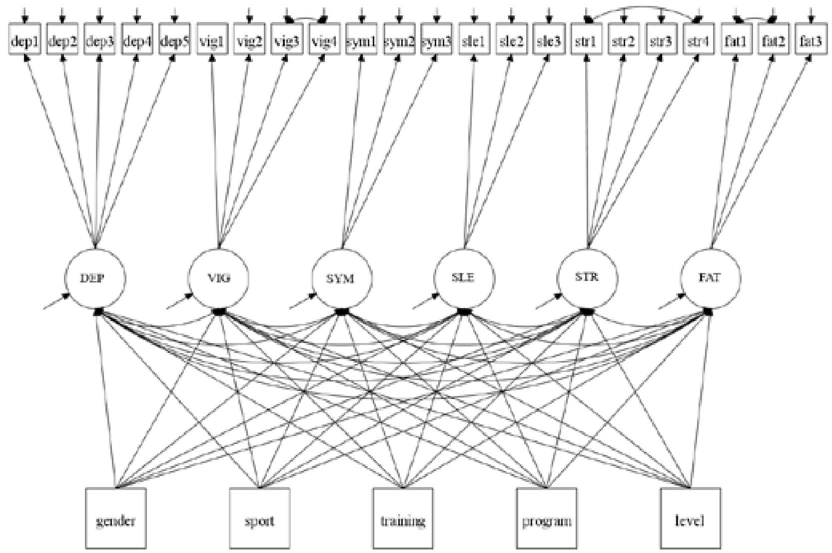

Figure 3. The multiple indicators multiple causes (MIMIC) model, where five covariates affect all the six factors. Gender (1 = male; 2 = female), sport (1 = individual sport; 2 = team sport), hours of training per week (continuous), program (1 = specialization in general studies; 2 = sports and physical education), and school level (1 = first grade; 2 = second grade; 3 = third grade).

After incorporating the five covariates, the factor structure remained unchanged and the model fit remained within acceptable values: $\chi^2 = 808.872$, *p*-value of $\chi^2 < 0.001$, RMSEA = 0.057 (90% CI: 0.052–0.061), CFI = 0.897, TLI = 0.871, and SRMR = 0.055. Further, the standardized (STD) results indicated that gender was a statistically significant positive predictor of the factor depression ($\beta = 0.269$, $p = 0.002$), physical symptoms ($\beta = 0.213$, $p = 0.022$), sleep disturbances ($\beta = 0.448$, $p < 0.001$), stress ($\beta = 0.502$, $p < 0.001$), and fatigue ($\beta = 0.235$, $p = 0.013$). The results suggest that male student-athletes tend to score lower on depression, physical symptoms, sleep disturbances, stress, and fatigue compared to female student-athletes. Participants in an individual sport tend to score lower on physical symptoms compared to team sports participants ($\beta = 0.231$, $p = 0.028$). Participants with fewer hours of training per week tend to score lower on physical symptoms compared to participants with more hours of training per week ($\beta = 0.024$, $p = 0.020$). Participants attending the school program specialization in general studies tend to score lower on depression ($\beta = 0.090$, $p = 0.020$), physical symptoms ($\beta = 0.110$,

$p = 0.007$), stress ($\beta = 0.105$, $p = 0.020$), and fatigue ($\beta = 0.094$, $p = 0.025$) compared to those attending the school program sport and physical education. Contrary, participants attending the school program specialization in general studies tend to score higher on vigor ($\beta = -0.237$, $p < 0.001$) compared to those attending the school program sport and physical education. Furthermore, student-athletes in first grade tend to score lower on depression ($\beta = 0.149$, $p = 0.008$) and vigor ($\beta = 0.141$, $p = 0.003$), compared to student-athletes in second- and third grade. The covariates that did not have a statistically significant effect on the six training distress factors indicate invariance in the means of the factors between the groups [52]. The explained variances in the six latent variables varied from 3.1–9.4%. In detail, the covariates accounted for 4.5%, 9.4%, 3.8%, 5.9%, 8.0%, and 3.1% of the variance in the factors of depression, vigor, physical symptoms, sleep disturbances, stress, and fatigue, respectively. Table 10 presents the standardized (STD) path coefficients for the effect of the covariates on the six factors in the MIMIC model. The score values of the covariances for the different groups can be found in Supplementary Materials Table S1.

Table 10. MIMIC model results of the covariates gender, age, type of sport, hours of training per week, county, school program, and school level on the factors depression, vigor, physical symptoms, sleep disturbances, stress, and fatigue.

Factor (Explained Variances)	Covariates	β	S.E.	p
Depression (0.045 = 4.5%)	Gender	0.269	0.086	0.002 *
	Sport	−0.172	0.103	0.096
	Training	−0.008	0.010	0.445
	Program	0.090	0.038	0.020 *
	Level	0.149	0.057	0.008 *
Vigor (0.094 = 9.4%)	Gender	0.135	0.079	0.089
	Sport	−0.062	0.092	0.501
	Training	−0.011	0.007	0.143
	Program	−0.237	0.038	0.000 **
	Level	0.141	0.048	0.003
Physical symptoms (0.038 = 3.8%)	Gender	0.213	0.093	0.022 *
	Sport	0.231	0.105	0.028 *
	Training	0.024	0.010	0.020 *
	Program	0.110	0.040	0.007 *
	Level	−0.008	0.061	0.895
Sleep disturbances (0.059 = 5.9%)	Gender	0.448	0.086	0.000 **
	Sport	−0.090	0.100	0.370
	Training	−0.012	0.008	0.163
	Program	0.044	0.034	0.193
	Level	0.073	0.055	0.186
Stress (0.080 = 8.0%)	Gender	0.502	0.089	0.000 **
	Sport	−0.042	0.105	0.686
	Training	−0.012	0.009	0.207
	Program	0.105	0.045	0.020 *
	Level	0.079	0.056	0.159
Fatigue (0.031 = 3.1%)	Gender	0.235	0.094	0.012 *
	Sport	0.048	0.106	0.650
	Training	−.016	0.009	0.090
	Program	0.094	0.042	0.025 *
	Level	0.066	0.064	0.306

Notes. S.E. = standard error; β = beta; * = $p < 0.05$; ** = $p < 0.001$.

Int. J. Environ. Res. Public Health **2020**, *17*, 7603

3.4. Estimating Group Differences in Factor Indicators

The MIMIC model was extended by including direct paths between the covariates and the factor indicators (i.e., MTDS-N items). The purpose of the extended model was to investigate if differences in response to items between groups would have any effect on the factor structure and the model fit. In the extended MIMIC model testing for DIF, a dummy variable was created for the covariate load (1 = more than 10 h of training per week; 0 = less than 10 h of training per week). The factors (depression, vigor, physical symptoms, sleep disturbances, stress, and fatigue) and all endogenous indicators except one of each latent variable were regressed on the covariates gender (1 = male; 2 = female), type of sport (1 = individual sport; 2 = team sport), school program (1 = specialization in general studies; 2 = sports and physical education), school level (1 = first grade; 2 = second grade; 3 = third grade), and load. To be able to identify the model, the first indicators dep1 of depression, vig1 of vigor, sym1 of physical symptoms, sle1 of sleep disturbances, str1 of stress, and fat1 of fatigue were not regressed on the covariates [52,73]. Figure 4 illustrates the extended MIMIC model testing for DIF.

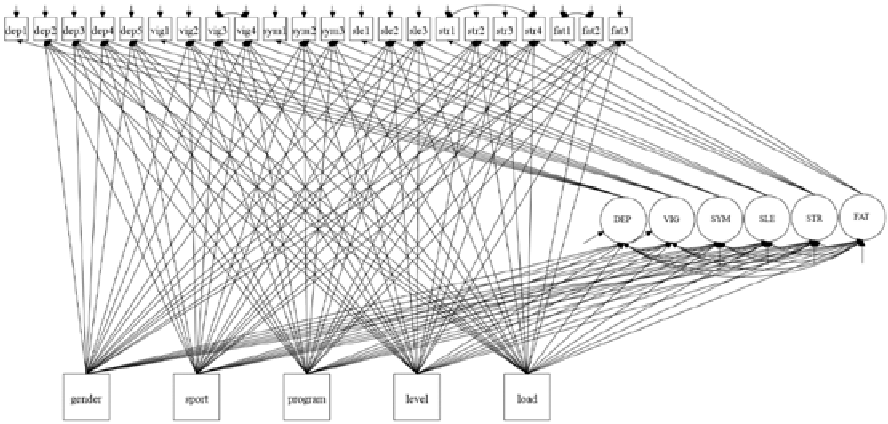

Figure 4. MIMIC model testing for differential item functioning (DIF). The five covariates affect all the six factors and all the items except one of each latent variable.

After incorporating the five covariates on the extended MIMIC model testing for DIF, the factor structure remained unchanged and the model fit remained within acceptable values: $\chi^2 = 414.661$, *p*-value of $\chi^2 < 0.001$, RMSEA = 0.043 (90% CI: 0.038–0.049), CFI = 0.958, TLI = 0.925, and SRMR = 0.036. The results indicated that there was DIF for 13 of the items in MTDS-N. The different items with DIF are presented in Table 11.

Results indicated that gender had a statistically significant positive effect on dep2 (unhappy), dep4 (downhearted), dep5 (depressed), and sle2 (restless sleep). This result suggests that male student-athletes tend to score lower on these items compared to female student-athletes, given the same level of depression and sleep disturbances. Contrary, gender had a statistically significant negative effect on str2 (cope), str3 (piling), and fat2 (sleepy), indicating that males tend to score higher on these items compared to females, given the same level of stress and fatigue. These results imply that there are statistically significant gender differences in response to seven items, controlling for the underlying factors. However, while DIF for these items is statistically significant, it appears variously in magnitude and does not accrue systematically across the seven items. The covariate type of sport had a statistically significant positive effect on dep3 (bitter), indicating that those in an individual sport tend to score lower on the item “bitter”, compared to those in team sports, given the same level of depression. However, the magnitude of the effect was small. The covariate program had a statistically significant positive effect on vig2 (lively), vig3 (active), str2 (cope), str3 (piling), and str4 (nervous), indicating that those attending the school program specialization in general studies tend to score lower on these items compared to student-athletes attending the school program sports and physical education, controlling for the underlying factors vigor and stress. Further, the covariate program had a statistically significant negative effect on dep2 (unhappy), dep4 (downhearted), and fat3 (worn-out), indicating that those attending the school program specialization in general studies tend to score higher on these items compared to student-athletes participating the school program sports and physical education, considering the same level of depression and fatigue. The results appear variously in magnitude, from a small effect for vig3, fat3, dep2, and str4 to a very large effect for str2 and str3. Further, DIF does not accrue systematically across the eight items. The covariate level had a statistically significant negative effect on fat2 (sleepy) and fat3 (worn-out), indicating that those in first grade tend to score higher on these items compared to those in second- and third grade, controlling for the underlying factor fatigue. The effect was very small and small for the two items, respectively. Lastly, the covariate load had a statistically significant negative effect on vig3 (active) and vig4 (alert), indicating that student-athletes with less than 10 h of training per week tend to score higher on the item active and the item alert compared to student-athletes with more than 10 h of training per week, given the same level of vigor (effect was small to medium). The score values of the covariances for the different groups on the items can be found in Supplementary Materials Table S2.

Table 11. Standardized (STD) model results for the MIMIC model testing DIF with the interpretation of effect sizes.

Indicators	Covariates	β	S.E.	p	Effect Size
dep2 (unhappy)	Gender Program	0.255 −0.194	0.072 0.045	0.000 ** 0.000 **	M S
dep3 (bitter)	Sport	0.164	0.072	0.023 *	S
dep4 (downhearted)	Gender Program	0.287 −0.213	0.075 0.043	0.000 ** 0.000 **	M M
dep5 (depressed)	Gender	0.182	0.064	0.004 *	S
vig2 (lively)	Program	0.231	0.046	0.000 **	M
vig3 (active)	Program Load	0.143 −0.174	0.033 0.069	0.000 ** 0.012 *	S S
vig4 (alert)	Load	−0.200	0.072	0.006 *	M
sle2 (restless sleep)	Gender	0.181	0.075	0.016 *	S
str2 (cope)	Gender Program	−0.295 0.528	0.108 0.061	0.006 * 0.000 **	M VL
str3 (piling)	Gender Program	−0.369 0.559	0.111 0.062	0.001 * 0.000 **	L VL
str4 (nervous)	Program	0.151	0.044	0.001 *	S
fat2 (sleepy)	Gender Level	−0.212 −0.090	0.070 0.045	0.002 * 0.047 *	M VS
fat3 (worn-out)	Program Level	−0.107 −0.177	0.047 0.060	0.017 * 0.003 *	S S

Note. * = $p < 0.05$; ** = $p < 0.001$; VS = very small; S = small; M = medium; L = large; VL = very large; sym2, sym3 and sle3 were DIF-free and were not included in the table.

4. Discussion

The purpose of the present study was to translate MTDS to the Norwegian context and to test the measurement instruments factorial validity, which is a form of construct validity [78]. Construct validity is essential to be able to make assumptions from scale scores about the underlying construct of interest [79]. To our knowledge, this is the first study evaluating the factor structure of MTDS by CFA. The main finding from the present study indicated that the alternative model with three error covariances set as free, fitted the data very well showing a high representativeness of all the items concerning the underlying construct of training distress. Furthermore, the MTDS-N factors scale reliability were found to be acceptable with McDonald's ω ranging from 0.725–0.862. After incorporating the five covariates on the MIMIC model and the extended MIMIC model testing for DIF, the factor structure remained unchanged and the model fit remained within acceptable values. These results indicate that MTDS-N can be considered as an acceptable psychometric tool and appears to be a promising measure of training distress among Norwegian athletes.

4.1. Confirmatory Factor Analysis

Similar results can be observed when comparing the factor loadings from the present study with the results from Main and Grove [29]. For instance, the standardized factor loadings from the alternative model in Table 6 show a similarity in depression (0.631–0.777 vs. 0.636–0.747) and vigor (0.404–0.864 vs. 0.494–0.781). The factor alert had the lowest factor loading in both this study (0.404) and in the Main and Grove [29] study (0.494), which is in line with the low factor loading in studies where BRUMS were translated into Chinese (<0.19) [80], Malaysian (0.46) [81], and Spanish (0.16) [82]. Furthermore, factor loadings of physical symptoms (0.613–0.790 vs. −0.672–−0.790), sleep disturbances (804–0.856 vs. −0.636–−0.947), stress (0.507–0.855 vs. 0.411–0.776), and fatigue (0.650–0.806 vs. −0.502–−0.785), were also found to be quite similarly loaded. However, as shown in Table 7, the inter-factor correlations from this study were not consistent with the Main and Grove study [29]. In the Main and Grove study [29], the inter-factor correlations ranged from 0.041–0.437, with most correlations indicating medium effect sizes. In the present study, the correlations ranged from 0.035–0.668, with the most correlation indicating large to very large effect sizes. The correlations between depression and sleep disturbances (0.460), depression and stress (0.668), depression and fatigue (0.634), physical symptoms and fatigue (0.502), sleep disturbances and stress (0.441), sleep disturbances and fatigue (0.541), and stress and fatigue (0.667) were statistically significant ($p < 0.001$) and indicated very large effect sizes (Table 7). In the Main and Grove study [29], the only inter-factor correlation that yielded a very large effect size was between depression and stress (0.437). The fact that there were a few relatively high inter-factor correlations between some of the factors tells that the constructs measured can be interrelated. For example, the statistically significant ($p < 0.001$) correlation between depression and fatigue (0.634) indicates that when the value of depression increases, the value of fatigue also tends to increase. According to Puffer and McShane [83], depression and fatigue are symptoms that can be used interchangeably by athletes to describe their symptoms and feelings. Furthermore, fatigue and depression tend to be comorbid, and it has been reported that at least 30% of young people with chronic fatigue syndrome also have symptoms of depression [84]. A study by Boolani and Manierre [85] reported that depression is a predictor of long-standing feelings of fatigue in a non-athlete convenience sample [85]. Further, a statistically significant ($p < 0.001$) result was found between depression and stress (0.668). Previous studies have found statistically significant correlations between high levels of depressive symptoms and high levels of chronic stress in athletes [86,87] and women [88]. According to Brown [60], factor correlations that exceed 0.80 or 0.85 are often used as a criterion to define poor discriminant validity. In the present study, none of the correlations met this criterion; hence we can assume that the discriminant validity of the factors is good. The inter-factor correlations indicate that the domains of training distress should be regarded as factors measuring different but related aspects of training distress. This can be due to that MTDS is based on three different questionnaires, such as PSS [42], the 24-item Brunel Mood State Scale (BRUMS) [43], and a checklist of 19 symptoms of acute overtraining [44]. Nevertheless, the results from this study support the notion that the six factors can be regarded as substantially unique, as was described by Main and Grove [29], where they identified six conceptually distinct factors. In detail, the factors depression, vigor, and stress were representative of measures associated with psychological overload. The factors physical symptoms, sleep disturbances, and fatigue reflected physical and behavioral complaints associated with training distress. As such, the findings from Main and Grove [29] identified depressed mood, reduced vigor, and perceived stress as important psychological indicators of training distress. Further, their findings confirmed that physical symptoms, sleep disturbances, and general fatigue were behavioral correlates of training distress.

Scale Reliability

The scale reliability for the factors in MTDS-N was also acceptable with McDonald's ω ranging from 0.725–0.862. To our knowledge, no other studies have used McDonald's ω regarding scale reliabilities for the MTDS factors. However, other studies have reported Cronbach's α. The internal consistency presented by Main and Grove [29] showed values of α ranging from 0.72–0.86, and the six-factor solution accounted for 67.01% of the common item variance. The following Cronbach's α has been reported from a study on alpine skiers: depressed = 0.84, vigor = 0.76, physical symptoms = 0.50, sleep disturbances = 0.87, stress = 0.81, and fatigue = 0.80 [35]. Another study reported the overall internal consistency as α = 0.90 [89]. Other studies that have used the MTDS have not reported values of α, or any other measure of scale reliability [31,33,34,36]. Collectively, the scale from the present study constitutes high scale reliability when compared with other studies that have used the same instrument. However, it is important to keep in mind the limitations that are associated with Cronbach's α as it has been found to underestimate or overestimate the scale reliability depending on measurement parameters [63]. Hence, it does not provide a dependable estimate of scale reliability, and for this reason, the McDonald's ω with CIs has been recommended and applied in this study to estimate scale reliability based on the results of CFA [52,64–66].

4.2. Estimating Group Differences in Latent Variables

The MIMIC model was conducted to investigate whether factor means were different between groups and to assess the effect of covariates on the factor structure and goodness of fit. The results from the present study indicated that the estimated factor structure remained unchanged and the model fit remained within acceptable values (χ^2 = 808.872, *p*-value of $\chi^2 < 0.001$, RMSEA = 0.057 (90% CI: 0.052–0.061), CFI = 0.897, TLI = 0.871, and SRMR = 0.055) after incorporating the five covariates to the model. Further, the analysis indicated statistically significant differences in factor scores for *gender* on the factors of depression, physical symptoms, sleep disturbances, stress, and fatigue. The statistically significant effect of gender on the MTDS-N factors represent population heterogeneity; that is, the factor means are different at different levels of the covariate gender [60]. Population heterogeneity in MTDS has also been reported showing that females have overall higher scores than males, indicating differing mood disturbances between the genders [32,90]. The MTDS is a recently developed ASRM instrument and hence less investigated [28]; however, similar results regarding gender differences for PSS, which include some of the same symptoms as in the MTDS, have been reported. Those results indicate that women tend to score significantly higher on PSS scores compared to men [91]. Further, a prospective study on young elite athletes revealed that females reported more stress and more depressive symptoms, compared to males [92]. Interestingly, there were no statistically significant differences in vigor factor scores for gender, indicating invariance in the factor means. Hence, the probability of a student-athlete receiving an observed score is not dependent on the individuals' gender, but the individuals' true score [93]. Nevertheless, research shows that females most often score consistently higher than males on instruments measuring negative characteristics [94–96]. The finding from the present study corresponds with previous research [94–96], where population heterogeneity was found for the negative symptoms and not for the positive symptoms from the factor vigor. However, it is not clear whether this trend is a result of reasonable gender differences in terms of the latent constructs being measures or caused by other secondary factors [94]. According to Terry, et al. [97], there are a number of theories and empirical attempts to explain gender disparity, among others, these differences are artifacts of measurement bias and not true differences between males and females. An artifact explanation is based on the hypothesis that males may be less willing than females to admit negative symptoms [98]. Thus, rates of the negative symptoms may be equivalent in males and females; however, depressive symptoms are perceived as less masculine, which could result in males unwillingness to report such symptoms [99–101]. The indication of gender differences suggests that caution should be taken if group comparison is the intended purpose when using the MTDS-N among student-athletes.

The results of the present study showed a statistically significant difference in physical symptoms factor scores for the type of sport, suggesting that participants from individual sports tend to score lower on physical symptoms compared to participants from team sports. This finding is not in line with previous research where it has been reported that athletes from individual sports are more likely to report anxiety and depression compared to team sport athletes [102–104], which is explained by the fact that team sports athletes, throughout adolescence, tend to have a protective effect against depressive symptoms compared to individual sport athletes [105]. Conversely, no statistically significant differences were observed for depression, vigor, sleep disturbances, stress, and fatigue (Table 10), which are in line with findings from Birrer, et al. [106], indicating no statistically significant differences in the prevalence of training distress and overtraining syndrome between individual sport and team sports. A potential explanation for this finding can be linked to differences in the practice of sport in a given country. Differences between countries exist based on the nation's geographical, economic, social, historical, political, and cultural profile [107–109].

Regarding the covariate hours of training, results indicated statistically significant differences in factor scores of physical symptoms. There were no statistically significant differences in factor scores for the other factors in MTDS-N. Although the effect was small, this result suggests that participants with fewer hours of training per week tend to score lower on physical symptoms compared to participants with more hours of training per week. Previous research has indicated a clear effect of training load on soreness and neuromuscular fatigue in rugby athletes [110]. Another study revealed that muscle soreness is moderately related to the daily training load in professional soccer players [111]. Training and competition load results in temporary decrements in physical performance and significant levels of post-competition fatigue [10]. These decrements have been explained by increased muscle damage [11], reduction in the effectiveness of the immune system [12], an imbalance in anabolic and catabolic processes in the body [13], athlete mood disturbance [14], and a reduction in the neuromuscular effectiveness [15].

The covariate school program was a statistically significant positive predictor for the factors of depression, physical symptoms, stress, fatigue, and a statistically significant negative predictor of vigor. Hence, indicating that participants attending the school program specialization in general studies tend to score lower on depression, physical symptoms, stress, and fatigue compared to those attending the school program sport and physical education. Contrary, participants attending the school program specialization in general studies tend to score higher on vigor compared to those attending the school program sport and physical education. This could be explained by the fact that, in Norway, athletes attending the school program sport and physical education have more subjects involving physical training compared to students attending specialization in general studies. Further, the finding can be linked to the statistically significant result regarding the covariate hours of training, suggesting that participants with more hours of training per week tend to score higher on physical symptoms compared to participants with fewer hours of training per week.

School level was a statistically significant positive predictor for the factor depression and vigor, indicating that student-athletes in first grade tend to score lower on depression and vigor, compared to student-athletes in second- and third grade. Previous research has indicated that freshmen (first year) and sophomores (second year) have higher training distress scores compared to juniors (third year) and seniors (fourth year), and for this reason, year in school has been identified as a possible variable that could serve as an indicator of training distress [32]. A study by Gustafsson, et al. [112] that used the Profile of Mood States (POMS) [113] discussed that vigor might be an important indicator of maladaptation and NFOR. For example, fatigue is more sensitive and captures general training fatigue, whereas a decrease in vigor might indicate a more severe state. According to Meeusen, Duclos, Gleeson, Rietjens, Steinacker and Urhausen [9], when the balance between training and recovery is not sufficiently respected, symptoms of prolonged training distress, including decreased vigor, will occur, leading to NFOR. However, a possible explanation of the results of vigor in this study could be attributed to the fact that the student-athletes in the first grade are fresh comers and not adapted to the increased training load, suggesting that school coaches and club coaches should pay attention to the total training load for fresh student-athletes. Another potential explanation for decreased vigor among student athletes in first grade might be due to biological reasons. Boolani, et al. [114] found that feelings of vigor are associated with mitochondrial function, which is usually lower in people who are not as well trained and those who are younger and do not have as much muscle mass. Further, their findings suggest that vigor is associated with normalized resting metabolic rate, which is usually higher in those who are not well trained [114].

4.3. Estimating Group Differences in Factor Indicators

The extended MIMIC model was conducted to investigate if there existed DIF in the responses of MTDS-N by examining the effect of covariates on factor indicators (i.e., items) and to assess if DIF would have an effect on the factor structure and goodness of fit. Such analysis can be considered as an extended method of construct validity, taking variables outside the questionnaire into account [115]. The main findings indicated that the estimated factor structure remained unchanged and the model fit remained within acceptable values (χ^2 = 414.661, p-value of χ^2 < 0.001, RMSEA = 0.043 (90% CI: 0.038–0.049), CFI = 0.958, TLI = 0.925, and SRMR = 0.036). However, the results indicated that 13 of 22 items exhibited statistically significant DIF. Responses to scale items were mostly affected by gender (seven DIF) and school program (eight DIF). However, the impacts of gender and school program on item responses were not systematic across the item set (i.e., four of seven items exhibited positive DIF for gender and five of eight items exhibited positive DIF for school program). The effect of the school program on item response was notable because two of the items (str2 and str3) were very large in magnitude (β > 0.50). The results of DIF in the present study indicate that the MTDS-N items functions differently for different groups; that is, they have a different probability of giving a certain response to the corresponding item given the same underlying factor score [116]. However, investigating the CFA factor loadings indicates that DIFs have been canceled out at the total test score. This means that while males and females have seven DIF and participants attending the school program specialization in general studies and participants attending the school program sport and physical education have eight DIF, differences were small in magnitude and their effect on the sociability dimension were negligible (Table 11). What are the practical consequences of the DIF in MTDS-N? Whether bias matters depends not just on the amount of bias, but also the purposes of the researcher [117]. Hence, one could shift the question from "is the test biased?" to "does the amount of bias in the test matter?". This shifting is especially vital because DIF would be detected in all items of all scales with sufficiently large samples [117]. In the present study, most of the statistically significant DIF was small in magnitude (Table 11). Borsboom [117] considers three possible uses of the test score. Firstly, if a researcher is interested in comparing means, biasing effects may be negligible if they are small in magnitude. Thus, violations of measurement invariance do not need to be a serious threat to validity. Secondly, if a researcher is interested in comparing within-group relations, bias may be entirely irrelevant. Finally, if the purpose is to select specific individuals (e.g., selection of diseases), then measurement invariance is a necessary condition for fair selection. However, further investigations are recommended to produce a more nuanced picture of the presence of DIF in the MTDS-N. If the scale is to be modified, different authors have proposed solutions to handle the presence of DIF in practice [118]. According to the authors of the review, researchers have recommended to split items exhibiting DIF to calibrate them in each group separately when the scale is used in a study; to remove items exhibiting DIF from the scale; or reformulate items exhibiting DIF [118].

The results from the present study must be considered in light of some limitations. First, data are based on self-report, which can result in response bias [20,119]. Additionally, the purpose of this study was to investigate the psychometric properties of the Norwegian version of MTDS, and therefore the data was collected at a single time point. Hence, a longitudinal approach would be ideal for investigating the perceptions captured by the MTDS-N over time. Regarding the choice of statistical analysis, the MIMIC model can only test non-invariances in factor means and item intercepts. To test non-invariance in factor loadings, factor variances, and measurement error variances, a multigroup CFA would be preferable. However, the MIMIC model has some advantages compared to the multigroup CFA. First, it does not require a large sample size. Further, it is possible to include continuous measures for the covariates in the MIMIC model, which is not appropriate for multigroup CFA [52].

5. Conclusions

The main objective of the present study was to examine the validity and reliability of the translated English version of MTDS into the Norwegian language to be able to assess the psychometric properties among Norwegian student-athletes. The alternative CFA model reported in this study yielded acceptable fit indices and strong scale reliability, indicating the suitability of the MTDS-N to be used in a Norwegian population to assess student-athletes training distress. There were indications of group effects, suggesting that different groups could score differently on the MTDS-N. Thus, caution is required if group comparison is the intended purpose when using the MTDS-N among student-athletes.

Supplementary Materials: The following are available online at http://www.mdpi.com/1660-4601/17/20/7603/s1. Table S1: Score values of on the factors for the different groups; Table S2: Score values of the factor predictors for the different groups; results of the preliminary pilot testing; results of the preliminary pilot testing with new model with "BY" statement; Mplus Code; source data.

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Supplementary

Table S1. Score values of the factors for the different groups.

Factor	Characteristics	Modalities	M ± SD
DEP	Gender	Male	7.90 ± 3.38
		Female	8.83 ± 3.88
	Type of sport	Individual	8.83 ± 4.23
		Team sport	8.14 ± 3.40
	Training hours	< 10 hours	8.45 ± 3.58
		> 10 hours	8.33 ± 3.79
	School program	Specialization in general studies	8.35 ± 3.59
		Sports and physical education	8.41 ± 3.88
	School level	First grade	7.96 ± 3.53
		Second grade	8.59 ± 3.83
		Third grade	8.66 ± 3.74
VIG	Gender	Male	10.41 ± 2.81
		Female	11.01 ± 2.96
	Type of sport	Individual	10.83 ± 3.09
		Team sport	10.63 ± 2.80
	Training hours	< 10 hours	11.00 ± 2.72
		> 10 hours	10.50 ± 2.98
	School program	Specialization in general studies	10.77 ± 2.93
		Sports and physical education	10.60 ± 2.83
	School level	First grade	10.39 ± 2.96
		Second grade	10.86 ± 3.03
		Third grade	10.89 ± 2.53
SYM	Gender	Male	6.88 ± 2.47
		Female	7.23 ± 2.42
	Type of sport	Individual	6.97 ± 2.45
		Team sport	7.10 ± 2.45
	Training hours	< 10 hours	6.86 ± 2.57
		> 10 hours	7.18 ± 2.36
	School program	Specialization in general studies	7.08 ± 2.45
		Sports and physical education	7.02 ± 2.45
	School level	First grade	7.06 ± 2.38
		Second grade	7.07 ± 2.52
		Third grade	7.02 ± 2.47
SLE	Gender	Male	5.46 ± 2.77
		Female	6.67 ± 3.26
	Type of sport	Individual	6.33 ± 3.26
		Team sport	5.89 ± 2.98
	Training hours	< 10 hours	6.18 ± 3.16
		> 10 hours	5.95 ± 3.02
	School program	Specialization in general studies	5.94 ± 3.02
		Sports and physical education	6.18 ± 3.15
	School level	First grade	5.79 ± 2.96
		Second grade	6.33 ± 3.17
		Third grade	5.98 ± 3.06
STR	Gender	Male	9.91 ± 3.13
		Female	11.62 ± 3.36
	Type of sport	Individual	11.04 ± 3.58
		Team sport	10.55 ± 3.22
	Training hours	< 10 hours	10.92 ± 3.37
		> 10 hours	10.60 ± 3.34
	School program	Specialization in general studies	10.77 ± 3.37
		Sports and physical education	10.67 ± 3.33

	School level	First grade	10.55 ± 3.16
		Second grade	10.84 ± 3.63
		Third grade	10.82 ± 3.20
FAT	Gender	Male	7.48 ± 2.53
		Female	7.89 ± 2.77
	Type of sport	Individual	7.59 ± 2.83
		Team sport	7.72 ± 2.57
	Training hours	< 10 hours	7.96 ± 2.81
		> 10 hours	7.50 ± 2.53
	School program	Specialization in general studies	7.62 ± 2.57
		Sports and physical education	7.78 ± 2.76
	School level	First grade	7.43 ± 2.60
		Second grade	7.88 ± 2.65
		Third grade	7.76 ± 2.72

Notes. Dep = Depression; Vig = Vigour; Sym = Physical symptoms; Sle = Sleep disturbances; Str = Stress; Fat = Fatigue; M = Mean; SD = Standard deviation.

Table S2. Score values of the factor predictors for the different groups.

Factor	Characteristics	Modalities	M ± SD
Dep1	Gender	Male	1.43 ± 0.79
		Female	1.48 ±.84
	Type of sport	Individual	1.53 ±.89
		Team sport	1.42 ± 0.77
	Training hours	< 10 hours	1.48 ±.78
		> 10 hours	1.44 ± 0.84
	School program	Specialization in general studies	1.43 ± 0.77
		Sports and physical education	1.50 ± 0.86
	School level	First grade	1.38 ± 0.75
		Second grade	1.52 ± 0.83
		Third grade	1.48 ± 0.86
Dep2	Gender	Male	1.59 ± 0.84
		Female	1.91 ± 1.00
	Type of sport	Individual	1.88 ± 1.07
		Team sport	1.68 ± 0.85
	Training hours	< 10 hours	1.76 ± 0.89
		> 10 hours	1.74 ± 0.96
	School program	Specialization in general studies	1.76 ± 0.93
		Sports and physical education	1.73 ± 0.93
	School level	First grade	1.64 ± 0.86
		Second grade	1.77 ± 0.95
		Third grade	1.88 ± 0.99
Dep3	Gender	Male	1.60 ± 0.81
		Female	1.66 ± 0.90
	Type of sport	Individual	1.63 ± 0.88
		Team sport	1.63 ± 0.84
	Training hours	< 10 hours	1.63 ± 0.88
		> 10 hours	1.63 ± 0.84
	School program	Specialization in general studies	1.67 ± 0.87
		Sports and physical education	1.58 ± 0.83
	School level	First grade	1.55 ± 0.81
		Second grade	1.67 ± 0.88
		Third grade	1.69 ± 0.88
Dep4	Gender	Male	1.84 ± 0.98
		Female	2.22 ± 1.10
	Type of sport	Individual	2.11 ± 1.13
		Team sport	1.99 ± 1.01

	Training hours	< 10 hours	2.05 ± 1.06
		> 10 hours	2.01 ± 1.05
	School program	Specialization in general studies	2.01 ± 1.04
		Sports and physical education	2.05 ± 1.08
	School level	First grade	1.90 ± 1.04
		Second grade	2.12 ± 1.10
		Third grade	2.06 ± 0.99
Dep5	Gender	Male	1.41 ± 0.83
		Female	1.55 ± 0.94
	Type of sport	Individual	1.60 ± 1.00
		Team sport	1.42 ± 0.83
	Training hours	< 10 hours	1.51 ± 0.89
		> 10 hours	1.46 ± 0.89
	School program	Specialization in general studies	1.48 ± 0.89
		Sports and physical education	1.48 ± 0.89
	School level	First grade	1.42 ± 0.85
		Second grade	1.51 ± 0.88
		Third grade	1.52 ± 0.96
Vig1	Gender	Male	2.62 ± 0.96
		Female	2.79 ± 1.03
	Type of sport	Individual	2.74 ± 1.03
		Team sport	2.68 ± 0.98
	Training hours	< 10 hours	2.77 ± 2.97
		> 10 hours	2.66 ± 1.01
	School program	Specialization in general studies	2.73 ± 0.99
		Sports and physical education	2.66 ± 1.00
	School level	First grade	2.55 ± 1.05
		Second grade	2.79 ± 1.03
		Third grade	2.78 ± 0.84
Vig2	Gender	Male	2.59 ± 0.95
		Female	2.65 ± 0.94
	Type of sport	Individual	2.69 ± 0.95
		Team sport	2.58 ± 0.94
	Training hours	< 10 hours	2.64 ± 0.93
		> 10 hours	2.60 ± 0.96
	School program	Specialization in general studies	2.65 ± 0.95
		Sports and physical education	2.57 ± 0.95
	School level	First grade	2.52 ± 0.98
		Second grade	2.67 ± 0.98
		Third grade	2.68 ± 0.84
Vig3	Gender	Male	2.42 ± 0.87
		Female	2.61 ± 0.91
	Type of sport	Individual	2.53 ± 0.94
		Team sport	2.50 ± 0.88
	Training hours	< 10 hours	2.62 ± 0.84
		> 10 hours	2.44 ± 0.92
	School program	Specialization in general studies	2.54 ± 0.90
		Sports and physical education	2.47 ± 0.89
	School level	First grade	2.44 ± 0.92
		Second grade	2.56 ± 0.90
		Third grade	2.54 ± 0.85
Vig4	Gender	Male	2.77 ± 0.95
		Female	2.97 ± 0.92
	Type of sport	Individual	2.87 ± 1.01
		Team sport	2.87 ± 0.90
	Training hours	< 10 hours	2.98 ± 0.89

		> 10 hours	2.80 ± 0.96
	School program	Specialization in general studies	2.84 ± 0.96
		Sports and physical education	2.90 ± 0.90
	School level	First grade	2.88 ± 0.99
		Second grade	2.84 ± 0.91
		Third grade	2.89 ± 0.90
Sym1	Gender	Male	2.42 ± 1.05
		Female	2.61 ± 1.00
	Type of sport	Individual	2.55 ± 1.03
		Team sport	2.50 ± 1.03
	Training hours	< 10 hours	2.37 ± 1.05
		> 10 hours	2.61 ± 1.01
	School program	Specialization in general studies	2.56 ± 1.02
		Sports and physical education	2.46 ± 1.04
	School level	First grade	2.53 ± 1.03
		Second grade	2.55 ± 1.05
		Third grade	2.44 ± 1.01
Sym2	Gender	Male	2.38 ± 0.98
		Female	2.48 ± 0.98
	Type of sport	Individual	2.35 ± 1.00
		Team sport	2.47 ± 0.97
	Training hours	< 10 hours	2.40 ± 0.99
		> 10 hours	2.45 ± 0.97
	School program	Specialization in general studies	2.43 ± 0.97
		Sports and physical education	2.41 ± 0.99
	School level	First grade	2.43 ± 0.97
		Second grade	2.43 ± 0.99
		Third grade	2.43 ± 0.98
Sym3	Gender	Male	2.07 ± 0.99
		Female	2.14 ± 1.06
	Type of sport	Individual	2.05 ± 1.05
		Team sport	2.14 ± 1.01
	Training hours	< 10 hours	2.10 ± 1.07
		> 10 hours	2.11 ± 1.00
	School program	Specialization in general studies	2.10 ± 1.00
		Sports and physical education	2.12 ± 1.06
	School level	First grade	2.10 ± 1.00
		Second grade	2.10 ± 1.02
		Third grade	2.14 ± 1.07
Sle1	Gender	Male	1.99 ± 1.13
		Female	2.31 ± 1.21
	Type of sport	Individual	2.23 ± 1.22
		Team sport	2.11 ± 1.16
	Training hours	< 10 hours	2.20 ± 1.22
		> 10 hours	2.12 ± 1.16
	School program	Specialization in general studies	2.13 ± 1.16
		Sports and physical education	2.18 ± 1.21
	School level	First grade	2.07 ± 1.16
		Second grade	2.26 ± 1.21
		Third grade	2.09 ± 1.16
Sle2	Gender	Male	1.80 ± 1.00
		Female	2.35 ± 1.25
	Type of sport	Individual	2.18 ± 1.23
		Team sport	2.00 ± 1.12
	Training hours	< 10 hours	2.08 ± 1.17
		> 10 hours	2.05 ± 1.16

	School program	Specialization in general studies	2.05 ± 1.17
		Sports and physical education	2.08 ± 1.16
	School level	First grade	1.96 ± 1.13
		Second grade	2.15 ± 1.18
		Third grade	2.08 ± 1.17
Sle3	Gender	Male	1.65 ± 0.98
		Female	2.01 ± 1.20
	Type of sport	Individual	1.90 ± 1.17
		Team sport	1.79 ± 1.07
	Training hours	< 10 hours	1.89 ± 1.15
		> 10 hours	1.78 ± 1.08
	School program	Specialization in general studies	1.76 ± 1.06
		Sports and physical education	1.92 ± 1.17
	School level	First grade	1.75 ± 1.05
		Second grade	1.92 ± 1.18
		Third grade	1.79 ± 1.08
Str1	Gender	Male	2.75 ± 1.06
		Female	3.40 ± 1.06
	Type of sport	Individual	3.18 ± 1.18
		Team sport	3.00 ± 1.07
	Training hours	< 10 hours	3.13 ± 1.10
		> 10 hours	3.02 ± 1.11
	School program	Specialization in general studies	3.09 ± 1.11
		Sports and physical education	3.02 ± 1.10
	School level	First grade	3.02 ± 1.08
		Second grade	3.10 ± 1.19
		Third grade	3.07 ± 1.01
Str2	Gender	Male	2.60 ± 1.00
		Female	2.94 ± 1.02
	Type of sport	Individual	2.79 ± 1.07
		Team sport	2.75 ± 1.01
	Training hours	< 10 hours	2.77 ± 0.99
		> 10 hours	2.75 ± 1.05
	School program	Specialization in general studies	2.73 ± 1.04
		Sports and physical education	2.81 ± 1.01
	School level	First grade	2.70 ± 0.96
		Second grade	2.82 ± 1.09
		Third grade	2.76 ± 1.02
Str3	Gender	Male	1.96 ± 0.90
		Female	2.28 ± 1.01
	Type of sport	Individual	2.20 ± 1.11
		Team sport	2.08 ± 0.88
	Training hours	< 10 hours	2.17 ± 0.94
		> 10 hours	2.08 ± 0.98
	School program	Specialization in general studies	2.12 ± 0.95
		Sports and physical education	2.12 ± 0.98
	School level	First grade	2.04 ± 0.92
		Second grade	2.17 ± 1.01
		Third grade	2.15 ± 0.95
Str4	Gender	Male	2.58 ± 1.05
		Female	3.00 ± 1.08
	Type of sport	Individual	2.87 ± 1.09
		Team sport	2.74 ± 1.08
	Training hours	< 10 hours	2.82 ± 1.13
		> 10 hours	2.75 ± 1.05
	School program	Specialization in general studies	2.83 ± 1.10

		Sports and physical education	2.71 ± 1.05
	School level	First grade	2.78 ± 1.06
		Second grade	2.74 ± 1.15
		Third grade	2.84 ± 1.02
Fat1	Gender	Male	2.60 ± 0.99
		Female	2.78 ± 0.98
	Type of sport	Individual	2.62 ± 1.02
		Team sport	2.72 ± 0.97
	Training hours	< 10 hours	2.81 ± 1.03
		> 10 hours	2.61 ± 0.95
	School program	Specialization in general studies	2.67 ± 0.92
		Sports and physical education	2.71 ± 1.07
	School level	First grade	2.53 ± 0.94
		Second grade	2.76 ± 1.01
		Third grade	2.80 ± 0.99
Fat2	Gender	Male	2.54 ± 1.06
		Female	2.53 ± 1.11
	Type of sport	Individual	2.47 ± 1.10
		Team sport	2.56 ± 1.08
	Training hours	< 10 hours	2.62 ± 1.13
		> 10 hours	2.47 ± 1.05
	School program	Specialization in general studies	2.49 ± 1.05
		Sports and physical education	2.59 ± 1.14
	School level	First grade	2.45 ± 1.07
		Second grade	2.59 ± 1.13
		Third grade	2.57 ± 1.04
Fat3	Gender	Male	2.34 ± 1.00
		Female	2.58 ± 1.13
	Type of sport	Individual	2.48 ± 1.09
		Team sport	2.44 ± 1.05
	Training hours	< 10 hours	2.52 ± 1.12
		> 10 hours	2.41 ± 1.03
	School program	Specialization in general studies	2.46 ± 1.07
		Sports and physical education	2.44 ± 1.06
	School level	First grade	2.42 ± 1.03
		Second grade	2.53 ± 1.09
		Third grade	2.39 ± 1.09

Notes. Dep1 = Miserable; Dep2 = Unhappy; Dep3 = Bitter; Dep4 = Downhearted; Dep5 = Depressed; Vig1 = Energetic; Vig2 = Lively; Vig3 = Active; Vig4 = Alert; Sym1 = Muscle soreness; Sym2 = Heavy arms or legs; Sym3 = Stiff/ sore joints; Sle1 = Difficulties falling asleep; Sle2 = Restless sleep; Sle3 = Insomnia; Str1 = Stressed; Str2 = Could not cope; Str3 = Difficulties piling up; Str4 = Nervous; Fat1 = Tired; Fat2 = Sleepy; Fat3 = Worn-out.

Results of the preliminary pilot testing

Participants

The participants in this study (n) were 162 respondents from different Counties in Norway divided between males (n = 111) and females (n = 51). The mean (M) age ± standard deviation (SD) of the participants was 17.4 ± 3.3 years old. Athletes were recruited from different sports with the majority (79.6%) from soccer, further, 5.6% from team handball, 6.2% from track and field, and 8.6% from other individual sports. Some participants combined teams- and individual sports (3.7%). Informed consent was obtained from all participants who agreed to take part in this study. The participants gave their consent by completing the electronic questionnaire. Guardians did not sign the consent.

1. Results of the preliminary pilot testing

1.1. Item analysis of MTDS-N

Of the 162 respondents included in the pilot study, there were no missing data. Table 1 presents descriptive statistics for the data. The skewness and kurtosis values ranged between 0.08–1.80 and -0.06–2.81, respectively. The data were a little skewed and kurtotic, but most of the items were within the values of ±2.0, indicating approximately normally distributed data. The items *miserable* and *depressed* did not meet the criteria of ±2.0, showing kurtosis values of 2.82 and 2.47, respectively. The statistical tests KS and SW yielded statistically significant ($p < 0.001$) results for all items, indicating not normally distributed data.

Table 1. Descriptive statistics for 162 participants on the items of MTDS-N.

Items	Descriptive Statistics			
	M	**SD**	**Skewness**	**Kurtosis**
Depression (dep1–dep5)				
Miserable (dep1)	1.49	0.83	1.78	2.82
Unhappy (dep2)	1.75	0.92	1.30	1.39
Bitter (dep3)	1.81	0.98	1.14	0.66
Downhearted (dep4)	2.08	1.01	0.79	0.06
Depressed (dep5)	1.49	0.88	1.80	2.47
Vigour (vig1–vig4)				
Energetic (vig1)	2.60	0.98	0.32	−0.33
Lively (vig2)	1.50	0.91	0.46	.14
Active (vig3)	2.55	0.97	0.44	−0.03
Alert (vig4)	2.86	0.87	0.27	−0.06
Physical symptoms (sym1–sym3)				
Muscle soreness (sym1)	2.93	0.92	0.15	−0.54
Heaviness (sym2)	2.60	1.01	0.28	−0.65
Joint stiffness (sym3)	2.35	1.05	0.43	−0.64
Sleep disturbances (sle1–sle3)				
Falling asleep (sle1)	1.96	1.04	1.03	0.31
Restless sleep (sle2)	2.12	1.13	0.79	−0.29
Insomnia (sle3)	1.74	0.98	1.34	1.28
Stress (str1–str4)				
Stressed (str1)	3.01	1.07	0.08	−0.41
Cope (str2)	2.63	0.97	0.14	−0.24
Piling (str3)	2.00	0.93	0.88	0.72
Nervous (str4)	2.71	1.02	0.26	−0.26
Fatigue (fat1–fat3)				
Tired (fat1)	2.77	1.08	0.32	−0.80
Sleepy (fat2)	2.73	1.11	0.32	−0.80
Worn out (fat3)	2.88	1.14	0.17	−0.80

M = Mean; SD = Standard deviation; Dep = Depression; Vig = Vigour; Sym = Physical symptoms; Sle = Sleep disturbances; Str = Stress; Fat = Fatigue.

To examine the extent to which athletes reported symptoms of psychophysiological stress related to training, scores from the MTDS-N were investigated. Taken collectively, as shown in Table 2, athletes' reports of training distress were moderate. Most of the subscales' (i.e., *vigour*, *physical symptoms*, *stress*, and *fatigue*) mean scores were between the range of "moderate amount" and "quite a bit." The only exception was *depression* (M = 1.73; SD = 0.92) and *sleep disturbances* (M = 1.94; SD = 1.05) scoring between "a little bit" and "moderate amount". The total score of the six factors was 14.31 (SD = 6.01).

Table 2. Mean scale scores for the six factors in MTDS.

	Descriptive Statistics	
Factor	**M**	**SD**
1. Depression (dep)	1.73	0.92
2. Vigour (vig)	2.63	0.93
3. Physical symptoms (sym)	2.63	1.00
4. Sleep disturbances (sle)	1.94	1.05
5. Stress (str)	2.59	1.00
6. Fatigue (fat)	2.79	1.11
Total score [a]	14.31	6.01

[a] Total score represents the sum of the six MTDS factors.

1.2. Confirmatory factor analysis

In the first step, a restrictive model (H0 model) were analysed, where all covariance between the six factors were fixed to zero. The results indicated a χ^2 value of 1174.13, degrees of freedom (df) = 209, and $p < 0.001$. None of the goodness-of-fit indices reached acceptable values: RMSEA = 0.169 (CI = 0.159–.178), CFI = 0.672, TLI = 0.638, and SRMR = 0.202.

In the second step, the six-factor solution proposed by Main and Grove (2009) were tested. This was a less restricted alternative (H1 model) compared to the H0 model. The result of the model comparison with the χ^2 difference test revealed a $p < 0.001$, indicating that constraining the parameters of the nested model statistically significantly worsened the fit of the model. Hence, the H1 model was preferred and retained.

The retained six-factor solution containing 22 items did not show a good fit with the data. As shown in Table 3, CFA results indicated a statistically significant χ^2 value = 409.77, df = 194, $p < 0.001$. The RMSEA value was 0.083, indicating a poor fit. The CFI and TLI were 0.93 and 0.91, respectively, which is below the 0.95 criterion for model acceptability. The SRMR was 0.08, which is the criterion for model acceptability.

Table 3. The test of model fit from the six-factor solution proposed by Main and Grove (2009) and the alternative model.

Fit indices	The six-factor solution	The alternative model
χ^2	409.77	315.251
df	194	191
p	<0.001	<0.001
RMSEA	0.083	0.063
CI	0.07–0.09	0.051–0.076
CFI	0.927	0.958
TLI	0.913	0.949
SRMR	0.077	0.067

χ2 = Chi-Square Value; Df = Degree of freedom; *P* = P-value; RMSEA = Root Mean Square Error of Approximation; CI = Confidence interval; CFI = Comparative Fit Index; TLI = Tucker-Lewis Index; SRMR = Standardized Root Mean Square Residual.

1.2.1. The test for the alternative measurement model

Because the hypothesized factor model yielded a poor fit, MI was examined as a guide in search of model misspecification. Modification indices reported three relatively high measurements errors; the item *alert* (vig4) with the item *active* (vig3) = 62.65 (EPC = 0.51), the factor *physical symptoms* by the item *bitter* (dep3) = 29.55 (EPC = 0.74), and the factor *stress* by the item *bitter* (dep3) = 20.89 (EPC = −0.88). An alternative model was run, where the measurement errors were taken into consideration. Taken together, as seen in Table 3, these changes yielded a CFA result indicating a statistically significant $\chi^2 = 315.25$, df = 191, $p < 0.001$. The RMSEA value was 0.063, which is close to the 0.06 criteria for a good fit. The CFI and TLI were 0.96 and 0.95, respectively, both above or at the 0.95 criterion for acceptability. The SRMR was 0.067, which is below the criterion for indicating a good model. According to the χ^2 difference test, where the MI was taken into consideration, the alternative model fitted the data statistically significantly better. The χ^2 difference test revealed a value of $p < 0.001$, indicating that the alternative model was preferred. Standardized factor loadings and R^2 from the hypothesized factor model and the alternative six-factor solution are provided in Table 4, while inter-factor correlations are shown in Table 5.

Table 4. Standardized factor loadings and R^2 values for each item in the questionnaire for the hypothesized model and the alternative model.

Item	Hypothesized	R^2	Alternative	R^2
Miserable (dep1)	0.888	0.788	0.884	0.782
Unhappy (dep2)	0.814	0.662	0.812	0.660
Bitter (dep3)	0.550	0.302	0.597	0.356
Downhearted (dep4)	0.728	0.530	0.719	0.517
Depressed (dep5)	0.946	0.896	0.941	0.886
Energetic (vig1)	0.926	0.858	0.937	0.877
Lively (vig2)	0.878	0.770	0.896	0.803
Active (vig3)	0.542	0.294	0.374	0.140
Alert (vig4)	0.475	0.226	0.267	0.071
Muscle soreness (sym1)	0.530	0.281	0.527	0.277
Heaviness (sym2)	0.857	0.734	0.861	0.742
Joint stiffness (sym3)	0.745	0.554	0.743	0.551
Falling asleep (sle1)	0.801	0.642	0.802	0.643
Restless sleep (sle2)	0.903	0.816	0.903	0.816
Insomnia (sle3)	0.908	0.824	0.908	0.824
Stressed (str1)	0.768	0.590	0.768	0.590
Cope (str2)	0.731	0.535	0.731	0.535
Piling (str3)	0.784	0.615	0.788	0.621
Nervous (str4)	0.756	0.572	0.753	0.567
Tired (fat1)	0.768	0.590	0.769	0.592
Sleepy (fat2)	0.745	0.555	0.743	0.552
Worn out (fat3)	0.852	0.726	0.853	0.727

R^2 = Coefficient of Determination.

Table 5. Standardized inter-factor correlations from the alternative model above the diagonal (in **Bold**) and inter-correlations from the initial study of MTDS are presented below the diagonal.

Factor	Depression	Vigour	Physical Symptoms	Sleep disturbances	Stress	Fatigue
DEP	1	**−0.210 ***	**0.101**	**0.441****	**0.777 ****	**0.632 ****
VIG	−0.194	1	**−0.159**	**−0.227***	**−0.143**	**−0.238 ***
SYM	−0.228	0.041	1	**0.269****	**0.019**	**0.470 ****
SLE	−0.394	0.110	0.247	1	**0.271 ****	**0.484 ****
STR	0.437	−0.259	−0.181	−0.273	1	**0.495 ****
FAT	−0.208	0.182	0.321	0.207	-.311	1

* = $p < 0.05$; ** = $p < 0.001$.

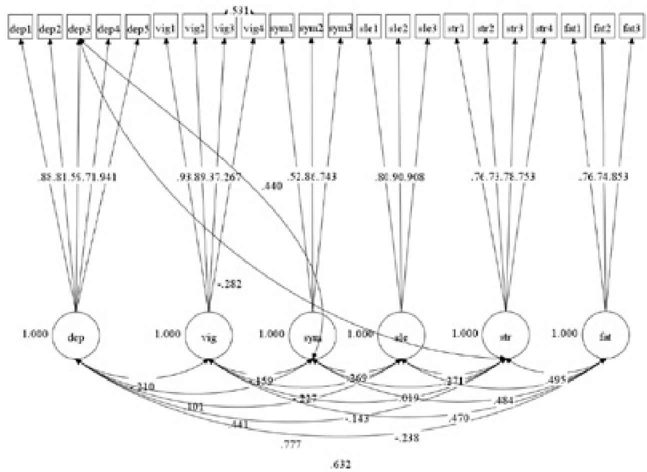

Figure 1. Standardized factor loadings and covariance estimates from the alternative model.

As presented in figure 1, all standardized factor loadings were statistically significant ($p < 0.001$) and in the expected direction, ranging from 0.267–0.941. The high loadings in the measurement model indicate a strong association between each of the latent factors and their respective items. Average factor loadings for *depression, vigour, physical symptoms, sleep disturbances, stress,* and *fatigue* were 0.791, 0.619, 0.710, 0.871, 0.760, and 0.788, respectively. Average factor loadings were all above the average R^2 value (.640, 0.473, 0.523, 0.761, 0.578, and 0.624, respectively).

3.3. Reliability analysis

Internal consistency of all factors were: α = 0.83 for factor 1 *depression*, α = 0.72 for factor 2 *vigour*, α = 0.72 for factor 3 *physical symptoms*, α = 0.87 for factor 4 *sleep disturbances*, α 0.80 for factor 5 *stress*, and α = 0.80 for factor 6 *fatigue*.

Results of the preliminary pilot testing.
New model with "BY" statement

```
Mplus VERSION 8.4
MUTHEN & MUTHEN
09/29/2020   1:00 PM

INPUT INSTRUCTIONS

   TITLE:  CFA with M.I;
        DATA:   FILE IS  MTDS to Mplus.dat;
        VARIABLE: NAMES ARE
                 DEP_1 DEP_2 DEP_3 DEP_4 DEP_5
                 VIG_1 VIG_2 VIG_3 VIG_4
                 SYM_1 SYM_2 SYM_3
                 SLE_1 SLE_2 SLE_3
                 STR_1 STR_2 STR_3 STR_4
                 FAT_1 FAT_2 FAT_3;

                 CATEGORICAL ARE
                 DEP_1 DEP_2 DEP_3 DEP_4 DEP_5
                 VIG_1 VIG_2 VIG_3 VIG_4
                 SYM_1 SYM_2 SYM_3
                 SLE_1 SLE_2 SLE_3
                 STR_1 STR_2 STR_3 STR_4
                 FAT_1 FAT_2 FAT_3;

    ANALYSIS: PARAMETERIZATION=THETA;

    MODEL: DEP by DEP_1* DEP_2 DEP_3 DEP_4 DEP_5;
           VIG by VIG_1* VIG_2 VIG_3 VIG_4;
           SYM by SYM_1* SYM_2 SYM_3;
           SLE by SLE_1* SLE_2 SLE_3;
           STR by STR_1* STR_2 STR_3 STR_4;
           FAT by FAT_1* FAT_2 FAT_3;

           DEP@1;
           VIG@1;
           SYM@1;
           SLE@1;
           STR@1;
           FAT@1;

           VIG_4 with VIG_3; !M.I. 62.65
           SYM  with  DEP_3;  !M.I.  29.55
           SYM by DEP_3;
           STR  with  DEP_3;  !M.I.  20.89
           STR by DEP_3;
           ! Comment from reviewer: include crossloading with BY statement



  OUTPUT:
  SAMPSTAT STANDARDIZED RESIDUAL MODINDICES (ALL) ;



INPUT READING TERMINATED NORMALLY



CFA with M.I;

SUMMARY OF ANALYSIS

Number of groups                                                 1
```

```
Number of observations                                       162
```

**Results of the preliminary pilot testing.
New model with "BY" statement**

```
Number of dependent variables                                22
Number of independent variables                               0
Number of continuous latent variables                         6

Observed dependent variables

  Binary and ordered categorical (ordinal)
   DEP_1       DEP_2       DEP_3       DEP_4       DEP_5       VIG_1
   VIG_2       VIG_3       VIG_4       SYM_1       SYM_2       SYM_3
   SLE_1       SLE_2       SLE_3       STR_1       STR_2       STR_3
   STR_4       FAT_1       FAT_2       FAT_3

Continuous latent variables
   DEP         VIG         SYM         SLE         STR         FAT


Estimator                                                 WLSMV
Maximum number of iterations                               1000
Convergence criterion                                 0.500D-04
Maximum number of steepest descent iterations                20
Parameterization                                          THETA
Link                                                     PROBIT

Input data file(s)
  MTDS to Mplus.dat

Input data format  FREE


UNIVARIATE PROPORTIONS AND COUNTS FOR CATEGORICAL VARIABLES

    DEP_1
      Category 1     0.673          109.000
      Category 2     0.204           33.000
      Category 3     0.086           14.000
      Category 4     0.031            5.000
      Category 5     0.006            1.000
    DEP_2
      Category 1     0.494           80.000
      Category 2     0.340           55.000
      Category 3     0.105           17.000
      Category 4     0.049            8.000
      Category 5     0.012            2.000
    DEP_3
      Category 1     0.481           78.000
      Category 2     0.315           51.000
      Category 3     0.123           20.000
      Category 4     0.068           11.000
      Category 5     0.012            2.000
    DEP_4
      Category 1     0.327           53.000
      Category 2     0.389           63.000
      Category 3     0.179           29.000
      Category 4     0.086           14.000
      Category 5     0.019            3.000
    DEP_5
      Category 1     0.704          114.000
      Category 2     0.154           25.000
      Category 3     0.093           15.000
      Category 4     0.043            7.000
      Category 5     0.006            1.000
    VIG_1
      Category 1     0.031            5.000
      Category 2     0.148           24.000
      Category 3     0.327           53.000
      Category 4     0.377           61.000
      Category 5     0.117           19.000
```

Results of the preliminary pilot testing.
New model with "BY" statement

```
 FAT_2          0.161         0.190         0.170         0.340         0.399
 FAT_3          0.393         0.286         0.335         0.455         0.358


           CORRELATION MATRIX (WITH VARIANCES ON THE DIAGONAL)
              STR_1         STR_2         STR_3         STR_4         FAT_1
              ________      ________      ________      ________      ________
 STR_2          0.461
 STR_3          0.517         0.690
 STR_4          0.653         0.506         0.532
 FAT_1          0.241         0.239         0.190         0.229
 FAT_2          0.225         0.327         0.379         0.281         0.638
 FAT_3          0.418         0.343         0.352         0.298         0.630


           CORRELATION MATRIX (WITH VARIANCES ON THE DIAGONAL)
              FAT_2         FAT_3
              ________      ________
 FAT_3         0.586


THE MODEL ESTIMATION TERMINATED NORMALLY



MODEL FIT INFORMATION

Number of Free Parameters                      130

Chi-Square Test of Model Fit

          Value                            308.413*
          Degrees of Freedom                   189
          P-Value                           0.0000

*   The chi-square value for MLM, MLMV, MLR, ULSMV, WLSM and WLSMV cannot be used
    for chi-square difference testing in the regular way.  MLM, MLR and WLSM
    chi-square difference testing is described on the Mplus website.  MLMV, WLSMV,
    and ULSMV difference testing is done using the DIFFTEST option.

RMSEA (Root Mean Square Error Of Approximation)

          Estimate                           0.062
          90 Percent C.I.                    0.050  0.075
          Probability RMSEA <= .05           0.056

CFI/TLI

          CFI                                0.959
          TLI                                0.950

Chi-Square Test of Model Fit for the Baseline Model

          Value                           3177.507
          Degrees of Freedom                   231
          P-Value                           0.0000

SRMR (Standardized Root Mean Square Residual)

          Value                              0.066

Optimum Function Value for Weighted Least-Squares Estimator

          Value                     0.78162231D+00



MODEL RESULTS
```

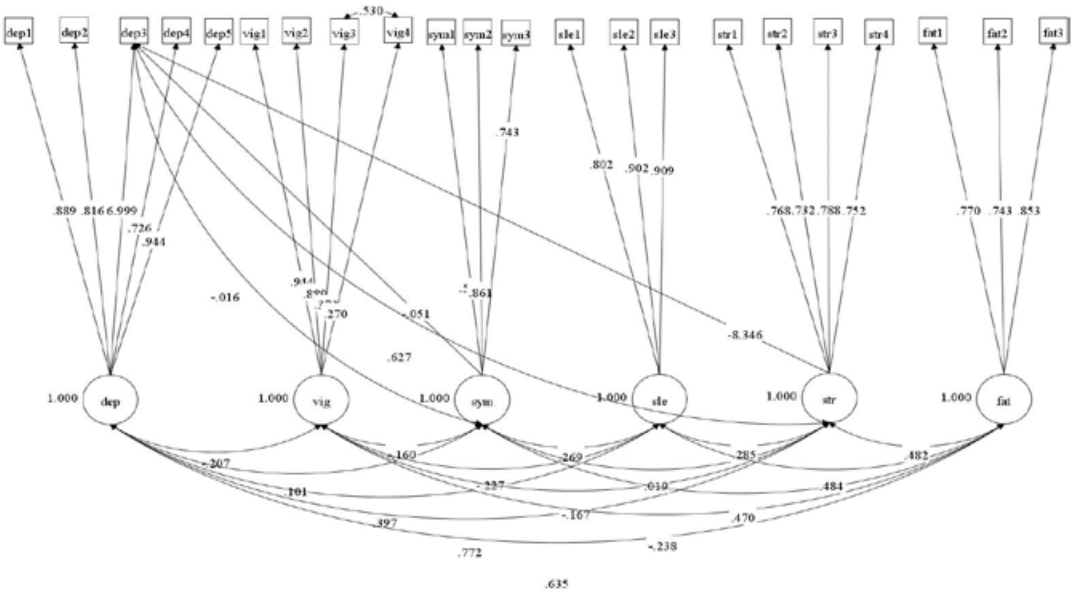

Figure. Results of the preliminary pilot testing. New model with "BY" statement.

Mplus Code_Hypothesized CFA

```
TITLE: MTDS 6- factor CFA with MLR;
DATA: File is SPSS to Mplus.dat;
VARIABLE:
NAMES ARE
Gender Age Sport Training
Countie Program Level
dep1 dep2 dep3 dep4 dep5
vig1 vig2 vig3 vig4
sym1 sym2 sym3
sle1 sle2 sle3
str1 str2 str3 str4
fat1 fat2 fat3;

USEVARIABLES are
dep1 dep2 dep3 dep4 dep5
vig1 vig2 vig3 vig4
sym1 sym2 sym3
sle1 sle2 sle3
str1 str2 str3 str4
fat1 fat2 fat3;


ANALYSIS: ESTIMATOR=MLR;


MODEL:   f1 by dep1 dep2 dep3 dep4 dep5; !depression
         f2 by vig1 vig2 vig3 vig4;      !vigour
         f3 by sym1 sym2 sym3;           !physical symptoms
         f4 by sle1 sle2 sle3;           !sleep disturbances
         f5 by str1 str2 str3 str4;      !stress
         f6 by fat1 fat2 fat3;           !fatigue


OUTPUT: TECH1 STDY MOD;

!TECH1 - parameter specification
!STDY - standardized solution
!MOD - modification indices
```

Mplus Code_Alternative CFA

```
TITLE: MTDS 6- factor CFA with MLR;
DATA: File is SPSS to Mplus.dat;
VARIABLE:
NAMES ARE
Gender Age Sport Training
Countie Program Level
dep1 dep2 dep3 dep4 dep5
vig1 vig2 vig3 vig4
sym1 sym2 sym3
sle1 sle2 sle3
str1 str2 str3 str4
fat1 fat2 fat3;

USEVARIABLES are
dep1 dep2 dep3 dep4 dep5
vig1 vig2 vig3 vig4
sym1 sym2 sym3
sle1 sle2 sle3
str1 str2 str3 str4
fat1 fat2 fat3;


ANALYSIS: ESTIMATOR=MLR;


MODEL:   f1 by dep1 dep2 dep3 dep4 dep5; !depression
         f2 by vig1 vig2 vig3 vig4;      !vigour
         f3 by sym1 sym2 sym3;           !physical symptoms
         f4 by sle1 sle2 sle3;           !sleep disturbances
         f5 by str1 str2 str3 str4;      !stress
         f6 by fat1 fat2 fat3;           !fatigue
         str4 WITH str1;
         vig4 WITH vig3;
         fat2 WITH fat1;


OUTPUT: TECH1 STDY MOD;

!TECH1 - parameter specification
!STDY - standardized solution
!MOD - modification indices
```

Mplus Code_MIMIC

```
TITLE: MTDS MIMIC without age and county;
DATA: File is Dataset MIMIC_1.dat;
VARIABLE:
NAMES =
Gender Sport County Age Training Program Level
dep1 dep2 dep3 dep4 dep5
vig1 vig2 vig3 vig4
sym1 sym2 sym3
sle1 sle2 sle3
str1 str2 str3 str4
fat1 fat2 fat3;

MISSING = ALL (-999);

USEVARIABLES =
dep1 dep2 dep3 dep4 dep5
vig1 vig2 vig3 vig4
sym1 sym2 sym3
sle1 sle2 sle3
str1 str2 str3 str4
fat1 fat2 fat3
Gender Sport Training Program Level;

MISSING = ALL (-999);

ANALYSIS: ESTIMATOR=MLR;

MODEL:   f1 by dep1 dep2 dep3 dep4 dep5; !depression
         f2 by vig1 vig2 vig3 vig4;      !vigour
         f3 by sym1 sym2 sym3;           !physical symptoms
         f4 by sle1 sle2 sle3;           !sleep disturbances
         f5 by str1 str2 str3 str4;      !stress
         f6 by fat1 fat2 fat3;           !fatigue
         vig1@0
         f1 on Gender Sport Training Program Level;
         f2 on Gender Sport Training Program Level;
         f3 on Gender Sport Training Program Level;
         f4 on Gender Sport Training Program Level;
         f5 on Gender Sport Training Program Level;
         f6 on Gender Sport Training Program Level;
         str4 with str1; !(133.13- EPC.45)
         vig4 with vig3; !(94.10- EPC.29)
         fat2 with fat1; !(45.33- EPC.30)


OUTPUT: SAMPSTAT TECH4 STAND MOD (ALL);

!TECH4 - parameter specification
!STDY - standardized solution
!MOD - modification indices
```

Mplus Code_Extended MIMIC

```
TITLE: MTDS Extended MIMIC model 2;
DATA: File is Dataset MIMIC_1.dat;
VARIABLE:
NAMES ARE
Gender Sport County Age Training Program Level
dep1 dep2 dep3 dep4 dep5
vig1 vig2 vig3 vig4
sym1 sym2 sym3
sle1 sle2 sle3
str1 str2 str3
str4 fat1 fat2 fat3;

MISSING=ALL (-999);

USEVARIABLES =
Gender Sport Program Level
dep1 dep2 dep3 dep4 dep5
vig1 vig2 vig3 vig4
sym1 sym2 sym3
sle1 sle2 sle3
str1 str2 str3 str4
fat1 fat2 fat3 Load;

DEFINE: Load=0; if Training>10 then Load=1;
!I create a dummy variable Load
!(1- more than 10 hours of training per week
!; 0- less than 10 hours training per week)

ANALYSIS: ESTIMATOR=MLR;


MODEL:   f1 by dep1 dep2 dep3 dep4 dep5; !depression
         f2 by vig1 vig2 vig3 vig4;      !vigour
         f3 by sym1 sym2 sym3;           !physical symptoms
         f4 by sle1 sle2 sle3;           !sleep disturbances
         f5 by str1 str2 str3 str4;      !stress
         f6 by fat1 fat2 fat3;           !fatigue
         f1 on Gender Sport Program Level Load;
         f2 on Gender Sport Program Level Load;
         f3 on Gender Sport Program Level Load;
         f4 on Gender Sport Program Level Load;
         f5 on Gender Sport Program Level Load;
         f6 on Gender Sport Program Level Load;
         str4 WITH str1; !error covariance
         vig4 WITH vig3; !error covariance
         fat2 WITH fat1; !error covariance

dep2 dep3 dep4 dep5 on Gender Sport Program Level Load;
vig2 vig3 vig4  on Gender Sport Program Level Load; sym2
sym3                 on Gender Sport Program Level Load;
sle2 sle3            on Gender Sport Program Level Load;
str2 str3 str4  on Gender Sport Program Level Load; fat2
fat3                 on Gender Sport Program Level Load;
!All indicators, except one, of each latent variable are regressed on
!covariates for the purpose of model identification, the first
!indicators for factors are not regressed on the covariates
!(Kaplan, 2000)

OUTPUT: SAMPSTAT STAND TECH4;
```

Paper *II*

PLOS ONE

RESEARCH ARTICLE

Progression in training volume and perceived psychological and physiological training distress in Norwegian student athletes: A cross-sectional study

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Abstract

This cross-sectional study examined self-reported weekly training volume and perceived training distress in Norwegian student athletes according to gender, type of sport, school program, and school year. The Norwegian version of the Multicomponent Training Distress Scale (MTDS-N) was completed by 608 student athletes (*M* age = 17.29 ± .94). Univariate and multivariate techniques were used in data analyses. Results revealed significant differences in weekly training volume between sport types. No significant differences in weekly training volume were found for gender, school year, or school program. However, a multivariate effect was found for gender, with females perceiving higher levels of training distress than males. A multivariate interaction effect between school year and training volume was also observed. We recommend that practitioners use a conceptual framework to periodize training and monitor training distress in student athletes, particularly in females, to preserve physiological and psychological well-being and ensure a progressive training overload leading to positive performance development.

Introduction

Becoming a world-class athlete requires systematic, quality training over time [1]. Data on elite female and male athletes from different sports indicate that athletes with an average of 10.5 training years have five training sessions and 16 hours of training per week with ~2.5 hours per training session and approximately 18 competitions a year [1]. The quality of the training is influenced by the training prescription, which should be in line with the desired outcome (i.e., goal/s), and is defined in terms of training volume, intensity, and frequency [2]. Research shows that these three components collectively referred to as training load, influence training adaptation and prevent or cause overtraining, illness, and injury [3]. Therefore, the optimal training outcomes depend on an adequate balance between training load components and non-training loads (i.e., stressors) and recovery [4, 5]. Hence, ongoing monitoring and modification of these elements are crucial in developing an optimal training prescription that can lead to high-standard performance and minimize undesired training outcomes [6–9].

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Competing interests: The authors have declared that no competing interests exist.

When determining the type and amount of training necessary at different stages of an athletic career, it is critical to understand the physiological and psychological demands arising from both the sport (i.e., its physiological and biomechanical profile) and the athlete's developmental stage [10, 11]. For example, puberty can be challenging in athletes' careers, with significant hormonally driven physical changes occurring in males and females, causing the body to respond differently to exercise. In addition, a rapid increase in growth has also been associated with an increased risk of bone and growth plate injuries [12]. Moreover, puberty can often be psychologically challenging, especially for females [13]. Another potentially challenging period is the transition from the lower secondary to the upper secondary school, which typically involves an increased training load [14–16] combined with school and other life demands [17]. Hence, both boys and girls can experience tremendous psychological pressure during this phase [17].

Understanding the sport's demands and the different stages in an athlete's development can help determine the optimal magnitude of the training components to target the desired outcome (i.e., goal/s) at different stages in an athlete's career. Practitioners can then monitor how athletes tolerate training load and make the necessary adjustments to optimize the physiological performance capacity [7, 18]. Furthermore, reference values can be established regarding training volumes in different sports and recommended progression from year to year, making it easier for both coaches and athletes to design optimal training plans. For example, elite athletes complete between 800–1200 training hours per year in typical endurance sports such as cross-country skiing [19–22], rowing [23, 24], triathlon [25], and swimming [1]. In more technically demanding sports such as soccer [26], handball [27], and athletics [28, 29], elite athletes complete between 500–700 annual training hours.

Several tools have been developed to monitor athletes' physical internal and external training loads [9, 18]. However, a holistic approach to athletes' monitoring should be adopted to consider physiological and psychological factors, especially for younger athletes with significant physiological and lifestyle changes [30]. Hence, the Multicomponent Training Distress Scale (MTDS) is a simple athlete self-report measure that combines physical and psychological stressors [31]. The questionnaire has been translated into Norwegian and assessed for its factorial validity. However, the relationship between physical and psychological training distress and different characteristics in student athletes in Norway has not been elucidated [32]. Therefore, the dual aims of this study were:

1. To describe student athletes´ weekly training volume in Norwegian upper secondary schools and determine differences in training volume according to gender, type of sport, school program, and school year.
2. To investigate whether weekly training volume, gender, type of sport, school program, or school year influence responses to the dimensions in the Norwegian Multicomponent Training Distress Scale (MTDS-N) and whether there are any interaction effects between these variables.

We had two general pre-specified research questions that we aimed to answer:

Question 1a: Are there any differences in training volume according to the type of sport?

Question 1b: Are there any differences in training volume according to the school program (i.e., students attending sports and physical education versus students attending specialization in general studies)?

Question 1c: Are there any differences in training volume according to school year (i.e., first, second and third-year students)?

Question 2a: Does the weekly training volume influence the responses to the dimensions in MTDS-N?

Question 2b: Does gender influences responses to the dimensions in MTDS-N?

Materials and methods

Participants

The "point of stability" approach was used to estimate the sample size [33–35]. This approach ensures that the deviation between the estimated sample and the population parameter is stable (small) and predicted to remain small at a stable statistical power (80%) [33, 34]. According to Cohen [36], to ensure small stability, the corridor of stability should not exceed a small correlation of 0.10. Schönbrodt and Perugini [34] suggested that the minimum number needed to reach the point of stability would be 240–250 participants. According to Kretzschmar and Gignac [33] the point-estimates of the correlation was stabilized at a sample size of 220 with perfect reliability (omega, $\omega = 1.0$) of both latent factors and a population correlation of $p = 0.20$. Because perfect reliability is almost never attained, the authors proposed that the required sample at a population correlation of $p = 0.20$ and reliability of $\omega = 0.7$ would be ≥ 490 participants [33]. Hirschfeld, Brachel and Thielsch [35] have reported similar results with the recommended sample size to reach a point of stability was > 500 participants. Consequently, the sample size that was required in this study was to be more or equal to the recommendations from comparable studies (i.e., $n \geq 500$).

The participants ($n = 632$) were recruited from 34 Norwegian upper secondary schools offering the optional subject "top-standard sport." This study was conducted according to the principles expressed in the Declaration of Helsinki, and all participants provided their written, informed consent. Furthermore, the study was approved by the Norwegian Social Science Data Services (NSD) (Project number: 836079) and the Regional Committees for Medical and Health Research Ethics (REK) (project number: 54584). Participants reporting ≤ 4 hours of training per week (n = 21) were excluded from the data analysis to guarantee a minimum training volume. Further, outliers in preliminary analyses with ≥ 30 hours of training per week ($n = 3$) were excluded, leaving a total sample size of 608 student athletes (308 male, 298 female, M age = 17.29 ± .94 years). The student athletes participated in a range of team ($n = 405$; e.g., soccer) and individual ($n = 202$; e.g., athletics) sports, training on average 12.76 hours (± 4.45) per week.

Instruments and procedures

The MTDS questionnaire was used to assess and describe the student athletes´ training distress [31]. The instrument consists of 22 items and six factors (depression, vigour, physical symptoms, sleep disturbances, stress, and fatigue). Depression, vigour, stress, and fatigue are measured in terms of their frequency and scored on a five-point Likert scale ranging from "never" (1)–"very often" (5). Physical symptoms and sleep disturbances are measured in terms of their intensity and scored on a five-point Likert scale ranging from "not at all" (1)–"an extreme amount" (5). Before data collection, the questionnaire was translated into Norwegian and assessed for factorial validity [32]. All upper secondary schools that offer the optional program subject top-standard sport in Norway ($n = 119$) were invited to participate in the present study. The MTDS-N was distributed electronically using SurveyXact version 8.0 [37] to the school management who agreed to participate ($n = 34$, 28.6%). Further, the school management distributed the questionnaire electronically to the student athletes at their respective schools ($n = 23$, 19.3%). The data collection took place during class and started in March 2020 and ended in May 2020. To assess the student athletes' training volume, student athletes reported their current weekly training hours. In addition, the survey included questions regarding age, gender, county, school name, study program, school year, and primary type of sport. The instrument and data collection procedure are fully described in [32].

Data analyses

All analyses were carried out using Statistical Package for the Social Sciences (SPSS) Version 25 (IBM Corporation, Armonk, NY, USA). First, the factor vigour from the MTDS questionnaire, with positive scores, was reversed. Descriptive statistics for all variables are presented as mean (*M*) and standard deviation of the mean (*SD*). Then, to investigate the difference in weekly training volume according to gender, type of sport, school program, and school year (independent variables), multiple one-way analyses of variance (ANOVA) were conducted. A Bonferroni adjustment was applied to correct for multiple comparisons and reduce the likelihood of Type I error [38, 39]. Next, a two-way ANOVA was conducted to investigate the trend in weekly training volume across the three school years and different sport types. Partial eta squared (η_p^2) was used to determine the effect size and were interpreted as 0.01 = small, 0.06 = medium, or 0.14 = large [36]. To assess whether the independent variables influenced the dependent variables in MTDS-N (i.e., depression, vigour, sleep disturbances, physical symptoms, stress, and fatigue), or if there was an interaction between training volume and the independent variables, four different factorial multivariate analyses of variance (MANOVA) were conducted [40]. Before performing the MANOVAs, preliminary assumptions were assessed (i.e., correlations among the dependent variables, normality, outliers, and the homogeneity of variance-covariance matrices). The results of the preliminary assumptions met the criteria for running MANOVA (S1 Table; S1 File).

The first MANOVA had a 3×2 factorial design with weekly training volume (5–10 hours, 10–15 hours, $\geq$ 15 hours) and gender (males, females) as the independent variables. Cutpoints of 5, 10, and 15 hours of training per week were chosen to ensure relatively equal group sizes [41]. The second MANOVA had a 3×3 factorial design with weekly training volume and school year (first year, second year, third year) as the independent variables. The third MANOVA included weekly training volume and sports type (soccer, other team- and ball sports, endurance sports, weight-bearing sports, other sports; S2 Table) as the independent variables, resulting in a 3×5 factorial design. The fourth MANOVA consisted of weekly training volume and school program (specialization in general studies, sports and physical education), resulting in a 3×2 factorial design. The Wilks' lambda (λ) criterion was used to interpret the results of the MANOVA. However, if the Box's M test was statistically significant ($p < 0.001$), the Pillai's Trace was used to interpret the results of the MANOVA. The Pillai's Trace is considered a robust test in place of Wilk's Lambda if the assumption of homogeneity of variance-covariance matrices is violated [42, 43]. Furthermore, descriptive discriminant analysis (DDA) was conducted as a multivariate post-hoc analysis for evaluating the MANOVA effects, which has been recommended rather than running several ANOVAs to test mean differences [40, 44, 45]. The composite variable means (i.e., training distress) were used to examine differences between groups. If a statistically significant main effect was observed for an independent variable, a one-way ANOVA was conducted with either training volume, gender, type of sport, school year, sports type, or school program as the independent variable and the saved discriminate function scores as the dependent variable to determine the magnitude of group differences. Furthermore, to determine which groups differed on the interaction composite, a two-way ANOVA with Bonferroni adjustment was conducted when a statistically significant interaction effect was observed. Then, a multivariate interaction composite was created, which was used as the dependent variable. Cohen's *d* effect sizes were calculated using the composite variable means and *SD* of the groups on the composite dependent variable to examine the composite variable means differences' magnitude and practical meaning [46]. Cohen's *d* effect sizes were converted to Person's *r* using Cohen's approximate conversion formula to measure the relationship between variables, and *r* were then multiplied to the power of 2 (i.e., r^2) to be able to estimate the "variance-accounted-for" between variable [46]. The relationships between the variables were interpreted based on the guidelines proposed by Funder and Ozer [47], where an *r* of 0.05 indicated a very small relationship; an *r* of 0.10 indicated a small relationship; an *r* of 0.20 indicated a medium relationship; an *r* of 0.30 indicated a large relationship; and an *r* of $\geq$ 0.40 indicated a very large relationship.

Results

Description of weekly training volume

Descriptive characteristics of the participants are presented in Table 1. Weekly training volume according to gender, type of sport, school program, and school year are presented in Table 2. The one-way ANOVA yielded a statistically significant difference in weekly training volume between the five sport types [F (4, 588) = 18.83, $p < 0.001$. The post-hoc test using Bonferroni adjustment indicated that student athletes playing soccer had a significantly less volume of training (11.69 hours ± 3.84) compared to those in endurance sports (15.06 hours ± 4.92; *M* difference = -3.37 hours, $p < 0.001$, $d = 0.76$, $r = 0.36$), weight-bearing sports (14.56 hours ± 4.74; *M* difference = -2.87 hours, $p < 0.001$, $d = 0.67$, $r = 0.32$), and other sports (15.10 ± 5.02; *M* difference = -3.41 hours, $p < 0.001$, $d = 0.76$, $r = 0.36$). No significant differences in weekly training volume were found between soccer and other team- and ball sports

Table 1. Descriptive characteristics of the 608 student athletes in the present study.

Characteristics (total)[1]	Modalities	Frequency or *M* ± *SD*	%
Gender (606)	Male	308	50.8
	Female	298	49.2
Age in years (yr) and months (mo) (607)	Total	17 yr 3.5 mo ± 11.3 mo	
	Male	17 yr 4.3 mo ± 11.5 mo	
	Female	17 yr 2.6 mo ± 10.9 mo	
Region (608)	West Norway	333	54.8
	East Norway	140	23.0
	Mid Norway	102	16.8
	Northern Norway	33	5.4
School program[2] (608)	Specialization in general studies	358	58.9
	Sports and physical education	250	41.1
School year (608)	First year	225	37.0
	Second year	234	38.5
	Third year	149	24.5
Type of sport (607)	Soccer	290	47.8
	Other teams- and ball sports	124	20.4
	Endurance	94	15.5
	Weight-bearing sports	52	8.6
	Other sports	47	7.7

M = Mean; *SD* = Standard Deviation; % = Percentage.

[1]Values in brackets indicate total responses from the participants.

[2] In specialization in general studies with top-standard sport, the student athletes attend regular specialization in general studies with the top-standard sport as an optional program subject. In sports and physical education, student athletes have theoretical and practical subjects related to sports. These include physical activity, sports science, training management, sports and society, and top-standard sport's optional program.

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Table 2. Descriptive statistics of weekly training volume[a] for gender, type of sport, school program, and school year.

Variable		*n*	*M*/h	*SD*/h	95% CI/h	
Gender[b]	Male	297	12.95	4.62	12.42	13.48
	Female	294	12.57	4.28	12.08	13.06
	Total	591	12.76	4.46	12.40	13.12
Type of sport	Soccer	283	11.69	3.84	11.24	12.14
	Other teams- and ball sports	120	11.85	3.84	11.16	12.54
	Endurance	93	15.06	4.92	14.05	16.07
	Weight-bearing sports	51	14.56	4.74	13.23	15.89
	Other sports	46	15.10	5.02	13.61	16.59
	Total	593	12.76	4.45	12.40	13.12
School program	SGS	351	12.69	4.37	12.23	13.15
	SPE	242	12.86	4.57	12.28	13.44
	Total	593	12.76	4.45	12.40	13.12
School year	First year	219	13.20	4.56	12.60	13.81
	Second year	229	12.58	4.11	12.05	13.12
	Third year	145	12.38	4.77	11.60	13.16
	Total	593	12.76	4.45	12.40	13.12

SGS = Specialization in general studies; SPE = Sports and physical education; n = sample size; M = mean; SD = standard deviation; CI = Confidence interval; h = hours.
[a] 15 missing values were observed for training volume.
[b] 2 missing values were observed for gender.

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(11.85 hours ± 3.84; *M* difference = -0.16 hours, $p = 1.000$). Furthermore, student athletes in other team- and ball sports had a significantly less training volume compared to those in endurance sports (*M* difference = -3.21 hours, $p < 0.001$, $d = 0.73$, $r = 0.34$), weight-bearing sports (*M* difference = -2.71 hours, $p = 0.001$, $d = 0.63$, $r = 0.30$), and other sports (*M* difference = -3.25 hours, $p < 0.001$, $d = 0.73$, $r = 0.34$). No significant differences in weekly training volume were observed for gender [F (1,589) = 1.08, $p = 0.229$], school program [F (1,591) = 0.20, $p = 0.652$], or school year [F (2,590) = 1.80, $p = 0.166$].

The two-way ANOVA indicated a statistically significant interaction between school year and sport type on weekly training volume [F (8, 578) = 1.978, $p = 0.047$, $\eta_p^2 = 0.027$]. Simple main effects analysis showed no significant difference in weekly training volume across the three school years for soccer, other teams- and ball sports, or endurance sports. Student athletes in weight-bearing sports had a significantly less training volume in third year compared to first year (*M* difference -4.04, $p = 0.020$, $d = 0.81$, $r = 0.38$). Student athletes in other sports had a significantly larger training volume in third year compared to first year (*M* difference 3.69, $p = 0.16$, $d = 0.77$, $r = 0.36$) and second year (*M* difference 3.58, $p = 0.03$, $d = 0.71$, $r = 0.34$). Fig 1 illustrates weekly training volume across the school years for the five different sport types.

Description of perceived psychological and physiological training distress

Table 3 reports descriptive statistics of the six dimensions of MTDS-N for male and female student athletes.

The effect of training volume, gender, school year, sport types, and school program on the combined characteristics of training distress

The correlation coefficients between the dependent variables (i.e., the dimensions of MTDS-N) ranged between $r = -0.00–0.44$ for males and $r = 0.03–0.64$ for females. All

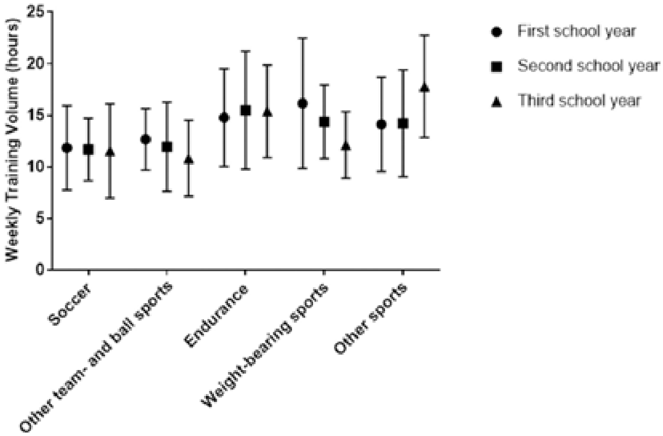

Fig 1. Progression in weekly training volume across school years in different sport types.

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correlations were positive and significant, except for the correlation between physical symptoms and vigour for males (r = -0.00) and females (r = 0.03). Based on the strength of the correlations between the dimensions of MTDS-N, it was determined that it was conceptually sound

Table 3. Mean scores for the dimensions in the Norwegian Multicomponent Training Distress Scale.

Dimension	Gender	*n*	*M*/ MTDS-N[a]	*SD*/ MTDS-N
Depression	Male	308	1.54	0.64
	Female	298	1.76	0.78
	Total	606	1.65	0.72
Vigour	Male	308	2.60	0.70
	Female	298	2.76	0.74
	Total	606	2.68	0.72
Physical symptoms	Male	308	2.31	0.81
	Female	298	2.41	0.81
	Total	606	2.36	0.81
Sleep disturbances	Male	308	1.79	0.90
	Female	298	2.22	1.09
	Total	606	2.00	1.02
Stress	Male	308	2.45	0.77
	Female	298	2.90	0.84
	Total	606	2.67	0.83
Fatigue	Male	308	2.46	0.82
	Female	298	2.63	0.93
	Total	606	2.54	0.88

[a] The mean score of the MTDS-N, ranging between 1–5, where 1 = never/ not at all, 2 = almost never/ a little, 3 = sometimes/ moderately, 4 = fairly often/ quite a bit, and 5 = very often/extremely.

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Table 4. Results from four multivariate analyses of variance examining the effect of training volume, gender, school year, sport types, and school program.

MANOVA	Effect	Criteria	Value	*F*	Hypothesis df	Error df	*p*
1 (*n* = 591)	TV	Λ	0.976	1.18[a]	12	116.00	0.292
	Gender	Λ	0.899	1.82[a]	6	58.00	0.000**
	TV × Gender	Λ	0.979	1.02[a]	12	116.00	0.428
2 (*n* = 593)	TV	Λ	0.977	1.12[a]	12	1158.00	0.336
	SY	Λ	0.978	1.06[a]	12	1158.00	0.392
	TV × SY	Λ	0.939	1.53	24	2021.10	0.048*
3 (*n* = 593)	TV	Λ	0.978	1.05[a]	12	1146.00	0.398
	ST	Λ	0.942	1.43	24	200.17	0.082
	TV × ST	Λ	0.931	0.87	48	2823.46	0.730
4 (*n* = 593)	TV	Pillai's trace	0.024	1.17	12	1166.00	0.300
	Program	Pillai's trace	0.004	0.40	6	582.00	0.877
	TV × Program	Pillai's trace	0.022	1.09	12	1166.00	0.368

Λ = Wilk's Lambda; TV = Weekly Training Hours; ST = Sport Types; SY = School Year.

[a] = Exact statistic.

* = $p < 0.05$.

** = $p < 0.001$

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to conduct a MANOVA (S1 Table). Based on the normal Q-Q plots and considering that the MANOVA analysis is robust against the violation of normality [38], we determined that it would be safe to proceed with further analysis (S1 File).

The results from the MANOVA analyses are presented in Table 4. The first MANOVA revealed no significant multivariate effect of weekly training volume on the combined characteristics of training distress, λ = 0.976, F (12, 1160) = 1.28, p = 0.292. The multivariate effect of gender on the combined characteristics of training distress was significant irrespective of training volume per week, λ = 0.899, F (6, 580) = 10.82, $p < 0.001$. No significant multivariate effect across the interaction between weekly training volume and gender were observed, λ = 0.979, F (12, 1160) = 1.02, p = 0.442. Hence, only the main effect of gender was further analysed [38]. The second MANOVA indicated a significant interaction effect for weekly training volume and school year, λ = 0.939, F (24, 2021.10) = 1.53, p = 0.048. No significant effects were observed from the third or the fourth MANOVA.

The effect of gender on perceived psychological and physiological training distress. The assumption of homogeneity of variance-covariance was considered to be met (S2 File). The DDA results indicate that gender explained 9.5% of the variance in the composite, λ = 0.905, Chi-square (6) = 60.140, $p < 0.001$, $R^2_c = 0.095$. As shown in Table 5, stress made the most significant contribution to the equation with a standardized function coefficient of 0.86, followed by sleep disturbances and fatigue with a standardized function coefficient of 0.50 and -0.30, respectively. Physical symptoms and depression did not generate the composite outcome variable score (i.e., training distress), with standardized function coefficients of 0.00 and -0.07, respectively. Female student athletes reported higher composite variable means (i.e., training distress) (0.33 ± 1.05; CI = 0.21, 0.45) than males (-0.32 ± 0.95; CI = -0.42, -0.21). A one-way ANOVA with gender as the independent variable and the saved discriminant function scores as the dependent variable was conducted to calculate the Cohen's d effect size to help quantify the magnitude of the difference [F (1, 607) = 63.57, $p < 0.001$, d = 0.65, r = 0.31].

The interaction effect of weekly training volume × school year on training distress. The assumption of homogeneity of variance-covariance was considered to be met (S2 File).

Table 5. The contribution of each outcome variable to the linear equation.

Factor	Dependent variables	R_c^2/ %	Standardized coefficient	r_s	r_s^2
Gender	Depression	0.095/ 9.5%	-0.07	0.47	0.22
	Vigour		0.14	0.33	0.11
	Physical symptoms		0.00	0.18	0.03
	Sleep disturbances		0.50	0.67	0.44
	Stress		0.86	0.87	0.76
	Fatigue		-0.30	0.31	0.09
TV × SY	Depression	0.061/ 6.1%	-0.49	-0.22	0.05
	Vigour		-0.31	-0.29	0.08
	Physical symptoms		0.66	0.68	0.47
	Sleep disturbances		0.60	0.49	0.24
	Stress		-0.20	-0.09	0.01
	Fatigue		0.14	0.24	0.06

R^2_c = squared canonical correlation (inverse of Wilks' lambda); r_s = structure coefficients; r_s^2 = squared structure coefficients.

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The DDA results indicated the presence of a significant interaction effect of weekly training volume × school year on training distress, $\lambda = 0.939$, F (24, 2021.10) = 1.53, $p = 0.048$. The interaction accounted for 6% of the variance in the composite, $R_c^2 = 0.06$. A two-way ANOVA was run to determine which groups differed on the interaction composite (S2 File). The results indicated significant differences among student athletes training 5–10 hours per week, F (2, 584) = 4.393, $p = 0.013$, as well as student athletes training more than 15 hours per week, F (2, 584) = 6.369, $p = 0.002$. There were no significant differences among student athletes training 10–15 hours per week. With 5–10 hours of training per week, the composite means were highest for second year student athletes (0.17 ± 1.01; CI = -0.04, 0.39) and lowest for first year student athletes (-0.31 ± 0.92; CI = -0.55, -0.07). The difference between the two groups was statistically significant ($p = 0.003$, $d = 0.48$, $r = 0.23$). For those training ≥ 15 hours per week, the composite means were highest for first year student athletes (0.33 ± 1.00; CI = 0.11, 0.56) and lowest for second year student athletes (-0.26 ± 1.18; CI = -0.49, -0.03). The difference between the two groups was statistically significant ($p < 0.001$, $d = 0.54$, $r = 0.26$). Fig 2 illustrates the interaction of weekly training volume by school year and how the training volume groups separate.

Discussion

The primary purpose of the present investigation was to describe student athletes´ weekly training volume in Norwegian upper secondary schools and determine whether there are differences in training volume according to gender, type of sport, school program, and school year. Furthermore, we aimed to investigate whether weekly training volume, gender, type of sport, school program, or school year influence responses to the dimensions in the Norwegian Multicomponent Training Distress Scale (MTDS-N) and whether there are any interaction effects between these variables. The main findings from this study revealed no significant differences in weekly training volume for gender, school program, or school year. Nevertheless, a significant difference in weekly training volume between sport types were detected, with endurance sports having a larger training volume than more technically demanding sports. An interaction effect of weekly training volume × school year on training distress was observed where those with larger weekly training volume experienced more training distress. Further

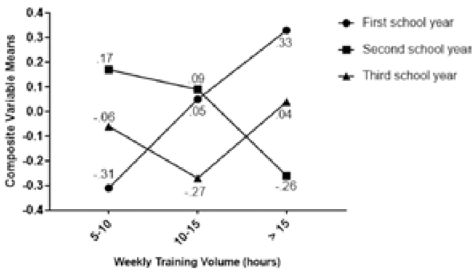

Fig 2. Linear discriminant function plot showing the interaction of weekly training volume by school year and how the training volume groups separate. The figure shows the means of each training volume group on the composite outcome variable that was created from the observed variables (i.e., training distress). To facilitate the interpretation of the figure, both the r_s and the standardized coefficients from Table 5 could be examined.

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analyses revealed a multivariate effect for gender on training distress, with females perceiving larger levels of training distress than males.

Student athletes' weekly training volume

The significant difference in weekly training volume between the five sport types, indicated that student athletes playing soccer or other team and ball sports trained fewer hours per week than student athletes in endurance sports, weight-bearing sports, and other sports (Table 2). Previous research indicates that elite athletes in typical endurance sports train between 800–1200 hours per year [1, 19, 21, 22, 24, 25], while elite athletes in more technically demanding sports train approximately 500–700 hours per year [26–29]. As such, the findings from the present study correspond with already existing reference values for training volume. However, the reference values on training volume are for senior athletes. Interestingly, the student athletes are already close to these values at the age of 15 to 18 while combining training and school. An unexpected finding is that student athletes in weight-bearing sports have a similar weekly training volume to endurance and other sports student athletes. Based on the literature [26–29], one would expect student athletes in weight-bearing sports to train fewer hours per week, with greater similarity to those playing soccer and other team and ball sports. A possible explanation for this finding is that gymnastics was included in the weight-bearing category and is a sport requiring high training volume for high-standard performance [48].

No significant differences in weekly training volume were found between school years (Table 2). It is well documented that sustained performance development requires athletes to be exposed to a systematic increase in training load over time, while adequate recovery is also ensured [49–51]. However, as shown in Fig 1, our results indicate a significant interaction effect of sports type and school year on weekly training volume, with a decreasing trend in weekly training volume for both weight-bearing sports and other team and ball sports across school years. The trend was relatively flat in soccer, while a slight increase in endurance sports. A significant progression in training volume was observed only in the category other sports, and then only from second year to third year. Based on the trends in weekly training volume across the school years, one can question whether a long-term periodized plan was adopted to ensure progressive overload and facilitate optimal performance development [6–9]. The periods within a training macrocycle could potentially contribute to explaining this finding. It is well known that different sports have different competition periods within a training macrocycle, which might have influenced the reported training volume. Hence, athletes in the competition season likely have less volumes with higher intensities. In comparison, athletes in the preparatory phase may have larger volumes with lower intensities where the focus is more on technical skills and the development of the general physical base [52].

Student athletes´ perceived psychological and physiological training distress

As shown in Table 3, scores for the different dimensions of training distress corresponded to "a little" to "moderate" amount of training distress. The results are similar to the results reported in a study of 173 student athletes competing in alpine skiing in Sweden, where the mean scores were between "a little" and "moderate" amount of training distress [53]. The Swedish student athletes' mean (± *SD*) training volume was reported to be 13.42 ± 4.07 hours per week, similar to the mean training volume in the current study of 12.76 ± 4.46 hours a week. Conversely, a study of 17 elite Australian rowers demonstrated a decline in performance in 5 km rowing combined by altered pacing strategy, suggesting an increase in fatigue. Simultaneously the total training distress scores increased significantly following four weeks of intensified training, suggesting that the athletes may have reached short-term performance decrements accompanied by psychological and physiological symptoms including mood disturbance [54]. Similar results have been found in fourteen male cyclists during a six-week training program, where increased training distress was significantly associated with increased training load (~150% of regular training load) [55]. Comparing the findings from these studies [54, 55] to the findings from this study suggest that participants training load in this study was not sufficient enough for the student athletes to reach high training distress indicated by the observed "little" to "moderate" training distress scores (Table 3). Furthermore, it has been demonstrated that those experiencing positive training adaptations are more likely to score highly on negative dimensions included in MTDS [56], which was not observed in this study. Such results suggest that the training load must be high enough to cause stress to induce the desired training adaptation. Such a concept is associated with the general adaptation syndrome (GAS) [57, 58], where adaptation is the response to stress and adequate recovery (i.e., supercompensation). This concept is also supported by the more refined stimulus-fatigue-recovery-adaptation (SFRA) theory [59, 60], which suggests that a greater stressor will result in greater fatigue and adaptation. By using MTDS-N over time, one can gather important information about athletes' psychological and physiological training distress changes and adjust their prescribed training to ensure an optimal training process. However, the authors suggest that care must be taken when interpreting psychological and physiological data. A baseline measure should always be established before decision-making, and, ideally, multiple monitoring tools should be used in parallel for a greater understanding of the athlete's overall state.

Gender differences in perceived psychological and physiological training distress. Irrespective of weekly training volume, the multivariate effect of gender (Table 4) indicates differences in the combined characteristics of training distress between male and female student athletes ($p < 0.001$). However, the effect size is small, accounting for approximately 10% of the variance in the composite variable. The results indicate that stress, sleep disturbances, and fatigue best discriminate between males and females (Table 5). Examining the results further indicates that depression had a relationship with the composite outcome variable, explaining 22% of its shared variance. Furthermore, the main effect observed was stress, but with a secondary contribution of sleep disturbances and depression, explaining 76%, 44%, and 22% of the shared variance, respectively. According to Main and Grove [31], depression, vigour, and stress represent measures associated with psychological overload, whereas physical symptoms, sleep disturbances, and fatigue reflect physical and behavioural complaints related to training distress. Thus, there is a strong possibility that psychological overload could explain the difference between males and females. We acknowledge that sleep disturbances reflect physical and behavioural complaints associated with training distress. However, one can assume that a psychological overload would also contribute to sleep disturbances (e.g., difficulties falling asleep, restless sleep, and insomnia) [61].

Considering the direction of the r_s in Table 5, it appears that females experienced more depression, sleep disturbances, physical symptoms, stress, fatigue, and less vigour than males. The effect size was large ($d = 0.65$, $r = 0.31$). These results corroborate findings of previous studies, which have also found female student athletes to have a higher prevalence of depressive symptoms [62] and greater fatigue levels with lower vigour levels [63, 64] compared to male student athletes. Furthermore, female student athletes have also been found to have relatively higher psychological distress levels [65]. Studies have also indicated that sleep disturbances are more prevalent in adolescent females [66, 67], with gender differences emerging after menses onset [68]. In addition, sleep disturbances among female athletes are more prevalent than for male athletes [69]. These findings, including the results from the current study, can be explained by maturation and growth differences between the two genders. Due to the increase of estrogen production and a slower rate of muscles development, girl adolescents may find it more challenging to adapt to the somatic growth spurt in the context of their sport or physical activity [70]. For example, the increase of estrogen production leads to increases in body fat deposition, breast development, and widening of the hips, which further contribute to changes in female body shape, the center of gravity, and strength-to-body mass ratio, which may negatively affect sports performance [71]. Conversely, males typically experience physical performance improvements during adolescence. The marked increase in hormonal concentrations in boys (i.e., testosterone, growth hormone, and insulin-like growth factor) typically leads to a significant increase in muscle mass and longer bones (i.e., widening of the shoulders and longer appendicular skeleton bones), leading to an acceleration in strength gains [72]. In addition, these developments in boys and girls increase the demand from the circulatory and respiratory systems to supply oxygen to skeletal muscle mitochondria for energy production. This causes an increase in cardiac output (i.e., increased blood volume, myocardial contractility, ventricular compliance, and angiogenesis), which, in turn, contribute to increases in peak oxygen uptake [73].

Furthermore, puberty can be psychologically challenging, especially for females [13]. At 15 years of age, a strong association has previously been found between menarche and mental distress [74]. However, this association was no longer statistically significant three years later among the same girls. Student athletes start upper secondary school the year they turn 16, indicating that extra consideration may be needed for females in their first year of upper secondary school. The effect of being different might be more noticeable during puberty with rapid body changes, compared to later stages when body dissatisfaction may be more related to elevated adiposity and living in an environment where the ideal is to be thin [75]. However, additional research is needed to test different variables that explain potential gender differences and mental health relationships in sports [76]. It should be noted that the polarity in willingness to report any psychological symptoms is a familiar issue when comparing psychological distress levels between genders [65]. Regardless, the available findings confirm the need for increased attention from those involved with female student athletes (e.g., parents, teachers, and club coaches) in order to prevent negative training and health outcomes.

Irrespective of gender differences, it is essential to emphasize that the student athletes´ self-reported training distress was generally low to moderate in the current study. Table 3 shows that the overall mean score was 2.18 and 2.45 for males and females, respectively, corresponding to "a little" to "a moderate" amount of training distress. In addition, a systematic review and meta-analysis found that symptoms of anxiety and depression were significantly lower among adolescents involved in sport than those who did not participate in sport, although the effect size was small [76]. Interestingly, of the six dimensions included in MTDS-N, depression had the lowest mean score of 1.54 and 1.76 for both males and females, respectively. Other studies have found that the prevalence of psychological distress among young elite athletes is lower than for general population controls [77]. Hence, elite sport participation does not appear to be related to elevated psychological distress levels [78]. Davis et al. [53] also concluded that student athletes´ stress levels were relatively low, which does not support the traditional assumption in sport psychology that student athletes combining both school and sports are more vulnerable to increased stress levels [79].

The interaction effect of weekly training volume × school year on perceived psychological and physiological training distress

The interaction between weekly training volume and school year ($p = 0.048$) indicates a difference in perceived training distress between school years with different training volumes per week (Table 4). In other words, one factor influences the effects of the other factor at a particular level [80]. Nevertheless, the interaction's effect size was small (Table 5), accounting for only 6% of the variance in the composite variable (i.e., training distress). Furthermore, the observed interaction effect was mainly for physical symptoms but with a secondary contribution of sleep disturbances, explaining 47% and 24% of the shared variance, respectively. Hence, the difference is mainly explained by physical and behavioural complaints associated with training distress [31]. This finding is contrary to the effect of gender, where the difference was explained primarily by psychological overload.

As shown in Fig 2, first year student athletes had significantly ($p = 0.003$, $d = 0.48$, $r = 0.23$) lower perceived training distress than second year student athletes with 5–10 weekly training hours. Conversely, amongst those training ≥ 15 hours per week, first year student athletes had significantly ($p < 0.001$, $d = 0.54$, $r = 0.26$) higher perceived training distress compared to student athletes in second year. In other words, the larger the training volume, the greater the perceived training distress among first year student athletes. This finding can be explained by two different hypotheses. Firstly, student athletes may adapt to the training load, so that by their second year they experience less training distress than in their first year, despite similar training volumes (≥ 15 hours). In light of the GAS concept [57, 58] and SFRA theory [59, 60], student athletes likely experience an adaptation during the transition from first year to second year. However, comparing the results between second-and third-year student athletes indicates that this adaptation does not continue after the second year. This could be due to a lack of change in training intensity, since we know that training volume was the same across the school years in the different sport types. It is well documented that one must influence either training volume and/or training intensity in order to improve performance [2]. The second hypothesis is that student athletes experience a higher level of training distress in their first year because they were not prepared for the increased training load they encounter when transitioning from lower secondary school to upper secondary school [14–16]. The weekly training volume may not have been appropriately adjusted to student athletes in their first year; hence, there is a possibility that the training load was too high, explaining the increased levels of training distress. Hence, practitioners (i.e., club coaches and school coaches) should carefully monitor and manage athletes' stress and recovery to avoid harmful outcomes. Further, to prepare student athletes for the increased training load they encounter when they are enrolled into upper secondary school, practitioners should cooperate and design an individualized training plan ensuring an appropriate progression in training load. Such a plan would also help to maintain performance development throughout second and third year. With low to moderate levels of training distress, as shown in Table 3, there may be room to increase the training intensity across the school years. By regularly monitoring student athletes, coaches can evaluate how they are coping with and tolerating the training load and make necessary adjustments to optimize performance capacity [7, 18].

Strengths, limitations and future research directions

The strength of the present study is the large number of participants from different counties in Norway. Further, DDA was conducted as a multivariate post-hoc analysis for evaluating the MANOVA effects, which has been recommended when running several ANOVAs to test mean differences [40, 44, 45]. However, some limitations need to be considered; first, the present study involved a self-reported questionnaire and, as such, response bias may have influenced the results. Second, weekly training volume was also self-reported and may be somewhat inaccurate, and the type of exercises and training intensities were not registered. Third, no similar studies have previously been conducted in an equivalent population, making it hard to compare the present results. However, this study can be seen as a starting point in establishing a norm for this population. Hence, future research should use a longitudinal design with student athletes reporting daily training and weekly perceived training distress with the MTDS questionnaire. Doing so makes it possible to detect spikes in perceived training distress and improve training periodisation. Finally, future research should also focus on other factors explaining performance development in student athletes, such as general life load and the prevalence of injury and health problems.

Conclusions and practical implications

To our knowledge, this is the first study to describe weekly training volume and perceived psychological and physiological training distress in student athletes enrolled in the subject "top-standard sport" in Norwegian upper secondary schools. Research to date, including the current study results, suggests the need for increased attention from practitioners involved with female student athletes to prevent adverse health outcomes and decreased performance. Practitioners should adhere to a conceptual framework for the periodization of training in order to facilitate a progressive training stimulus leading to positive adaptation and performance development. A long-term training plan is essential to smooth the transition from lower secondary school to upper secondary school and ensure that the training load is appropriately adjusted to match each individual´s anthropometric, physical, and metabolic characteristics. Regular monitoring with a user-friendly questionnaire such as MTDS-N can help practitioners preserve student athletes' physiological and psychological well-being and ensure positive performance development.

Supporting information

S1 Table. Pearson bivariate correlations among study variables.
(DOCX)

S2 Table. The categorization of the different sports in the present study.
(DOCX)

S1 File. Testing normality.
(DOCX)

S2 File. Descriptive discriminant analysis.
(DOCX)

S1 Dataset. Source data.
(XLSX)

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S1 Table. **Pearson bivariate correlations among study variables.** Male are above the diagonal (n = 308) and female are below the diagonal (n = 298).

	DEP	VIG	SYM	SLE	STR	FAT
DEP	-	0.269**	0.083	0.275**	0.436**	0.381**
VIG	0.204**	-	-0.002	0.147**	0.187**	0.211**
SYM	0.346**	0.030	-	0.208**	0.163**	0.343**
SLE	0.424**	0.233**	0.256**	-	0.273**	0.380**
STR	0.638**	0.218**	0.269**	0.392**	-	0.372**
FAT	0.524**	0.214**	0.351**	0.467**	0.539**	-

* *p* <.05, ** *p* <.01

S2 Table. The categorization of the different sports in the present study. In the research literature, training load is juxtaposed with the product of duration, intensity, and frequency. The categorization in the table below is made on the basis that the load in the various sports is approximately equal, as well, as they have similar sport demands. Three experts have categorized the sports equally.

Type of Sport	Sport[a]	*n*	%
Soccer	Soccer	290	45.9
	Total	290	45.9
Other team- and ball sports	Handball	90	14.2
	Ice hockey	19	3.0
	Badminton	5	0.8
	Tennis	4	0.6
	Floorball	1	0.2
	Volleyball	5	0.8
	Total	124	19.6
Endurance sports	Swimming	24	3.8
	Cross-country skiing	34	5.4
	Orienteering	8	1.3
	Cycling	12	1.9
	Rowing	3	0.5
	Biathlon	11	1.7
	Triathlon	2	0.3
	Total	94	14.9
Weight-bearing sports	Track & Field/ Athletics	21	3.3
	Gymnastics	11	1.7
	Alpine skiing	15	2.4
	Strength training	4	0.6
	Freeski	1	0.2
	Total	52	8.2
Other sports	Golf	3	0.5
	Show Jumping	12	1.9

	Ice Skate	4	0.6
	Sailing	6	0.9
	Martial Art	7	1.1
	Cheerleading	1	0.2
	Sky Jumping	1	0.2
	Diving	1	0.2
	Sports drill	4	0.6
	Shooting	1	0.2
	Snowboard	1	0.2
	Jetski	1	0.2
	Dance	1	0.2
	Motocross	2	0.3
	Climbing	1	0.2
	Figure skating	1	0.2
	Total	47	7.7

n = sample size

[a]1 missing value was observed for sport

S1 File. Testing normality. Information regarding the normality assumption for running MANOVA.

The normality assumption was examined by conducting Shapiro-Wilk (SW) and Kolmogorov-Smirnov (KS) tests. A statistically significant ($p<0.05$) test would indicate not normally distributed data (Verma, 2015, p. 57). A limitation of these tests is that they can become significant even for a slight deviation from normality in the case of large samples (Verma, 2015, p. 55). Hence, normal Q-Q plots were also investigated to check the level of normality. The SW and KS tests for both males and females were statistically significant ($p<.001$) for all dependent variables, indicating nonnormal data distribution. However, the points in the Normal Q-Q plot were along the line for vigor, physical symptoms, stress, and fatigue, for both males and females, indicating a normal data distribution. The points had minor deviations from the line for depression and sleep disturbances for both males and females. The box-plot indicated some outliers, but these were not considered as outliers because the range of responses was small (i.e., one to five). Similarly, for the training hours classifications, the SW and KS tests were statistically significant ($p<.001$). However, when inspecting the QQ-plots, the points had only small deviations from the line. No outliers were found in the training load classification data. It was not surprising that the SW and KS tests were statistically significant, given the relatively large sample size in the present study. Considering that the MANOVA analysis is robust against the violation of normality (Verma, 2015, p. 210), we determined that it would be safe to proceed with further analysis.

S2 Information. Descriptive discriminant analysis.

The DDA evaluating the effect of gender on training distress showed that the Box's M test was not statistically significant (p>.001). Further, the log determinants were relatively similar, so the assumption of homogeneity of variance-covariance was considered to be met.

To save the discriminant function scores for an interaction effect, we followed the guidelines proposed in DDA literature (Barton et al., 2016; Enders, 2003; Smith et al., 2019). The Box's M test was not statistically significant (p>.001), and the log determinants ranged between -5.22 and -3.01. The log determinant of the pooled covariance matrix was -3.51. As such, the assumption of homogeneity of variance/ covariance was considered to be met.

A two-way ANOVA was run to determine which groups were different on the interaction composite. We created a multivariate interaction composite, which was used as the dependent variable. Simple comparisons were conducted to examine differences among training groups within each school level. A Bonferroni adjustment was used to control for Type 1 error inflation across the set of three comparisons (i.e., α = .05/3 = .016).

Paper III

sports

MDPI

Article

A Holistic Analysis of Team Dynamics Using Relational Coordination as the Measure regarding Student Athlete Total Load: A Cross-Sectional Study

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Abstract: Background: Despite its small population, Norway wins a disproportionately large number of medals in international competitions. Therefore, it has been thought that the Norwegian sports model and sports school programs are influential in developing young Norwegian athletes to achieve such results. Today, more than 110 Norwegian private and public schools offer the elite sports program in Norway. Most student athletes attending those schools combine their high school education with elite sports, where they attend training sessions at both school and clubs. The number of people involved with the student athlete on a daily basis (i.e., other student athletes, club coaches, school coaches, schoolteachers, parents, and health personnel) indicate the importance of optimal communication and coordination. However, to the authors' knowledge, no previous studies have explored communication and coordination among this population group. Therefore, the primary objective of this study was to use a holistic analysis of team dynamics using the Relational Coordination Survey as a measure to explore the relational coordination within and between student athletes, club coaches, and school coaches. A secondary objective of this study was to explore student athletes', club coaches', and school coaches' relational coordination with schoolteachers, parents, and health personnel. In addition, the study aimed to explore differences in student athletes' relational coordination with their significant others according to sport, school, performance level, sex, and school year. Methods: The quality of relational coordination was measured by a cross-sectional questionnaire of student athletes (n = 345), club coaches (n = 42), and school coaches (n = 25) concerning training load and life load. Multiple one-way analyses of variance were used to assess differences between groups. Results: The results show that student athletes, club coaches, and school coaches perceived moderate to weak relational coordination with parents, schoolteachers, and health personnel. Student athletes' relational coordination score with parents was the only strong score observed. Furthermore, the results reveal notable differences in student athletes' relational coordination with the roles according to their characteristics. Conclusions: The findings suggest a potential for enhancing relationships and communication within and between the significant roles involved with student athletes. The results further indicate that those involved with the student athlete should consider a holistic approach to enhance communication and coordination, including physical, psychological, and other life factors, for optimal student athlete management and development. More resources are necessary to facilitate effective communication and coordination regarding the student athlete's total load.

Keywords: relational coordination; student athlete management; student athlete wellbeing

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1. Introduction

Despite its small population, Norway wins a disproportionately large number of medals in international competitions [1–4]. In Norway, the Norwegian sports model and sports school programs are considered influential in developing young athletes [5–7]. Since 1981, when the first private Norwegian elite sports school was established, student athletes have had the opportunity to combine high school education with elite sports [6]. Over the last few years, many of Norway's best individual and team sport athletes have attended elite sports schools, which offer proper facilities and highly qualified coaches. In 2006, the Norwegian national curriculum introduced elite sports as an optional subject in public schools [6–9]. Today, more than 110 private and public schools offer the elite sports program [10], one of Norway's most popular programs among high school students [8]. Although differences exist between the programs offered by private and public schools [5,10], a fundamental similarity is that student athletes in the "Elite Sport" program will likely experience a considerable increase in physiological (i.e., training load) and psychological (i.e., stress associated with academic demands, social commitments, employment, and sports participation) loads after enrolment [11–13]. Additionally, most Norwegian high schools keep competitive sports and education separate [14], and the majority of student athletes will also participate in club training sessions in the evening, in addition to training during school hours. Hence, multiple people are involved with and influence the student athlete's progression (e.g., club coaches, school coaches, schoolteachers, parents, health personnel, and peers). Therefore, it could be expected that effective communication and coordination dynamics within and between the people involved with the student athlete are of high importance to ensure optimal training load management, foster athletic and academic development, and prevent adverse outcomes [15–20]. For example, effective communication and coordination concerning training, schoolwork, and other life demands is essential to ensure sufficient recovery and reduce the risk of injury [11,12,21–23]. However, previous research has indicated that the level of coordination and communication between student athletes, schools, and sports clubs varies considerably and depends on local conditions and circumstances [10,11]. Effective communication strategies are critical to put the student athlete at the centre of a holistic, well-rounded development program [24,25].

The effectiveness of communication and coordination and its importance has been proposed in several theories, including Team Dynamics Theory (TDT) and the holistic ecological approach (HEA). Suppose we assume that the people involved with the student athlete and the student athlete themselves are a team. In that case, TDT aims to explain part of the variability in team dynamics and predict team outcomes [26]. The theory involves four inputs: (1) cohesion, which historically has been regarded as a vital variable when studying small-group dynamics [27–29]; (2) team mental models [30]; (3) coordination [31–37]; and (4) collective efficacy [38]. Team Dynamics Theory focuses on the team, with the inter-relationship between individuals as the measurement approach. Therefore, cohesion, team mental models, coordination, and collective efficacy are processes at the team level.

On the other hand, the HEA is built around two working models: (1) the athletic talent development environment (ATDE) and (2) the model of environmental success factors (ESF) [5]. The HEA, with its two working models, has shown its value as a lens to aid the study of a specific environment in talent development [39–41]. The dual-career development environment (DCDE) working model is based on the original ATDE working model, where the main change is a revision of the environmental domain [42]. The model illustrates, at the micro-level, that student athletes are at the centre and surrounded by those closest to them (i.e., study peers, family, friends, teachers, and sports coaches). The DCDE considers sports, studies, and private life as domains in student athletes' development. The sport domain involves the part of the student athletes' environment directly connected to the sport, the study domain represents elements related to their school activities, and private life refers to the other areas of the student athletes' lives.

The Relational Coordination Survey (RCS) is a proposed measure used to address team dynamics using a holistic analysis approach [43]. Relational coordination (RC) theory was developed by Jody Hoffer Gittell in the early 1990s from an in-depth field study of flight departures in the airline industry [43]. The theory's core construct is "a mutually reinforcing process of interaction between communication and relationships carried out for the purpose of task integration" [44]. The theory suggests that the high-quality relationships of shared goals, shared knowledge, and mutual respect contribute to the support of frequent, timely, accurate, and problem-solving communication, thereby allowing key stakeholders to coordinate their work effectively across boundaries. The opposite effect is expected with low-quality relationships, weakening the quality of communication, and hampering stakeholders' ability to effectively coordinate their work [45]. The network approach to measuring RC involves separately measuring each dyadic tie in a work process. Instead of asking a respondent to evaluate the quality of their communication and relationships with all roles globally, respondents are asked to separately evaluate each of the key roles involved in the work process. This enhances the accuracy of the measurement compared to a global assessment. Furthermore, by assessing each tie separately, one can differentiate the strength of ties within and between different roles in the work process. As a result, it is possible to diagnose which ties are the weakest, and where it may be necessary to intervene to increase the strength of RC [45].

Hence, the primary objective of this study was to use a holistic analysis of team dynamics using the RCS as a measure to explore perceived RC regarding total load (i.e., training load and life load) within and between student athletes, club coaches, and school coaches [43]. A secondary aim was to explore student athletes', club coaches', and school coaches' perceived RC with schoolteachers, parents, and health personnel. In addition, the study aimed to explore differences in student athletes' perceived RC with their coaches and significant others according to the type of sport, school, performance level, sex, and school year. To the author's knowledge, this is the first study investigating RC in a sports context.

2. Materials and Methods

2.1. Study Design

The study employed a cross-sectional design. All Norwegian high schools in a selected county offering the optional school subject "Elite Sport" were given equal opportunity to participate (n = 10; 2 private, 8 public). Student athletes born between 2004 and 2006 and enrolled in the elite sport program were eligible for inclusion. The school coaches and club coaches included in the study were connected to one or more of the included student athletes. Five high schools agreed to participate (1 private, 4 public). Figure 1 shows the participant flow.

2.2. Sample Size

In accordance with Statistics Norway (SSB, www.ssb.no, accessed on 24 January 2023), the total number of student athletes attending a sports program in Norwegian high schools in 2020 was measured at 12,547. The sample size was calculated using the online Raosoft sample size calculator (Raosoft, Inc., 2004, http://www.raosoft.com/samplesize.html, accessed on 29 January 2023). With a confidence level of 95%, a margin of error of 5%, and a response distribution of 50%, the recommended sample size was 373.

2.3. Participants

The participants in the study were 412 respondents, including student athletes enrolled in the elite sport program (n = 345; 84%), club coaches (n = 42; 10%), and school coaches (n = 25; 6%). The student athletes were involved in 23 different sports, where football (43%), handball (20%), ice hockey (6%), swimming (5%), and cycling (4%) were the most frequently reported sports. Descriptive statistics of the participants are presented in Table 1. Informed consent was obtained from all participants. The study was approved by the Norwegian Social Science Data Services (NSD) (project number 836079).

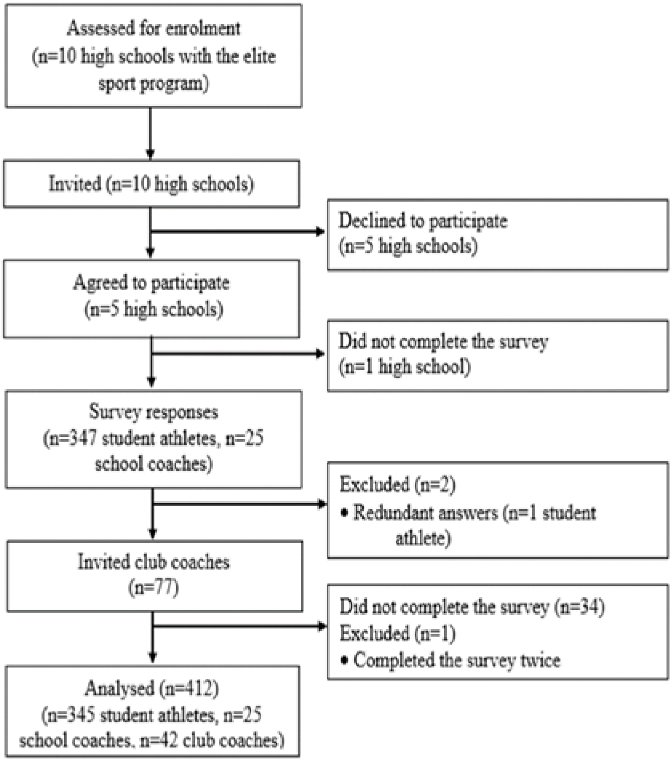

Figure 1. Participant flow throughout the study.

2.4. Instrument

The validated RCS [46,47] was first used in the Nine-Hospital Study of Surgical Patients [48] and has since then been used in numerous different contexts, including the commercial, education, health care, and human service sectors [43].

The RCS consists of two factors: communication and relationship. Communication consists of four items (frequent communication, timely communication, accurate communication, and problem-solving communication), whereas relationship consists of three items (shared goals, shared knowledge, and mutual respect). The items are answered on a 5-point Likert scale (Supplementary Materials, Table S1). In addition to the response options 1 through 5, a "not applicable" option was included to allow respondents to indicate that RC with a particular role was not needed. These answers were recoded as missing values [49]. Respondents were asked to complete each item according to their perception of communication or relationships with specific roles included in the study (i.e., student athletes, parents, schoolteachers, school coaches, club coaches, and health personnel). Figure 2 illustrates the included roles engaged in student athletes' training load, performance development, and life load.

Table 1. Descriptive statistics of the 412 participants in the study.

Characteristics	Modalities	M ± SD or Frequency		
Role		Athletes (n = 345)	Club coaches (n = 42)	School coaches (n = 25)
Age		17.15 ± 0.94	38.15 ± 12.27	40.44 ± 8.41
Sports experience in years (2) [1]		11.08 ± 2.56		
Sex	Female	147	10	4
	Male	198	32	21
School year	First year	142		
	Second year	95		
	Third year	108		
Training volume (4)	Sports-friendly programme	13.88 ± 3.74		
	Elite sport programme	15.45 ± 4.84		
School program [2]	Specialisation in general studies	204		
	Sports and physical education	141		
Type of sport (2)	Individual	98	8	
	Team sport	245	34	
Performance level	Top 1–5%	18	1	
	Top 5–25%	159	9	
	Top 25–50%	153	24	
	<Top 50%	15	8	

Note. M = mean; SD = standard deviation. [1] Values in brackets indicate missing values for athletes. [2] Student athletes attending a specialisation in general studies have chosen "Elite Sport" as an optional program subject. Student athletes attending sports and physical education have, in addition to the optional program subject "Elite Sport", theoretical and practical subjects related to sports (i.e., physical activity, sports science, training management, and sports and society).

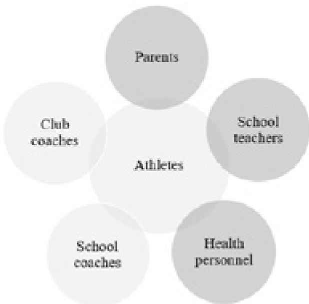

Figure 2. The included roles engaged in student athletes' training load, performance development, and life load (*light grey was surveyed, whereas dark grey was not surveyed*).

The RCS was previously translated from the original English to Norwegian by Hustoft et al. [50]. A psychometric assessment of the Norwegian version of the RCS suggested a two-factor solution with a Cronbach's alpha (α) of 0.93 and 0.80 for communication and relationship factors, respectively [50]. We used the version from Hustoft et al. [50] as a guide when changing the wording in the survey so that it would be appropriate to our setting.

2.5. Data Collection

Survey data were collected between February and April 2020. By using SurveyXact version 8.0 [51], the questions from the RCS were manually added to the program. In addition, we included background questions regarding age, sports experience, sex, school year, type of school, training volume, school program, type of sport, and performance level. Student athletes were asked to evaluate their current performance level with the following question: "In your opinion, how would you rate your performance level compared to other peers in the same sport in Norway, where the top 1% is the best in your sport?" For the analysis, responses were dichotomised into above the top 5%, top 5–25%, top 25–50%, or below the top 50%. Three different roles were surveyed, and participants from each group received a questionnaire formulated for student athletes, school coaches, or club coaches. The questionnaires were tested by distributing a link electronically to two independent persons. First, the questionnaire targeting student athletes was distributed electronically to the schools that agreed to participate in the study. The Head of Department further distributed the questionnaire to the student athletes during an allocated teaching hour. During the data collection, investigators were present at the school to answer any potential questions. The questionnaire targeting school coaches was distributed to them personally. Finally, club coaches were contacted for participation in the study based on the responses from the student athletes (e.g., which sports club they belonged to and their performance level).

2.6. Statistical Analysis

All analyses were carried out using IBM SPSS statistics version 27.0 (IBM Corporation, Armonk, NY, USA) and Mplus version 8.4 (Muthén and Muthén, Los Angeles, CA, USA). Descriptive statistics are presented as the mean (M) and standard deviation of the mean (SD) or frequencies. First, responses for the item "frequent communication" were re-coded such that 1 = "far too little", 2 = "far too much", 3 = "too little", 4 = "too much", and 5 = "just right" [49]. Then, preliminary analyses investigating the normal distribution were conducted (Table 2). Skewness and kurtosis were examined, and the Kolmogorov–Smirnov test (KS), the Shapiro–Wilk test (SW), and a multivariate normality test were conducted. Skewness and kurtosis values between ±1.0 were considered excellent, and values in the range of ±1.0–2.0 were considered acceptable [52]. For the KS, SW, and the multivariate normality test, a *p*-value of >0.05 was used to indicate normally distributed data [53].

Table 2. Descriptive statistics of the items and tests of normality.

Item	N	M	SD	Skewness	Kurtosis	KS (*p*)	SW (*p*)
Frequent communication	411	4.1	0.8	−1.1	1.3	0.000	0.000
Timely communication	408	3.0	0.8	0.2	0.0	0.000	0.001
Accurate communication	408	2.9	0.9	0.2	0.1	0.000	0.000
Problem-solving communication	403	3.5	1.0	−0.2	−0.6	0.004	0.000
Shared goals	403	3.5	0.8	−0.1	−0.4	0.000	0.000
Shared knowledge	409	3.2	0.7	−0.1	0.1	0.020	0.124
Mutual respect	407	3.8	0.9	−0.4	−0.2	0.000	0.000

Note. M = mean; SD = standard deviation; KS = Kolmogorov–Smirnov test; SW = Shapiro–Wilk test.

An exploratory factor analysis (EFA) was conducted to test the construct validity of the RSC [54]. We used the goemin (oblique) rotation and a maximum likelihood estimator (MLR), considering the multivariate non-normality in the measures (Table 2). The number of factors was determined based on the eigenvalues, the scree plot, and the parallel analysis [55]. Model fit indices were not considered, as growing evidence indicates that it is inappropriate to use model fit indices to select the number of factors in a scale evaluation framework [56]. According to Kaiser's rule, the number of eigenvalues ≥1 would represent unique factors [55]. In the scree plot, the number of factors above the elbow would indicate the optimal number of factors. For the parallel analysis, the factor should be retained when the average eigenvalues from the random data were smaller than the reported eigenvalues for the EFA [57]. McDonald's omega (ω) with confidence intervals (CIs) was calculated to estimate scale reliability. A value of ≥0.70 was considered acceptable [58,59], and a maximal estimate of 0.90 was determined regarding redundant items [52,60]. Cut-off points for weak, moderate, and strong RC ties within and between roles are based on norms from previously collected RC scores collected between 2012 and 2015 (Table 3) [45].

Table 3. Cut off points for weak, moderate, and strong relational coordination ties.

Strength	Within Roles	Between Roles
Weak	<4.1	<3.5
Moderate	4.1–4.6	3.5–4.0
Strong	>4.6	>4.0

Note. The cut off point is from Gittell (2018).

To investigate the difference in perceived RC between the surveyed roles (i.e., student athletes, club coaches, and school coaches), multiple one-way analyses of variance (ANOVAs) were conducted. In addition, multiple one-way ANOVAs were conducted to investigate the difference in student athletes' perceived RC according to the type of sport (individual or team), school (public sports-friendly high school or private elite sport high school), performance level (above the top 5%, top 5–25%, top 25–50%, or below the top 50%), sex (female or male), and school year (first, second, or third year). A Bonferroni adjustment was applied to correct for multiple comparisons and reduce the likelihood of Type I error [61,62]. Partial eta squared (η_p^2) was used to determine the effect size and was interpreted as 0.01 = small, 0.06 = medium, or 0.14 = large [63].

3. Results

3.1. Exploratory Factor Analysis

The one-factor solution was preferred based on analyses of eigenvalues (Table 4) and the scree plot (Figure 3) containing data-based and parallel-analysis-based eigenvalues. Table 5 shows the factor loadings, residual variances, and the calculated McDonald's ω. All items had high factor loadings in the one-factor solution (0.627–0.903). The factor also constituted high reliability with a McDonald's ω of 0.892 (95% CI 0.876–0.919). The estimated unexplained residual variances (i.e., uniqueness) ranged from 0.184 to 0.607. Hence, the results reveal that the RCS has good construct validity and high reliability.

Table 4. Eigenvalues for sample correlation matrix.

Factor	Eigenvalue
1	4.32
2	0.91
3	0.48
4	0.44
5	0.36
6	0.33
7	0.15

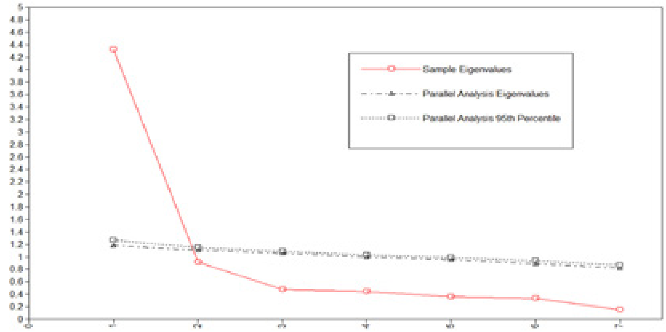

Figure 3. Scree plot showing the data-based and parallel-analysis-based eigenvalues.

Table 5. Geomin rotated loadings, McDonald's omega (ω), and residual variances for the one-factor solution.

	One-Factor Solution	
Item	**1**	**Residual Variances**
Frequent communication	0.627 *	0.607
Timely communication	0.903 *	0.184
Accurate communication	0.889 *	0.210
Problem-solving communication	0.705 *	0.502
Shared goals	0.677 *	0.542
Shared knowledge	0.686 *	0.530
Mutual respect	0.649 *	0.579
McDonald's ω (95% CI)	0.892 (0.876–0.919)	

Note. * Significant at the 5% level.

3.2. The Strength of Perceived RC

The mean values of RC with the roles included in the present study are presented in Table 6. Figure 4 is based on the information from Table 6 and illustrates RC among the roles according to the cut-off points from Gittell (2018) (Table 3).

Table 6. Mean values of perceived relational coordination within and between the roles.

		Rating of								
		CC	**SC**	**A Top > 5%**	**A Top 5–25%**	**A Top 25–50%**	**A < Top 50%**	**ST**	**P**	**HP**
Ratings by	CC	3.7	2.6	3.8	3.6	3.6	3.1	1.9	3.3	3.7
	SC	3.6	3.9	4.1	3.9	3.6	3.5	3.2	3.3	3.3
	A top 1–5%	4.0	3.8	3.5	3.5	3.5	3.3	3.1	4.3	3.8
	A top 5–25%	3.7	3.7	3.0	3.2	3.0	2.9	2.9	4.1	3.6
	A top 25–50%	3.5	3.5	2.9	3.12	3.0	2.6	2.9	3.9	3.4
	A < top 50%	3.8	3.7	3.2	3.5	3.5	3.5	3.5	4.1	3.6
	All	3.7	3.5	3.4	3.5	3.3	3.1	2.9	3.8	3.6

Note. CC = club coaches; SC = school coaches; ST = school teachers; P = parents; HP = health personnel; A = athletes.

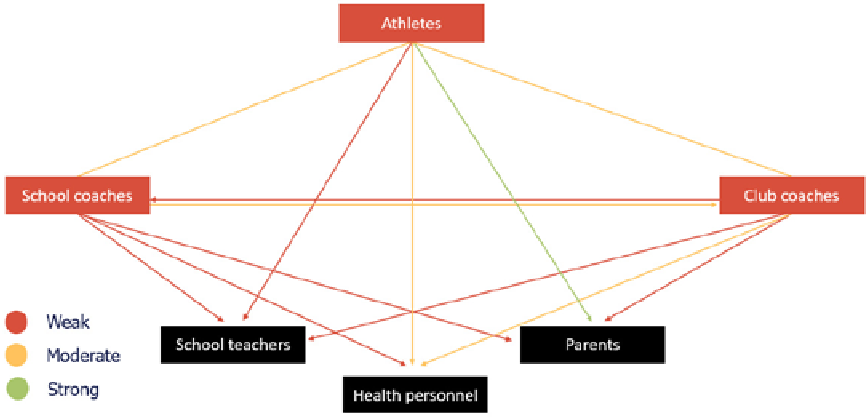

Figure 4. The quality of relational coordination among the participants. Note: Black boxes indicate roles that were not surveyed. Arrows from one box to another indicate the perceived quality of relational coordination between the roles. Lines between two boxes indicate a mutual quality of relational coordination between the roles.

3.3. Differences in Perceived RC between Roles

The one-way ANOVA results with descriptive statistics and effect sizes are presented in Table 7. No marked differences were observed in student athletes', school coaches', or club coaches' perceived RC with club coaches or health personnel ($p > 0.05$). However, the results indicate notable differences in student athletes', school coaches', and club coaches' perceived RC with school coaches ($p < 0.001$), schoolteachers ($p < 0.001$), parents ($p < 0.001$), and student athletes ($p < 0.001$). Post hoc tests with Bonferroni adjustment indicated marked differences between student athletes' and club coaches' RC with school coaches (M difference = 0.99, $p < 0.001$) and between school coaches' and club coaches' RC with school coaches (M difference = 1.27, $p < 0.001$). Furthermore, notable differences were found between student athletes' and club coaches' RC with schoolteachers (M difference = 1.05, $p < 0.001$) and between school coaches' and club coaches' RC with schoolteachers (M difference = 1.31, $p < 0.001$). In addition, there were marked differences between student athletes' and club coaches' RC with parents (M difference = 0.77, $p < 0.001$) and between student athletes' and school coaches' RC with parents (M difference = 0.77, $p < 0.001$). Lastly, the results indicate notable differences between student athletes' and school coaches' RC with student athletes (M difference = −0.63, $p = 0.002$) and between student athletes' and club coaches' RC with student athletes (M difference = −0.45, $p = 0.005$).

Table 7. One-way ANOVA results with descriptive statistics and effect sizes.

RC with	Role	N	M	SD	95% CI		*p*	η_p^2
					LB	UB		
Club coach	Athlete	337	3.64	0.95	3.54	3.74	0.875	0.00
	School coach	24	3.61	0.86	3.25	3.98		
	Club coach	40	3.71	0.84	3.45	3.98		
School coach	Athlete	341	3.60	0.85	3.51	3.69	<0.001	0.11
	School coach	25	3.89	0.71	3.59	4.18		
	Club coach	38	2.62	1.05	2.27	2.96		
School teacher	Athlete	327	2.96	1.02	2.85	3.07	<0.001	0.09
	School coach	23	3.22	0.65	2.94	3.50		
	Club coach	31	1.90	0.66	1.66	2.15		
Parents	Athlete	345	4.05	0.73	3.97	4.13	<0.001	0.13
	School coach	25	3.28	0.71	2.99	3.57		
	Club coach	39	3.28	0.71	3.05	3.51		
Health personnel	Athlete	298	3.52	0.98	3.41	3.63	0.310	0.01
	School coach	21	3.27	1.08	2.77	3.76		
	Club coach	38	3.67	0.86	3.39	3.96		
Athlete	Athlete	295	3.15	0.89	3.04	3.25	<0.001	0.05
	School coach	24	3.78	0.65	3.50	4.05		
	Club coach	42	3.59	0.71	3.37	3.81		

Note. LB = lower bound of 95% confidence interval; UB = upper bound of 95% confidence interval; η_p^2 = partial eta squared.

3.4. Student Athletes' Perceived RC According to Characteristics

The one-way ANOVA results with descriptive statistics and effect sizes are presented in Table 8. For the type of sport, there was a notable difference between team sport student athletes' and individual sport student athletes' RC with club coaches (M difference = −0.36), school coaches (M difference = −0.33), schoolteachers (M difference = −0.40), parents (M difference = −0.37), and health personnel (M difference = −0.52). No marked differences in perceived RC with the different roles were found for the type of school. Regarding performance level, there was a notable difference in perceived RC between student athletes based on performance level (i.e., above the top 5%, top 5–25%, top 25–50%, and below the top 50%) with parents ($p = 0.048$). No marked differences in perceived RC with club coaches, school coaches, schoolteachers and health personnel were found between student athletes of the four performance-level categories. There was a marked difference in perceived RC with parents between the performance-level categories. However, when examining multiple comparisons with Bonferroni adjustment, there was no marked difference in RC between the student athletes of the four performance-level categories. With regard to sex, no notable differences were found between female and male student athletes' perceived RC with club coaches, school coaches, schoolteachers, parents, or health personnel. Lastly, the results regarding the school year indicated no notable difference in RC with club coaches, school coaches, schoolteachers, or health personnel. There was a marked difference in first-, second-, and third-year student athletes' perceived RC with parents. Post hoc tests with Bonferroni adjustment indicated a marked difference in RC with parents between first- and second-year student athletes (M difference = 0.28, $p = 0.012$).

Table 8. Multiple comparisons of athlete's perceived RC according to the type of sport, performance level, sex, and school year.

		N	M	SD	95% CI		p	η_p^2
					LB	UB		
RC by Type of Sport								
Club coach	Team	240	3.54	0.92	3.42	3.66	0.002	0.03
	Individual	95	3.90	0.99	3.70	4.10		
School coach	Team	243	3.51	0.85	3.40	3.62	0.001	0.03
	Individual	96	3.84	0.82	3.67	4.00		
Schoolteacher	Team	232	2.84	1.00	2.71	2.97	0.002	0.03
	Individual	93	3.24	1.04	3.02	3.45		
Parents	Team	245	3.95	0.75	3.86	4.05	<0.001	0.05
	Individual	98	4.32	0.62	4.19	4.44		
Health personnel	Team	213	3.38	0.95	3.25	3.51	<0.001	0.06
	Individual	83	3.90	0.97	3.69	4.11		
RC by Type of school								
Club coach	Sports-friendly	240	3.59	0.96	3.47	3.71	0.177	0.01
	Elite school	97	3.75	0.93	3.56	3.94		
School coach	Sports-friendly	243	3.58	0.86	3.47	3.69	0.474	0.00
	Elite school	98	3.65	0.85	3.48	3.82		
Schoolteacher	Sports-friendly	235	2.96	1.02	2.83	3.09	0.999	0.00
	Elite school	92	2.96	1.05	2.74	3.17		
Parents	Sports-friendly	246	4.05	0.71	3.96	4.14	0.918	0.00
	Elite school	99	4.06	0.79	3.90	4.21		
Health personnel	Sports-friendly	211	3.48	0.97	3.35	3.61	0.254	0.00
	Elite school	87	3.62	0.99	3.41	3.83		
RC by Performance level								
Club coach	Top 1–5%	17	3.97	0.73	3.59	4.34	0.149	0.00
	Top 5–25%	156	3.70	1.01	3.54	3.86		
	Top 25–50%	150	3.52	0.92	3.37	3.67		
	<Top 50%	14	3.80	0.74	3.37	4.23		
School coach	Top 1–5%	18	3.82	0.69	3.48	4.17	0.116	0.00
	Top 5–25%	157	3.68	0.88	3.54	3.82		
	Top 25–50%	152	3.48	0.82	3.35	3.61		
	<Top 50%	14	3.69	0.97	3.13	4.25		
Schoolteacher	Top 1–5%	18	3.08	0.93	2.62	3.54	0.248	0.00
	Top 5–25%	149	2.94	1.02	2.77	3.11		
	Top 25–50%	145	2.91	1.05	2.74	3.08		
	<Top 50%	15	3.45	0.89	2.96	3.95		
Parents	Top 1–5%	18	4.30	0.65	3.97	4.62	0.048	0.01
	Top 5–25%	159	4.13	0.70	4.02	4.24		
	Top 25–50%	153	3.94	0.74	3.82	4.05		
	<Top 50%	15	4.06	0.93	3.54	4.57		

Table 8. *Cont.*

RC by Type of Sport								
		N	M	SD	95% CI		*p*	η_p^2
					LB	UB		
Health personnel	Top 1–5%	16	3.79	0.67	3.44	4.15	0.065	0.00
	Top 5–25%	140	3.64	0.98	3.48	3.81		
	Top 25–50%	128	3.35	1.00	3.18	3.53		
	<Top 50%	14	3.55	0.93	3.01	4.08		
RC by Sex								
Club coach	Female	145	3.65	0.93	3.50	3.80	0.808	0.00
	Male	192	3.63	0.98	3.49	3.77		
School coach	Female	145	3.63	0.87	3.48	3.77	0.629	0.00
	Male	196	3.58	0.85	3.46	3.70		
Schoolteacher	Female	136	2.99	1.03	2.82	3.17	0.590	0.00
	Male	191	2.93	1.02	2.79	3.08		
Parents	Female	147	3.96	0.79	3.83	4.09	0.054	0.01
	Male	198	4.12	0.68	4.02	4.21		
Health personnel	Female	132	3.53	1.03	3.35	3.71	0.905	0.00
	Male	166	3.52	0.93	3.37	3.66		
RC by School year								
Club coach	First year	140	3.71	0.94	3.55	3.87	0.367	0.01
	Second year	93	3.64	0.85	3.47	3.82		
	Third year	104	3.53	1.05	3.33	3.74		
School coach	First year	141	3.72	0.82	3.59	3.86	0.064	0.02
	Second year	92	3.47	0.83	3.29	3.64		
	Third year	108	3.56	0.89	3.39	3.73		
Schoolteacher	First year	133	3.06	1.00	2.89	3.23	0.181	0.01
	Second year	90	2.80	0.97	2.60	3.00		
	Third year	104	2.97	1.10	2.76	3.18		
Parents	First year	142	4.20	0.69	4.08	4.31	0.008	0.03
	Second year	95	3.92	0.68	3.78	4.06		
	Third year	108	3.98	0.81	3.82	4.13		
Health personnel	First year	121	3.66	0.97	3.48	3.83	0.120	0.01
	Second year	82	3.38	0.89	3.19	3.58		
	Third year	95	3.47	1.04	3.26	3.68		
	Elite school	87	3.62	0.99	3.41	3.83		

4. Discussion

The purpose of the present investigation was to use a holistic analysis of team dynamics using RCS as a measure to explore perceived RC within and between student athletes, club coaches, and school coaches. A secondary aim was to explore student athletes, club coaches, and school coaches' perceived RC with schoolteachers, parents, and health personnel. In addition, the study aimed to explore differences in student athletes' perceived RC with their coaches and significant others according to the type of sport, school, performance level, sex, and school year. The main finding from this investigation was that the RC level between the surveyed roles (i.e., student athletes, school coaches, and club coaches) was moderate to weak. Furthermore, student athletes, club coaches, and school coaches perceived a moderate to weak RC with parents, schoolteachers, and health personnel. The only strong RC present was student athletes' RC with parents. The results also revealed notable differences in student athletes' RC with the roles (i.e., club coaches, school coaches, schoolteachers, parents, and health personnel) according to their characteristics.

4.1. Perceived RC between the Student Athlete, Club Coach, and School Coach

The results from this investigation indicate that the RC ties between and within the student athletes, school coaches, and club coaches were either moderate or weak (Figure 4). As shown in Table 7, student athletes and school coaches perceive a moderate RC with club coaches. Furthermore, student athletes perceive a moderate RC with school coaches, while club coaches perceive a weak RC with school coaches. Lastly, school and club coaches perceive a moderate RC with student athletes. These results suggest a potential for enhancing team dynamics between and within these roles to meet the minimum optimal RC score (i.e., between RC = >4.0 and within RC = >4.6). It is well known that the relationships between those involved in the student athlete's training are key to their development and sporting success [15–17]. In addition, according to the RC theory, high-quality relationships of shared knowledge, goals, and mutual respect reinforce and are reinforced by frequent, timely, accurate, and problem-solving communication, resulting in effective coordination [43]. Therefore, student athletes, school coaches and club coaches should strive to develop high-quality relationships. However, relationships of low quality undermine effective communication, hindering successful coordination [43], and potentially impairing the student athlete's academic and sporting development. According to Jowett [64], viewing coaching as centred around the coach–student athlete relationship, in which coaches and student athletes are meaningfully connected, can promote mutually empowering inclusivity. Such meaningful partnerships can also function as a tool that motivates, guarantees, pleases, and supports well-being, performance, and experiences [65]. Implementing the correct communication strategies (i.e., support, motivation, and conflict management strategies) can influence the athlete–coach relationship positively, resulting in a higher degree of athlete training satisfaction, individual treatment, and performance [66–69]. Hence, a good starting point for achieving effective team dynamics is to initiate regular informal and formal communications (i.e., meetings) between the roles, educate to enhance competence, and utilize electronic diaries for relevant roles.

4.2. Perceived RC from Student Athletes, School Coaches, and Club Coaches with Parents

As shown in Table 7, student athletes perceive a notably better RC with parents compared to club coaches and school coaches. As illustrated in Figure 4, the RC tie from student athletes to parents was the only strong tie in the present investigation. This finding implies that student athletes perceive high-quality relationships and communication with their parents, which can facilitate effective coordination regarding their total load [43]. It is well-established in the literature that parental involvement and support play a vital role in the youth sports experience and in performance and skill development [70–75]. For example, parents' behaviours can strongly influence a student athlete's motivational characteristics in sports, such as perceived competence, enjoyment, enthusiasm, and intrinsic motivation [76,77]. According to Smoll et al. [78], parents are inextricably involved in the youth sports experience. Hence, they are essential roles at the micro-level and have the potential to impact the quality of the experience for all involved roles. Fostering positive parental involvement and strengthening the relationship between parents and coaches can therefore generate beneficial outcomes. Research has shown that poor communication, mistrust, and a lack of shared goals between parents and coaches compromises student athletes' development [79]. In the present investigation, we do not have data regarding parents' perceived RC with the other roles. This limits our ability to generate a coherent picture of the mutual relationships between the roles, especially the parent–coach relationship. However, several guidelines for communicating and working with parents in youth sports have been proposed [73,78,80,81].

4.3. Perceived RC from Student Athletes, Club Coaches, and School Coaches with Schoolteachers

Figure 4 illustrates that student athletes, club coaches, and school coaches perceive weak RC with schoolteachers. However, although the strength of the relationship was considered weak with all the surveyed roles, Table 7 shows that student athletes and school coaches perceive a notably stronger RC with schoolteachers than with club coaches. A possible explanation for this is that school coaches and schoolteachers work in the same location, perhaps making communication easier. School coaches and schoolteachers must adhere to the curriculum, making it difficult to coordinate all their activities with sports clubs. The interaction between school and club can lead to conflict when both want maximal endeavour from the student athlete [82]. Previous research has suggested that formal and informal communication can be helpful in the coordination of activities between the club, school, and sports association [83]. Hence, when coaches create training plans it is essential to consider information from the schoolteachers, so that during periods with increased schoolwork the training load can be adequately reduced, and vice versa.

Research shows that burnout and drop-out from sports are frequently linked to non-training-related stressors. As such, a holistic analysis approach based on a conscious decision about the acceptable overall load on the student athlete was advised [84]. Strengthening communication and coordination regarding the student athletes' total load, within and between roles at both the micro and macro-level, is necessary to ensure optimal athlete wellbeing and reduce the risk of injury [11,12,21–23]. For instance, one can measure both external and internal load to obtain an overview of the student athletes' training status and training load [85]. Furthermore, to reveal physiological and psychological training-related stress, one can use weekly subjective self-report measures such as the Multicomponent Training Distress Scale [86,87]. In addition, to capture the student athlete's general life stress, one can use the Adolescent Stress Questionnaire monthly [88,89]. These measures have previously been used in combination, when individualised sport-specific training programs were given weekly to student athletes transitioning to a sports academy high school [90].

4.4. Student Athletes, Club Coaches, and School Coaches Perceived RC with Health Personnel

As shown in Table 7, there were no marked differences in perceived RC with health personnel between student athletes, school coaches, and club coaches. Perceived RC with health personnel will likely vary according to the student athlete's health status. It is reasonable to assume that injured student athletes and their respective roles communicate more with health personnel than non-injured student athletes. Previous research has indicated that the quality of communication between the medical team and the coach is associated with injury burden and player availability in elite football [23]. In addition, a previous injury is a leading intrinsic risk factor for sustaining a new injury [91–93]. Hence, and due to the high injury prevalence in student athletes enrolled in elite sports schools [94,95], enhancing the relationship dynamics between health personnel and coaches may facilitate faster and better injury diagnosis, benefit the rehabilitation process, and contribute to more robust student athletes returning to sport post injury [96,97]. Monitoring athletes' training load and implementing strategic recovery periods can not only reduce injury risk, but also maximise performance [20].

4.5. Student Athletes' Perceived RC with the Roles According to Their Characteristics

4.5.1. Type of Sport

As shown in Table 8, student athletes from individual sports perceive markedly higher RC with all roles compared with team student athletes. The effect size was small to moderate. Previous research suggests that it is often more challenging to facilitate relationship dynamics between the federation, club and region in team sports compared with individual sports [18]. It is reasonable to assume that it is easier for student athletes from individual sports to communicate and coordinate factors influencing their total load (e.g., physical training, competitions, schoolwork, and general life stress) compared with team sport athletes. In individual sports, coaches can focus more on managing and optimising load for a single athlete, rather than having a whole team of players to consider. The findings in the present investigation correspond with research from Rhind et al. [69], indicating that student athletes from individual sports report being closer and more committed to their coach. In addition, student athletes in individual sports believed that their coach felt more respect, trust, and appreciation for them compared to team student athletes, likely due to interacting more frequently on a one-to-one basis [69]. The reason why individual student athletes perceived stronger RC with their parents than team student athletes are unknown. Previous research has suggested that student athletes with resourceful parents, in combination with physiological advantages (e.g., puberty stage and growth), manage the increase in training and dual workload better [12], which could explain this finding.

4.5.2. Student Athletes' Performance Level

No notable differences were found in perceived RC with any of the roles between student athletes of different performance levels (Table 8). However, Table 6 indicates that student athletes performing in the top 5% perceive a strong RC with club coaches, while lower performing athletes perceive only a moderate RC with club coaches (Table 6). Furthermore, Table 6 shows that the strength of RC is reduced with lower performance level for both club coaches and school coaches. Findings from Berntsen and Kristiansen [98] indicate an obvious endorsement misfit between student athletes participating in sports "for fun", and their coaches with a "work hard" mentality which undermines the student athletes' need-satisfaction, commitment, performance, and well-being. Successful coaching in the elite sport school context requires coherence between the aims of the coach and the aims of the student athlete [98]. A possible explanation for the findings in the present study could be that student athletes at the highest performance level have shared goals with their coaches, more so than student athletes of lower performance levels. If the student athlete, club coach, and school coach have a shared goal of performing at the highest level it is more likely that they will achieve effective coordination dynamics regarding the student athletes' total load to meet this goal.

4.5.3. The Type of School

We did not find a notable difference in student athletes' perceived RC with the roles according to school type (i.e., private elite sports school or public sports-friendly school). In contrast, a recent study of football players and their coaches found that the close integration of the school and club settings in elite sports schools enables better communication dynamics regarding the overall workload compared to less structured sports-friendly schools [10]. There are several possible explanations for these contradictory findings. First, our results are based on a number of different individual and team sports, and not exclusively football. Second, we used a quantitative method and collected data from both sexes within three school years. Third, the data were collected from a larger sample and in another Norwegian county. Lastly, coach experience and qualifications may have a role to play in how coaches communicate with their student athletes [99]. These factors may influence the student athlete's perceived RC regarding training load and general life stress with the essential roles around them, further highlighting the importance of context.

4.5.4. School Year

We did not find marked differences in perceived RC with club coaches, school coaches, schoolteachers, or health personnel between first-, second-, or third-year student athletes. In light of TDT [26], every team has a start and end point. It would therefore be reasonable to assume that relationships between the roles at the micro-level would become more robust over time due to regular meetings, potentially fostering suitable conditions for better communication and coordination dynamics. Our results indicate that first-year student athletes perceived a stronger RC with parents than second-year student athletes. The effect size was small to moderate. Within the dual-career pathway, and especially in the transitions involved, student athletes might face challenges and stressors in sports (e.g., pressure to train and perform well, and increased training loads) and education (e.g., attending classes, completing assignments, and passing exams) [100]. That the perceived RC is strongest among first-year student athletes is a positive finding, since the challenges they face may be more substantial during transition periods (e.g., transitioning to a sports high school).

5. Conclusions

Perceived RC between student athletes, school coaches, and club coaches was moderate to weak. Furthermore, student athletes, club coaches, and school coaches perceived a moderate to weak RC with parents, schoolteachers, and health personnel. The only strong RC present was student athletes' RC with parents. The results also revealed notable differences in student athletes' RC with the roles according to their characteristics.

The findings presented in this study offer several important practical implications. First, there is a need for the different roles to strengthen their relationships and communication to achieve effective team dynamics regarding student athletes' total load. This can be accomplished through regular informal and formal meetings, education to enhance competence, and by using electronic diaries available for the relevant roles. Educating student athletes and encouraging them to monitor and register their training, lifestyle, competitive performances, and psychological aspects may help in the early identification of an overtrained or stressed state [101].

However, many student athletes might experience self-report measures as an additional burden [85]. Consequently, such measures should be incorporated into theoretical sessions during school hours. Teachers and coaches should highlight the value of such measures by facilitating an understanding of training loads and the implications for attendance, performance, and health [84]. Involving the student athlete when designing training plans can provide a significant developmental and educational opportunity [102]. At the micro-level, the importance of talking to the student athletes should not be undervalued, in order to better understand how individual student athletes are tolerating and responding to the training [85]. In addition, a partnership between student athletes and the roles should be developed at the micro and macro-level to ensure purposeful, accurate and valuable data collection relevant to the individual's sport, while also considering less burdensome data collection methods [85]. The combination of regular conversations and student athlete self-report measures can potentially strengthen the shared knowledge between the student athletes and the involved roles, facilitating a higher degree of team dynamics [43]. Managing data from training diaries and questionnaires is time-consuming and requires extra resources in the school or club. Employing qualified persons responsible for student athlete monitoring who are able to pass on information to relevant roles connected to the student athlete could enhance communication and coordination dynamics within and between the roles at the micro-level. Increased communication and coordination dynamics concerning the student athletes' total load can hopefully improve team outcomes, increase motivation, reduce student athlete drop-out rates, and promote optimal sporting and academic development.

Limitations and Future Research

Although the current study provides a number of valuable insights, some limitations must be acknowledged. First, only student athletes from one Norwegian county were included, limiting generalisability to different cultures and countries. Second, we did not record the duration of the relationships of the included roles, which could have impacted the results. Third, we used a cross-sectional design to measure perceived RC at a given point in time. A longitudinal research design, where relationship quality is measured over time, would provide valuable information. Fourth, only three roles within the student athlete environment were surveyed (student athletes, school coaches, and club coaches). Future research should collect data from all roles involved with the student athlete, giving a more complete picture of the mutual relationships between the roles. That said, roles within the macro-level, such as regional and national clubs and sports associations, could also be included in further research. The study would also have been more informative if it had included interviews with those who had the strongest RC scores. By doing this, it would be possible to identify concrete measures leading to strong perceived RC. In the future, a mixed-method design could yield valuable insights, by first utilising the RCS and subsequently interviewing and observing high-RC environments. In this way one could gain an in-depth understanding of how relationship quality is conceptualised across separate dyadic connections and what different roles believe are the critical elements of their relationships with other groups [103].

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/sports11050104/s1: Table S1: dataset.

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Table 1

The Likert scale in the relational coordination survey

Item	The Likert scale (1 through 5)					
FREQ[1]	Far too little	Too little	Just right	Too much	Far too much	Not relevant
TIME	Never	Rarely	Occasionally	Often	Always	Not relevant
ACCUR	Never	Rarely	Occasionally	Often	Always	Not relevant
PROBL	Never	Rarely	Occasionally	Often	Always	Not relevant
GOAL	Not at all	A little	Somewhat	A lot	Completely	Not relevant
KNOW	Not at all	A little	Somewhat	A lot	Completely	Not relevant
RESP	Not at all	A little	Somewhat	A lot	Completely	Not relevant

Note. FREQ = frequent communication; TIME = timely communication; ACCUR = accurate communication; PROBL = Problem-solving communication; GOAL = Shared goals; KNOW; Shared knowledge; RESP = Mutual respect.

[1]More frequent communication does not indicate higher quality communication. Responses for this question was recoded for analysis such that 1 = "Far too little", 2 = "Far too much", 3 = "Too little", 4 = "Too much", and 5 = "Just right" (Gittell, 2018).

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The effect of progressive and individualised sport-specific training on the prevalence of injury in football and handball student athletes: a randomised controlled trial

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Objective: To evaluate the effectiveness of communication and coordination combined with designing a progressive and individualised sport-specific training program for reducing injury prevalence in youth female and male football and handball players transitioning to a sports academy high school. An additional aim was to investigate the characteristics of the reported injuries.

Methods: Forty-two Norwegian athletes were randomised into an intervention or control group. Mean age, height, weight and BMI was 15.5 ± 0.5 years, 178.6 cm ± 6.3 cm, 71.3 ± 9.8 kg, 22.3 ± 2.7 BMI for the intervention group (IG) ($n = 23$), and 15.4 ± 0.5 years, 175.6 cm ± 6.6 cm, 67.1 ± 9.8 kg, 21.7 ± 2.4 BMI for the control group (CG) ($n = 19$). During the summer holiday, the intervention group received weekly progressive, individualised sport-specific training programs and weekly follow-up telephone calls from the researchers. All athletes completed a baseline questionnaire and a physical test battery. Training data and injuries were recorded prospectively for 22 weeks using the Oslo Sports Trauma Research Center Questionnaire on Health Problems (OSTRC-H2). A two-way chi-square (χ^2) test of independence was conducted to examine the relationship between groups and injury.

Results: Average weekly prevalence of all injuries was 11% (95% CI: 8%–14%) in IG and 19% (95% CI: 13%–26%) in CG. Average weekly prevalence of substantial injuries was 7% (95% CI: 3%–10%) in IG and 10% (95% CI: 6%–13%) in CG. The between-group difference in injuries was significant: χ^2 (1, $N = 375$) = 4.865, $p = .031$, $\phi = .114$, with 1.8 times higher injury risk in CG vs. IG during the first 12 weeks after enrolment.

Conclusions: For student athletes transitioning to a sports academy high school, progressive individualised, sport-specific training programs reduced the prevalence of all-complaint injuries following enrolment. Clubs and schools should prioritise time and resources to implement similar interventions in periods where student athletes have less supervision, such as the summer holidays, to facilitate an optimal transition to a sports academy high school.

KEYWORDS
student athletes, injury prevalence, load management, communication and coordination, progressive overload

1. Introduction

Several injury prevention programs are used in teams sports, such as the FIFA 11+ warm-up programme (1, 2), and Sportsmetrics (3), while other programs target specific injury locations, such as the shoulder (4) and hamstring (5). Injury prevention is complex, and requires consideration of the multiple factors contributing to injury (6). Therefore, practitioners should collaborate in a multimodal injury prevention process (6), and load management through individualised training programs has been suggested as a preventive measure (7).

Following sports academy high school enrolment, elite youth athletes are at high risk of injury (8–10). Rapid increases in training load can increase the risk of injury (11), with almost 60% of non-contact injuries occurring during the transition back into training following a period of inactivity (10). If the applied physical load is substantially higher than the athlete's physical capacity, tissue tolerance will be exceeded and injury can occur (12). Previous research has reported high injury prevalence in youth elite handball and football players (7, 9, 13, 14). Injuries and absence from training and matches can impede individual development (14, 15), and potentially have negative psychological effects (15–17). Furthermore, injuries negatively impact the team and individual athletic success (18). This study therefore aimed to evaluate the effect of a progressive, individualised sport-specific training program with weekly follow-up on injury prevalence in football and handball players transitioning to a sports academy high school. An additional aim was to investigate the characteristics of the reported injuries.

2. Materials and methods

2.1. Study design and recruitment

The study was conducted as a 22-week randomised controlled trial from June to November 2021. Student athletes were recruited from three sports academy high schools in Norway. Student athletes who applied and were accepted to the selected schools in 2021 were eligible for inclusion. Other inclusion criteria were that they played football or handball, were born in 2005, and could perform a physical test battery without pain (i.e., injury free). Eligible participants were randomly allocated to an intervention group (IG) or control group (CG) using a computer-generated, random allocation sequence generated by two of the researchers in this study. Randomisation was stratified by sex, sport, and performance level (i.e., physical fitness, motor performance, sport-specific and skills). The athletes' coaches (school, club and regional) took part in assessing and ranking each participant based on their level of performance prior to randomisation.

The participants and their guardians were informed of the experimental risks and signed an informed consent document prior to the investigation. This study was registered at Norwegian Social Science Data Services (NSD) (Project number: 836079) and approved by the West Norwegian Regional Committees for Medical and Health Research Ethics (REK) (project number: 54584).

2.2. Participants

Out of 84 eligible athletes who applied to the selected schools, 49 agreed to participate. Six participants withdrew, and one participant stopped responding, leaving a total sample of 42 participants (22 females, 20 males). Of these, 64% were on regional and/or national teams, and all competed for sports clubs not affiliated with their sport's high schools. The football players were distributed among five sports clubs, while handball players were distributed among 11 sports clubs. Baseline characteristics were collected in May 2021 using an electronic questionnaire (Survey Xact) (19), including information about the participant's school, type of sport, and training history for the past two weeks. **Figure 1** illustrates the participant flow.

2.3. Procedure and intervention

To improve compliance, all participants, guardians, and coaches were invited to a meeting where information about the study purpose, procedures, and timeline was provided. **Figure 2** illustrates when the meetings, data collection and intervention took place. All participants received information about the physical test battery one week before completion. On the day of testing, the research team demonstrated the different tests and participants got to try the different exercises before registration. During the 8-week transition period (i.e., the summer holiday from mid-june to mid-August), participants in IG and CG received an injury prevention program and were instructed to perform the program three times a week. In addition to the injury prevention program, IG received weekly progressive individualised sport-specific training programs during the 8-week transition period. The CG did not receive a progressive individual sport-specific training and were asked to do their normal training. After the 8-week transition period, all participants did their normal training (i.e., IG did not receive progressive individualised sport-specific training programs and none of the groups were required to complete the injury prevention program).

2.4. The progressive individual sport-specific training programs

Prior to the intervention period (8-week transition), communication in the form of individual meetings were conducted with the athletes' coaches to collect information about individual players' current training load, injury history, club training during the summer and expected training load when starting at the sports academy high school. This information was used to prepare the first weekly training program. Each subsequent weekend, two of the researchers is this study completed phone calls with each of the players in the IG, where information about their week was collected (i.e., how they felt, if they had done all the prescribed training, which changes had been made to the program, how did they tolerate the training program, available training facilities, and their vacation plans). Based on the communication with the student athlete, a new

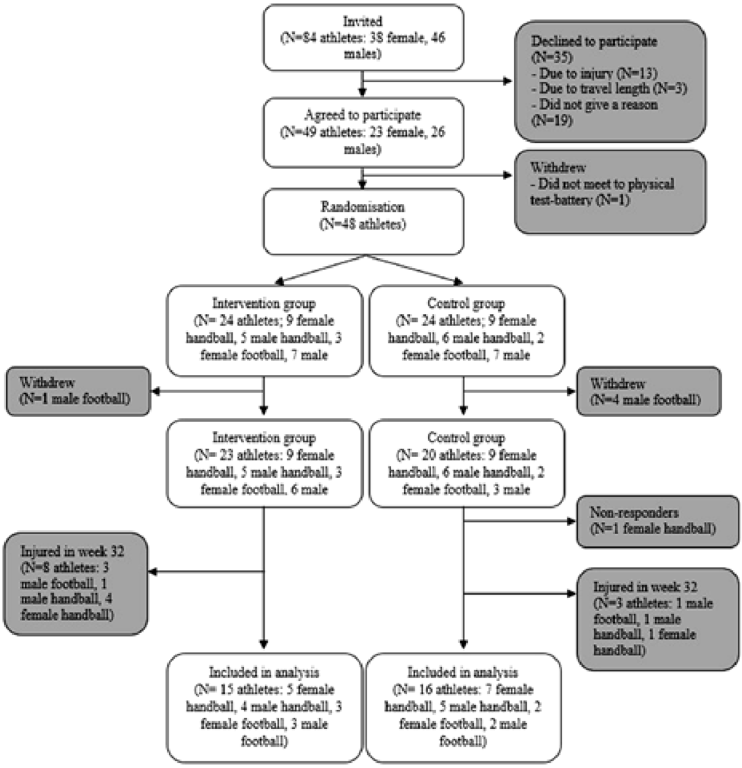

FIGURE 1
Participant flow throughout the study. The final analyses did not include athletes reporting an injury the week prior to enrolment (week 32).

training program with a progressive stimulus for the next week was created and emailed to the athlete, guardians and coaches. Halfway through the intervention (week 4), all the coaches were sent an email requesting feedback and input on the training plans. If coaches, athletes, or guardians had any questions, they could contact two of the researchers via SMS or telephone anytime during the study.

The training plans were developed by an expert in sports science with experience working with Olympic and World champions from various sports (e.g., swimming, handball, track and field, cross-country skiing). The principle of progressive overload was used by increasing the training load gradually when the athlete had adapted to a specific training load or stimuli (20, 230). A form of fluctuating overload was applied (20, 228–229). Using evidence-based practice, the training plans were developed focusing on tissue-specific strength and tissue-specific stress and strain to improve the participant's tolerance for sport-specific training (6, 21). Furthermore, participants had access to a digital platform where the researchers published videos and other resources on how to perform the different exercises in their weekly training plan. An example of a training plan for a handball and football player can be found in the supplementary material (**Supplementary Figure S1**).

The expert developing the training plans adopted a holistic view (e.g., took into account social factors, family obligations, and a need for mental regeneration) when defining individual training variables (e.g., frequency, volume, intensity) and modalities of the exercise intervention (22). Other factors carefully considered during the eight weeks of training prescription were player training background, accumulated training, match exposure, injury history, player's personality and preferences, and off-season length (22). The program was not

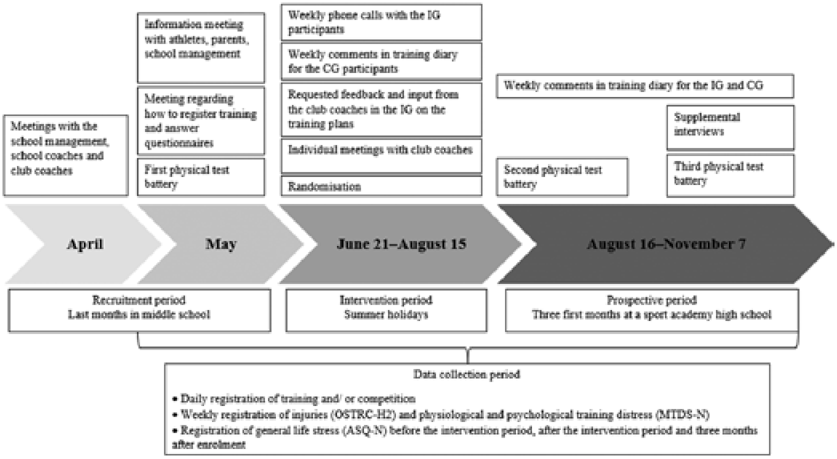

FIGURE 2
Timeline of the study.

always done exactly as prescribed. However, with weekly follow-ups by the researchers, it was possible to make adjustments to ensure progressive overload and appropriate distribution of physical or sport-specific training. We believe that weekly follow-ups ensured high compliance.

2.5. Training diary and injury reporting

All participants recorded their training using an electronic training diary (www.bestr.no, Lørenskog, Norway). They reported training duration for handball or football activities, strength training, endurance, sprint and jump training, stretching, and injury prevention. Rating of perceived exertion (RPE) was also reported in the electronic training diary and was collected using the modified Borg category ratio RPE scale (23). Session RPE (sRPE) was derived by multiplying RPE by session duration (minutes). In addition, the participants reported weekly physiological and psychological training distress in the electronic training diary by using the Norwegian version of the Multicomponent Training Distress Scale (MTDS-N) (24). Three times during the data collection (i.e., before the intervention period, after the intervention period and after three months after enrolment), the participants reported general life stress in the electronic training diary by using the Norwegian version of The Adolescent Stress Questionnaire (ASQ-N) (25). In week 20, one of the researchers conducted individual meetings with participants to review the registered training and ensure that data were being reported correctly. Due to its scope, the data collected from the physical test batteries, MTDS-N and ASQ-N are not included in the results.

The Oslo Sports Trauma Research Centre Questionnaire on Health Problems (OSTRC-H2) was used to record injuries (26). Players received the questionnaire electronically every Friday and were instructed to report health problems for the previous seven days. Participants were instructed to report all complaints, irrespective of their consequences for sports participation. If a participant answered "full participations without any health problems" (first answer option), all further questions were redundant, and a total severity score of 0 was assigned. If a participant answered "could not participate due to a health problem," questions 2–4 were redundant, and a total severity score of 100 was assigned. If a health problem was reported, the athlete was asked to report additional information, such as the type of the problem and its location or main symptoms (27). The location was categorised according to the OSTRC Questionnaire on Health Problems (27). The mode of onset was collected according to the most recent IOC consensus (28). If a player registered alternative two or higher (i.e., moderate to severe reduction or inability to participate) in question 2 (training volume) or 3 (performance), the health problem was registered as substantial. Non-responders received a personal SMS reminder every Monday. At the end of the study, in-person interviews were conducted with each participant to supplement missing data and verify the collected data's accuracy.

2.6. Outcome measures

The primary outcome measure was weekly prevalence of injuries registered after enrolment. An injury was defined as a response above the minimum value on at least one of the four key questions in the OSTRC-H2 (i.e., all complaint definition) (27). Only injuries resulting directly from participation in a competition or from training of fundamental sporting skills were included (28). The secondary outcomes included injury location and mode of onset. Substantial injuries were defined as injuries leading to a moderate or severe reduction in training volume or performance or inability to participate (27).

2.7. Statistical methods

All statistical procedures were performed using IBM SPSS statistics V.27.0. Continuous variables are presented as mean (M) and standard deviation (SD). Ordinal or categorical variables are presented as percentages. Independent sample *t*-tests were performed to investigate differences in baseline characteristics, sRPE and training volume (hours). Injury prevalence was calculated by dividing the number of athletes reporting an injury or a substantial injury by the total number of respondents in each group (29). For all injury prevalence variables, 95% confidence intervals (CI) were calculated. A two-way chi-square (χ^2) test of independence was conducted to examine the relationship between groups and injury. Period (week 11–14; 15–18; 19–22) was used as a stratifying variable. Fisher's exact test was used to reduce the chance of making a Type I error (30, 290), and the statistical significance level was set at $p < 0.05$ for all analyses. The effect size was evaluated using the phi coefficient (ϕ). A value of 0.1, 0.3, and 0.5 indicated small, medium, and large associations between groups, respectively (31). Relative risk (RR) and corresponding 95% CI was also calculated. No data imputations were made for missing data. All analyses were performed according to the intention-to-treat principle. One participant stopped responding during the project and could, for this reason, not be included in the final analysis. In addition, the final analyses did not include athletes reporting an injury the week prior to enrolment.

2.8. Sample size

The sample size was based on the number of observations per group using the sequential Bayes Factor Design Analysis (BFDA) (32–34), calculating the number of observations required to estimate a difference that is 80% true and a nondifference that is 80% true. To avoid underestimating the sample number of observations, we used an effect size of $d = 0.2$ with a small symmetric decision boundary of 6 (i.e., moderate evidence) (35). All calculations were conducted using the BFDA app (33) at http://shinyapps.org/apps/BFDA/. The results of the sequential BFDA indicated that for the difference to be 80% correct using the default Prior on Effect Size, this required ≥235 observations, and ≥120 observations for the none difference to be 80% correct. In this study, the OSTRC-H2 observations were 727 (376 from IG and 351 from CG). A total of 6,864 training session observations were registered (3,981 from IG and 2,883 from CG), and sRPE was registered for 6,565 training sessions (3,836 from IG and 2,729 from CG). Finally, 4,095 exposure hours were recorded (2,406 for IG and 1,689 for CG).

3. Results

Mean age, height, and weight was 15.5 ± 0.5 years, 178.6 cm ± 6.3 cm, 71.3 ± 9.8 kg for IG ($n = 23$), and 15.4 ± 0.5 years, 175.6 cm ± 6.6 cm, 67.1 ± 9.8 kg for CG ($n = 19$) (**Table 1**). A total of 924 OSTRC-H2 questionnaires were sent to the participants for 22 weeks, and 727 were completed, resulting in a response rate of 79%. The response rate in the IG was 74%, while the response rate in the CG was 84%. After completing the supplemental interviews, 100% of the questionnaires were answered. **Table 2** provides a summary of the training conducted during the intervention period.

The athletes' mean training volume and weekly sRPE after enrolment are presented in **Table 3**. There were no significant differences in training volume between IG and CG after enrolment, other than for injury prevention, where IG (all) and IG (football) performed less injury prevention compared to CG (all) and CG

TABLE 1 Baseline characteristics of the intervention and control group ($n = 42$)[1].

	Intervention ($n = 23$)		Control ($n = 19$)	
Age (years)	15.52 ± 0.51		15.37 ± 0.50	
Sex[2] (n)	F (12)	M (11)	F (10)	M (9)
Type of sport[3] (n)	HB (9)	HB (5)	HB (8)	HB (6)
	FB (3)	FB (6)	FB (2)	FB (3)
	F	M	F	M
Height (cm)	174.17 ± 4.04	183.45 ± 4.37	172.40 ± 5.13	179.22 ± 6.46
Weight (kg)	67.30 ± 4.05	75.59 ± 12.34	64.32 ± 8.10	70.21 ± 10.95
CMJ (cm)	29.33 ± 3.19	36.03 ± 5.68	29.80 ± 3.62	39.54 ± 5.86
Sit-ups (reps)	15.08 ± 6.64	20.36 ± 6.67	15.50 ± 5.04	20.89 ± 6.94
30 meter (sec)	4.88 ± .18	4.44 ± .23	4.86 ± .20	4.42 ± .19
Throwing/shooting velocity (km/t)	84.25 ± 8.66	104.09 ± 9.79	79.00 ± 6.04	99.78 ± 8.77
Bleep test (m)	1,495.00 ± 254.29	2,100.00 ± 337.52	1,492.00 ± 204.44	2,142.22 ± 216.44

[1]Data are presented as M ± SD unless otherwise specified.
[2]F, female; M, male.
[3]HB, handball; FB, football.

TABLE 2 Mean training volume (hours) during the intervention period (week 2–9).

	Control group			Intervention group		
Type of training	All (n = 19)	Handball (n = 14)	Football (n = 5)	All (n = 23)	Handball (n = 14)	Football (n = 9)
Total	7.8 ± 2.4	7.9 ± 2.4	7.7 ± 2.9	10.7 ± 1.9*	10.5 ± 2.0*	11.1 ± 1.8*
Specific[1]	2.4 ± 1.3	1.9 ± 0.6	4.1 ± 1.6	3.7 ± 1.7*	2.7 ± 1.1*	5.1 ± 1.4
Physical	3.2 ± 2.2	3.8 ± 2.1	1.2 ± 1.3	4.4 ± 1.0*	4.8 ± 0.7	3.7 ± 0.9*
Injury prevention	0.8 ± 0.4	0.7 ± 0.3	1.2 ± 0.5	1.1 ± 0.3*	1.2 ± 0.3*	1.0 ± 0.3
sRPE[2]	40.7 ± 12.8	42.8 ± 10.5	33.1 ± 18.9	50.6 ± 10.5*	53.6 ± 10.1*	46.0 ± 10.0

[1]Sport-specific training performed individually or with the team. Physical training includes endurance, strength, speed/velocity, and jump training. Total training is the sum of specific, physical, injury prevention, warm-up and other training.
[2]Weekly total session rating of perceived exertion during the intervention period (mean ± SD).
*Statistically significant difference from CG (p < 0.05).

TABLE 3 Mean training volume (hours) during the 12 first weeks at sports academy high school.

		Control group			Intervention group		
Period (week)	Type of training	All (n = 16)	Handball (n = 12)	Football (n = 4)	All (n = 15)	Handball (n = 9)	Football (n = 6)
11–14	Total	12.3 ± 3.3	12.3 ± 3.6	12.1 ± 2.3	11.7 ± 1.8	10.7 ± 1.4	13.1 ± 1.1
	Specific[1]	6.1 ± 1.5	6.3 ± 1.5	5.4 ± 1.3	6.4 ± 2.7	5.4 ± 1.7	7.9 ± 3.4
	Physical	2.4 ± 1.0	2.5 ± 1.2	2.2 ± 0.4	3.2 ± 2.7	3.8 ± 3.3	2.2 ± 0.8
	Injury prevention	0.4 ± 0.4	0.4 ± 0.4	0.1 ± 0.1	0.1 ± 0.1*	0.1 ± 0.1*	0.1 ± 0.1
	sRPE[2]	50.3 ± 16.1	52.4 ± 17.1	41.5 ± 7.2	52.5 ± 9.4	52.9 ± 11.7	51.9 ± 6.1
15–18	Total	11.1 ± 2.5	11.2 ± 2.4	10.9 ± 3.3	12.2 ± 2.5	11.4 ± 1.7	13.3 ± 3.3
	Specific	5.7 ± 1.3	5.6 ± 1.4	6.2 ± 1.1	6.6 ± 2.8	5.3 ± 1.0	8.5 ± 3.7
	Physical	2.5 ± 1.1	2.6 ± 1.2	2.5 ± 1.1	2.9 ± 2.0	3.1 ± 2.4	2.8 ± 1.2
	Injury prevention	0.2 ± 0.2	0.3 ± 0.2	0.0 ± 0.0	0.1 ± 0.1	0.1 ± 0.1*	0.1 ± 0.2
	sRPE	44.8 ± 10.7	47.6 ± 9.9	33.3 ± 3.8	55.1 ± 10.0*	55.3 ± 7.5	54.8 ± 13.7*
19–22	Total	10.5 ± 3.1	10.5 ± 3.1	10.4 ± 3.6	10.9 ± 2.3	10.4 ± 2.6	11.7 ± 1.7
	Specific	4.7 ± 2.1	4.7 ± 2.4	4.6 ± 1.2	5.6 ± 2.5	5.1 ± 1.6	6.4 ± 3.4
	Physical	3.1 ± 1.7	3.2 ± 1.9	2.0 ± 0.6	2.8 ± 1.8	3.3 ± 2.2	2.1 ± 0.8
	Injury prevention	0.3 ± 0.5	0.4 ± 0.6	0.0 ± 0.0	0.1 ± 0.3	0.2 ± 0.4	0.1 ± 0.1
	sRPE	42.8 ± 13.3	44.0 ± 14.5	38.0 ± 6.8	48.8 ± 7.4	48.6 ± 7.9	49.1 ± 7.4

[1]Specific training consists of sport-specific training performed individually or with the team. Physical training includes endurance, strength, speed/velocity, and jump. Total training consists of specific, physical, injury prevention, warm-up and other training (e.g., volleyball at school, tennis during vacation etc).
[2]Weekly total sRPE during the intervention period (mean ± SD).
*Statistically significant difference from CG (p < 0.05).

(football). Further, weekly sRPE in weeks 14–18 was notably higher in IG (all) and IG (football) compared to CG (all) and CG (football).

3.1. Intervention effect on injury prevalence in groups

The average weekly prevalence of all injuries was 11% (95% CI: 8%–14%) in IG and 19% (95% CI: 13%–26%) in CG. The average weekly prevalence of substantial injuries was 7% (95% CI: 3%–10%) in IG and 10% (95% CI: 6%–13%) in CG. The prevalence measures are illustrated in Figure 3. The proportion of athletes reporting an injury after enrolment differed between groups: χ^2 (1, N = 375) = 4.865, p = .031, ϕ = .114, indicating a small effect size. The RR was 1.75 (95% CI: 1.05–2.89). When dividing the 12 weeks into three periods, the proportion of athletes who reported an injury differed by group in weeks 11–14: χ^2 (1, N = 125) = 6.904, p = .012, ϕ = .235 and in weeks 19–22: χ^2 (1, N = 124) = 4.402, p = .042, ϕ = .188. The RR was 3.57 (95% CI: 1.26–10.17) and 2.28 (95% CI: 1.02–5.10), respectively. There were no significant group differences in weeks 15–18. The injury prevalence in groups by sport can be found in the supplementary material (Supplementary Figure S2).

3.2. Characteristics of the reported injuries

After enrolment, 20 injuries were reported by the 15 athletes in the IG (50% were acute, 15% were repetitive with a sudden onset, and 35% were repetitive with a gradual onset). By the 16 athletes in CG, 37 injuries were reported (24% were acute, 43% were repetitive with a sudden onset, and 33% were repetitive with a gradual onset). The location of the injuries is shown in Figure 4. Figure 5 shows the cumulative number of injury incidents each week after enrolment, illustrating the number of athletes with at least one injury.

4. Discussion

The main findings of the present study are that average weekly prevalence of all injuries was 11% (95% CI: 8%–14%)

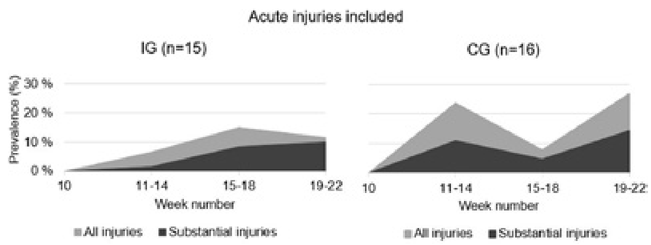

FIGURE 3
Point prevalence proportion of all injuries (light area) and substantial injuries (dark area) in IG and CG 12 weeks after enrolment into a sports academy high school.

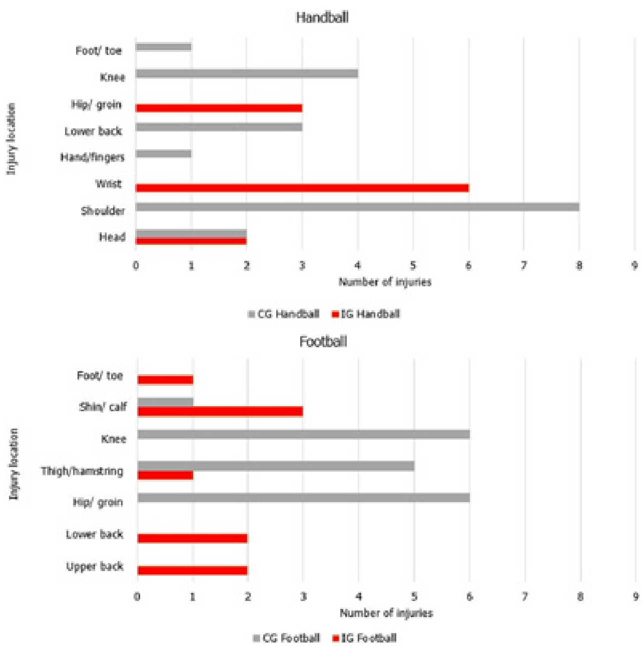

FIGURE 4
Injury location for the reported injuries after enrolment in the intervention group and the control group in handball and football players of both sexes. The same injury could be reported in subsequent weeks by an athlete.

in IG and 19% (95% CI: 13%–26%) in CG. Average weekly prevalence of substantial injuries was 7% (95% CI: 3%–10%) in IG and 10% (95% CI: 6%–13%) in CG. The athletes in CG had a 1.8 times higher risk of injury after enrolment compared to IG.

4.1. Intervention effect on injury prevalence in groups

Injury prevalence was lower in our study compared to previous studies in a comparable sample (7, 9). This could be due to the fact

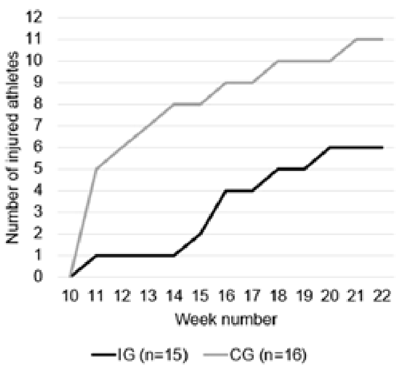

FIGURE 5
Cumulative incidence cases show the number of athletes sustaining an injury weekly in IG and CG after enrolment into sports academy high school.

that the present study included only injuries resulting directly from participation in a competition or training in the sport's fundamental skills over a short period (12 weeks) compared to Bjørndal, et al. (9) and Moseid, et al. (7) who included all injuries over a more extended period (~33 and ~22 weeks, respectively). In addition, both IG and CG in our study completed an injury prevention program three times a week during the summer.

In the current study, IG experienced more acute injuries than CG. A higher proportion of acute injuries correspond with previous findings in youth team athletes (7, 9, 36–38). However, athletes in CG were more prone to repetitive injuries. This is an important finding since acute injuries occur relatively frequently due to the nature of the activities (13). In football and handball, players perform multiple intense movements in different directions (accelerations, decelerations, side-cutting, jumping, and landing) and are involved in tackling situations (39–41), increasing the risk of injury (42, 43). Hence, acute injuries are difficult to prevent with the progressive individualised sport-specific training programs that IG received. We believe that such training programs are primarily preventative against injuries occurring from a gradual accumulation of low-energy transfer over time (e.g., bone stress injury) or from a combination of acute and gradual onset (e.g., repetitive training resulting in tendon weakness, presenting acutely as a tear from acceleration forces applied during a sprint) (28).

After enrolment, CG had 1.8 times higher injury risk compared to IG. When dividing the first 12 weeks into three periods, CG had a 3.5 and 2.3 higher risk of becoming injured in the first and last four weeks after enrolment, respectively. As shown in **Figure 5**, 40% of athletes in IG became injured, whereas ~69% became injured in CG. Injuries were distributed between several different athletes in the groups, particularly in CG. Since alterations resulting from previous injuries may overload other structures not involved in the initial injury (6), sustaining an injury increases the risk of a recurrence of both the original injury as well as subsequent injury of any type (44, 45). However, a gradual, and systematic increase in training load during the summer (**Table 2**) appears to contribute to a safe progression in training load, improving players' tolerance to training towards the end of the summer. This in turn can reduce injury risk and enhance performance (46, 47).

4.2. Characteristics of the reported injuries

In handball athletes, wrist and shoulder/collarbone injuries were the most frequently reported in IG and CG, respectively, with the second most frequently reported injury being the knee for CG (**Figure 4**). The wrist and shoulder/collarbone injuries could be gradual onset injuries caused by the repetitive throwing motion in handball (37). However, 100% of the wrist injuries were categorised as acute. For the shoulder/collarbone injuries, 75% of the injuries were categorised as repetitive with a sudden onset, while 15% were categorised as repetitive with a gradual onset. The OSTRC shoulder injury prevention programme has been shown to reduce the prevalence of shoulder injuries when used during warm-up in elite handball players (4). No shoulder or knee injuries were observed in IG, indicating that the individualised training program involving strength training, throwing with medicine and tennis balls, handball drills, sprints, agility and jump exercises during the summer holiday might be effective in preventing injuries in these locations. **Table 2** indicates that CG lacked sport-specific training during the summer, resulting in greater injury risk when performing technically demanding skills after enrolment.

In football players, the most common injury location was the shin/calf for IG, followed by the lower back and ribs/upper back. In CG, injuries to the hip/groin and knee were the most frequent, followed by the thigh. No knee injuries occurred in IG. The injury locations in CG are comparable with previous research reporting that the thigh, knee, ankle, and hip/groin are the most frequently injured locations in youth elite football players (38, 48–51). After enrolment, no knee injuries occurred in IG. The injury pattern in IG differs from other studies in these age groups (14). A possible explanation is the low number of athletes and injuries in the current study. Previous research has shown that including the Nordic Hamstrings exercise in injury prevention programmes reduces the risk of hamstring injuries (5). In addition, the Copenhagen Adductor exercise might function to prevent groin injuries (52, 53). A combination of these exercises does also seem to be beneficial (54, 55). However, disregarding the effectiveness of separate exercises or combinations of exercises, we believe a comprehensive and holistic training program including specific football exercises, strength training, sprints, agility, and jump exercises might prevent common injuries in football, suggesting that specificity is a vital training principle to prevent injuries. Still, we acknowledge that training load is only one of many contextual factors that must be considered when managing athlete injury and readiness to perform (47, 56).

4.3. Methodological considerations and limitations

To our knowledge, this is the first study investigating this population in this particular transition period in a Scandinavian context. A strength of this study is the high compliance with the training programs and the high response rates for training data and the OSTRC-H2. To minimise the survey burden, we followed the 2020 update of the OSTRC-H2 (28), where the survey ends if the player reports "full participation without health problems" for the first question. However, the OSTRC-H2 is not a validated approach for adolescent population (26), and must be considered as a limitation in the current study. The age group and study context should be considered when adapting and applying the OSTRC-H2 to adolescents (57). In addition, athlete-self reported data may have resulted in inaccurate reporting.

Another limitation of the study is the low participation rate. Out of 84 eligible athletes, only 49 agreed to participate (58% of eligible players) and only 42 completed the study (50% of 84 eligible players), which reduced effective sample size, statistical power and increased the risk for selection bias (58). Due to the small sample size, we used the sequential BFDA (32–34). The sample was also obtained using a convenience sampling method, limiting generalisability. The intention-to-treat principle could introduce selection bias due to the participants not being included in the final analysis. Lastly, we did not account for previous injuries in the randomisation. The objective of randomisation is to have balanced groups (59), but with the small sample size in the current study, it might be a chance that the proportion of athletes with previous injuries could differ due to random bias, which could have significant effects on the results.

4.4. Practical implications

As a coach, it can be challenging to individualise training for a team athlete, particularly during longer breaks from organised club training. Close supervision and individualised training programs during the summer holidays should not be an additional task left solely to the coach, but should be prioritised by the club and school, and given extra resources. Implementing this type of intervention also requires close communication, not only with the athletes themselves but also with other key persons such as guardians, coaches, the school, and potentially a medical support system. An effective injury prevention strategy can increase sports participation and performance development and should therefore be prioritised.

5. Conclusion

The results indicated a reduction in the prevalence of injuries in IG compared to CG. Managing training load with a holistic perspective and ensuring a progressive overload in athletes during the summer holidays appears to be an effective intervention to prevent injuries after enrolment in football and handball athletes of both sexes. The results of this study can increase awareness of the importance of implementing measures in periods where the club and school have reduced organised activities for the athletes. Someone must take responsibility for making plans and following up on the athlete when they are not part of organised training activity, such as during the summer holidays. Future studies should include larger sample size and possible confounders like sleep, nutrition and hydration.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by Norwegian Social Science Data Services (NSD) and West Norwegian Regional Committees for Medical and Health Research Ethics (REK). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

CH, ET, JH and SS: planned the study. The data collection was done by CH, ET and SS. Randomisation was done by CH and SS. ET and CH: completed the intervention. CH: performed individual meetings in week 20. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fspor.2023.1106404/full#supplementary-material

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Training plan for (name) week 3 – Handball

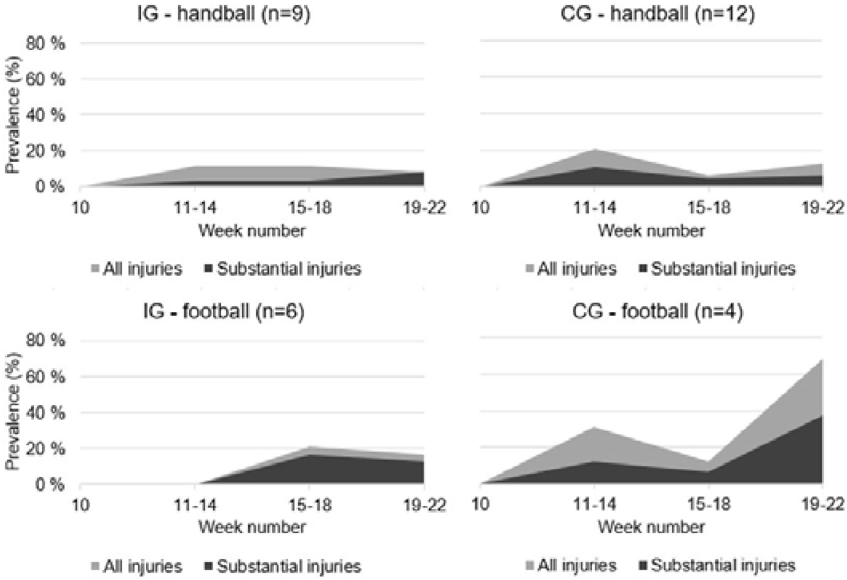
Hours: 10:00 | Sessions: 9 | Load: High | Ball sessions: 2 | Speed/jump: 1+1 | Strength: 3 | Endurance: 1+1 | Injury prevention: 3		
	Session 1	Session 2
Monday (2:30h)	Injury prevention – program 1 (30min) Endurance 1 – Intervals – 45min 5x3min, R=1:30min + 10x30sec, R=15sec	Strength (Whole body) – 1:15h
Tuesday (0:00h)	REST DAY – travel home from vacation	REST DAY
Wednesday (2:15h)	Injury prevention – program 1 (30min) Jump and sprint program (45min)	60min specific training – handball: create your handball session focusing on skills you should practice. Get inspiration from sessions in the TEAMS-group! Feel free to train with a friend.
Thursday (1:15h)	Strength (Upper body) – 1:15h	REST
Friday (2:15h)	Injury prevention – program 1 (30min) Jump and sprint program – 45min	60min specific training – handball: create your handball session focusing on skills you should practice. Get inspiration from sessions in the TEAMS-group! Feel free to train with a friend.
Saturday (1:15h)	Strength (Lower body) – 1:15h	REST
Sunday (0:45h)	30min jog on a soft surface 15min of core training	REST

Training plan for (name) week 8 – Football

Hours: 12:45 | Sessions: 9 | Load: Moderate | Ball sessions: 5 | Speed/jump: 1+1 | Strength: 3 | Endurance: 0 | Injury prevention: 3		
	Session 1	Session 2
Monday (3:00t)	Injury prevention – program 1 or 2 (30min) Strength (Upper body) – 1:00	Club training (1:30t) – Low intensity
Tuesday (1:30h)	Football match (1:30h) – High intensity	REST
Wednesday (1:30t)	Injury prevention – program 1 or 2 (30min) Strength (Lower body) – 1:00	REST
Thursday (1:30t)	REST	Club training (1:30t) – High intensity
Friday (2:45t)	Club training (1:30h) – Low intensity	Strength (Whole body) – 1:15
Saturday (0:00t)	REST DAY	REST DAY
Sunday (2:30t)	Injury prevention – program 1 or 2 (30min) Sprint program – 60min	60min specific training – football: Play 2 vs 2 or 3 vs 3 with friends or create an individual session focusing on skills you should practice (i.e., passing, shooting, dribbling, feinting). Get inspiration from example sessions in the TEAMS-group!

Daily load:	REST	Low load	Moderate load	High load

Supplementary Figure 1. An example of a sport-specific training plan for a handball and football athlete.



Supplementary Figure 2. Point prevalence proportion of all injuries (light area) and substantial injuries (dark area) in IG (handball and football) and CG (handball and football) 12 weeks after enrolment into a sports academy high school.

Appendices

Appendix 1 – Copyright Figure 2

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Appendix 5 – Copyright Figure 6

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Revisiting Relational Coordination: A Systematic Review

Author: Rendelle Bolton, Caroline Logan, Jody Hoffer Gittell

Publication:
The Journal of Applied Behavioral Science: A Publication of the NTL Institute

Publisher: SAGE Publications

Date: 2021-09-01

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BACK CLOSE WINDOW

Appendix 6 – NSD Study *I* and *II*

Meldeskjema / Treningsbelastning og livsbelastning hos unge utøvere som er tilknytt... / Vurdering

Vurdering

Referansenummer	Type	Dato
836079	Standard	27.11.2019

Prosjekttittel
Treningsbelastning og livsbelastning hos unge utøvere som er tilknyttet toppidrett i Rogaland

Behandlingsansvarlig institusjon
Universitetet i Stavanger / Fakultet for utdanningsvitenskap og humaniora / Institutt for grunnskolelærerutdanning, idrett og spesialpedagogikk

Prosjektansvarlig
Cathrine Nyhus Hagum

Prosjektperiode
01.11.2019 - 31.12.2025

Kategorier personopplysninger
Alminnelige
Særlige

Rettslig grunnlag
Samtykke (Personvernforordningen art. 6 nr. 1 bokstav a)
Uttrykkelig samtykke (Personvernforordningen art. 9 nr. 2 bokstav a)

Behandlingen av personopplysningene kan starte så fremt den gjennomføres som oppgitt i meldeskjemaet. Det rettslige grunnlaget gjelder til 31.12.2030.

Meldeskjema

Kommentar
Det er vår vurdering at behandlingen vil være i samsvar med personvernlovgivningen, så fremt den gjennomføres i tråd med det som er dokumentert i meldeskjemaet den 27.11.2019 med vedlegg, samt i meldingsdialogen mellom innmelder og NSD. Behandlingen kan starte.

MELD VESENTLIGE ENDRINGER
Dersom det skjer vesentlige endringer i behandlingen av personopplysninger, kan det være nødvendig å melde dette til NSD ved å oppdatere meldeskjemaet. Før du melder inn en endring, oppfordrer vi deg til å lese om hvilke type endringer det er nødvendig å melde:

https://nsd.no/personvernombud/meld_prosjekt/meld_endringer.html

Du må vente på svar fra NSD før endringen gjennomføres.

TYPE OPPLYSNINGER OG VARIGHET
Prosjektet vil behandle særlige kategorier av personopplysninger om helse (gjelder utvalg 1 og 2), samt alminnelige personopplysninger frem til 31.12.2025. Data med personopplysninger oppbevares internt ved behandlingsansvarlig institusjon for mulige oppfølgingsstudier frem til 31.12.2030.

LOVLIG GRUNNLAG
Prosjektet vil innhente samtykke fra de registrerte til behandlingen av personopplysninger. Vår vurdering er at prosjektet legger opp til et samtykke i samsvar med kravene i art. 4 nr. 11 og art. 7, ved at det er en frivillig, spesifikk, informert og utvetydig bekreftelse, som kan dokumenteres, og som den registrerte kan trekke tilbake.

Utvalg 1 og 2: Lovlig grunnlag for behandlingen vil være den registrertes uttrykkelige samtykke, jf. personvernforordningen art. 6 nr. 1 a), jf. art. 9 nr. 2 bokstav a, jf. personopplysningsloven § 10, jf. § 9 (2).

Utvalg 3: Lovlig grunnlag for behandlingen vil være den registrertes samtykke, jf. personvernforordningen art. 6 nr. 1 bokstav a.

PERSONVERNPRINSIPPER
NSD vurderer at den planlagte behandlingen av personopplysninger vil følge prinsippene i personvernforordningen om:

- lovlighet, rettferdighet og åpenhet (art. 5.1 a), ved at de registrerte får tilfredsstillende informasjon om og samtykker til behandlingen
- formålsbegrensning (art. 5.1 b), ved at personopplysninger samles inn for spesifikke, uttrykkelig angitte og berettigede formål, og ikke viderebehandles til nye uforenlige formål
- dataminimering (art. 5.1 c), ved at det kun behandles opplysninger som er adekvate, relevante og nødvendige for formålet med prosjektet
- lagringsbegrensning (art. 5.1 e), ved at personopplysningene ikke lagres lengre enn nødvendig for å oppfylle formålet

DE REGISTRERTES RETTIGHETER
Så lenge de registrerte kan identifiseres i datamaterialet vil de ha følgende rettigheter: åpenhet (art. 12), informasjon (art. 13), innsyn (art. 15), retting (art. 16), sletting (art. 17), begrensning (art. 18), underretning (art. 19), dataportabilitet (art. 20).

NSD vurderer at informasjonen som de registrerte vil motta oppfyller lovens krav til form og innhold, jf. art. 12.1 og art. 13.

Vi minner om at hvis en registrert tar kontakt om sine rettigheter, har behandlingsansvarlig institusjon plikt til å svare innen en måned.

FØLG DIN INSTITUSJONS RETNINGSLINJER
NSD legger til grunn at behandlingen oppfyller kravene i personvernforordningen om riktighet (art. 5.1 d), integritet og konfidensialitet (art. 5.1. f) og sikkerhet (art. 32).

SurveyXact er databehandler i prosjektet. NSD legger til grunn at behandlingen oppfyller kravene til bruk av databehandler, jf. art 28 og 29.

For å forsikre dere om at kravene oppfylles, må dere følge interne retningslinjer og eventuelt rådføre dere med behandlingsansvarlig institusjon.

OPPFØLGING AV PROSJEKTET
NSD vil følge opp underveis (hvert annet år) og ved planlagt avslutning for å avklare om behandlingen av personopplysningene er avsluttet/pågår i tråd med den behandlingen som er dokumentert.

Lykke til med prosjektet!

Kontaktperson hos NSD: Karin Lillevold
Tlf. Personverntjenester: 55 58 21 17 (tast 1)

Meldeskjema / Treningsbelastning og livsbelastning hos unge utøvere som et tilknytt... / Vurdering

Vurdering

Referansenummer	Type	Dato
429894	Standard	31.01.2020

Prosjekttittel
Treningsbelastning og livsbelastning hos unge utøvere som et tilknyttet toppidrett i Rogaland - DEL 2

Behandlingsansvarlig institusjon
Universitetet i Stavanger / Fakultet for utdanningsvitenskap og humaniora / Institutt for grunnskolelærerutdanning, idrett og spesialpedagogikk

Prosjektansvarlig
Cathrine Nyhus Hagum

Prosjektperiode
01.02.2020 - 31.12.2025

Kategorier personopplysninger
Alminnelige
Særlige

Rettslig grunnlag
Samtykke (Personvernforordningen art. 6 nr. 1 bokstav a)
Uttrykkelig samtykke (Personvernforordningen art. 9 nr. 2 bokstav a)

Behandlingen av personopplysningene kan starte så fremt den gjennomføres som oppgitt i meldeskjemaet. Det rettslige grunnlaget gjelder til 31.12.2030.

Meldeskjema

Kommentar
BAKGRUNN
Prosjektet er vurdert og godkjent av REK etter helseforskningsloven (hfl.) § 10 (REK sin ref: 54584).

Det er NSD sin vurdering at behandlingen også vil være i samsvar med personvernlovgivningen, så fremt den gjennomføres i tråd med det som er dokumentert i meldeskjemaet datert 31.01.2020 med vedlegg, samt i meldingsdialogen mellom innmelder og NSD. Behandlingen kan starte.

MELD VESENTLIGE ENDRINGER
Dersom det skjer vesentlige endringer i behandlingen av personopplysninger, kan det være nødvendig å melde dette til NSD ved å oppdatere meldeskjemaet. Før du melder inn en endring, oppfordrer vi deg til å lese om hvilke type endringer det er nødvendig å melde: https://nsd.no/personvernombud/meld_prosjekt/meld_endringer.html
Du må vente på svar fra NSD før endringen gjennomføres.

TYPE OPPLYSNINGER OG VARIGHET
Prosjektet vil behandle særlige kategorier av personopplysninger om helseforhold og alminnelige kategorier av personopplysninger. Prosjektslutt er 31.12.2025. Deretter skal opplysningene oppbevares frem til 31.12.2030 av dokumentasjonshensyn.

LOVLIG GRUNNLAG
Prosjektet vil innhente samtykke fra de registrerte til behandlingen av personopplysninger. Vår vurdering er at prosjektet legger opp til et samtykke i samsvar med kravene i art. 4 nr. 11 og art. 7, ved at det er en frivillig, spesifikk, informert og utvetydig bekreftelse, som kan dokumenteres, og som den registrerte kan trekke tilbake.

Lovlig grunnlag for behandlingen vil dermed være den registrertes uttrykkelige samtykke, jf. personvernforordningen art. 6 nr. 1 bokstav a, jf. art. 9 nr. 2 bokstav a, jf. personopplysningsloven § 10, jf. § 9 (2).

PERSONVERNPRINSIPPER
NSD vurderer at den planlagte behandlingen av personopplysninger vil følge prinsippene i personvernforordningen om:

- lovlighet, rettferdighet og åpenhet (art. 5.1 a), ved at de registrerte får tilfredsstillende informasjon om og samtykker til behandlingen
- formålsbegrensning (art. 5.1 b), ved at personopplysninger samles inn for spesifikke, uttrykkelig angitte og berettigede formål, og ikke viderebehandles til nye uforenlige formål

viderebehandles til nye uforenlige formål

- dataminimering (art. 5.1 c), ved at det kun behandles opplysninger som er adekvate, relevante og nødvendige for formålet med prosjektet
- lagringsbegrensning (art. 5.1 e), ved at personopplysningene ikke lagres lengre enn nødvendig for å oppfylle formålet

DE REGISTRERTES RETTIGHETER
Så lenge de registrerte kan identifiseres i datamaterialet vil de ha følgende rettigheter: åpenhet (art. 12), informasjon (art. 13), innsyn (art. 15), retting (art. 16), sletting (art. 17), begrensning (art. 18), underretning (art. 19), dataportabilitet (art. 20).

I utgangspunktet har alle som registreres i forskningsprosjektet rett til å få slettet opplysninger som er registrert om dem. Etter helseforskningsloven § 16 tredje ledd vil imidlertid adgangen til å kreve sletting av sine helseopplysninger ikke gjelde dersom materialet eller opplysningene er anonymisert, dersom materialet etter bearbeidelse inngår i et annet biologisk produkt, eller dersom opplysningene allerede er inngått i utførte analyser. Regelen henviser til at sletting i slike situasjoner vil være svært vanskelig og/eller ødeleggende for forskningen, og dermed forhindre at formålet med forskningen oppnås.

Etter personvernforordningen art. 17 nr. 3 d kan man unnta fra retten til sletting dersom behandlingen er nødvendig for formål knyttet til vitenskapelig eller historisk forskning eller for statistiske formål i samsvar med artikkel 89 nr. 1 i den grad sletting sannsynligvis vil gjøre det umulig eller i alvorlig grad vil hindre at målene med nevnte behandling nås.

NSD vurderer dermed at det kan gjøres unntak fra retten til sletting av helseopplysninger etter helseforskningslovens § 16 tredje ledd og personvernforordningen art. 17 nr. 3 d, når materialet er bearbeidet slik at det inngår i et annet biologisk produkt, eller dersom opplysningene allerede er inngått i utførte analyser.

Vi presiserer at helseopplysninger inngår i utførte analyser dersom de er sammenstilt eller koblet med andre opplysninger eller prøvesvar. Vi gjør oppmerksom på at øvrige opplysninger må slettes og det kan ikke innhentes ytterligere opplysninger fra deltakeren.

NSD vurderer at informasjonen som de registrerte vil motta oppfyller lovens krav til form og innhold, jf. art. 12.1 og art. 13.

Vi minner om at hvis en registrert tar kontakt om sine rettigheter, har behandlingsansvarlig institusjon plikt til å svare innen en måned.

FØLG DIN INSTITUSJONS RETNINGSLINJER
NSD legger til grunn at behandlingen oppfyller kravene i personvernforordningen om riktighet (art. 5.1 d), integritet og konfidensialitet (art. 5.1. f) og sikkerhet (art. 32).

SurveyXact er databehandler i prosjektet. NSD legger til grunn at behandlingen oppfyller kravene til bruk av databehandler, jf. art 28 og 29.

For å forsikre dere om at kravene oppfylles, må dere følge interne retningslinjer og eventuelt rådføre dere med behandlingsansvarlig institusjon.

OPPFØLGING AV PROSJEKTET
NSD vil følge opp underveis (hvert annet år) og ved planlagt avslutning for å avklare om behandlingen av personopplysningene er avsluttet/pågår i tråd med den behandlingen som er dokumentert.

Lykke til med prosjektet!

Kontaktperson hos NSD: Lise A. Haveraaen
Tlf. Personverntjenester: 55 58 21 17 (tast 1)

Appendix 8 – REK Study III

REK
REGIONALE KOMITEER FOR MEDISINSK OG HELSEFAGLIG FORSKNINGSETIKK

Region:	Saksbehandler:	Telefon:	Vår dato:	Vår referanse:
REK vest	Camilla Gjerstad		10.01.2020	54584
			Deres referanse:	

Shaher A. I. Shalfawi

54584 Fysisk- og psykisk treningsbelastning og livsbelastning hos unge utøvere tilknyttet programfaget toppidrett i videregående skole

Forskningsansvarlig: Universitetet i Stavanger

Søker: Shaher A. I. Shalfawi

Søkers beskrivelse av formål:

Hensikten med prosjektet er å undersøke forholdet mellom unge utøveres fysiske- og psykiske treningsbelastning, livsbelastning, prestasjonsutvikling, skoleprestasjoner og forekomsten av sykdom og skade på programfaget toppidrett i videregående skoler. Dyptgående og nyansert informasjon skal kunne bidra til at programfaget kan få en enda større effekt på utøvernes prestasjonsutvikling, skoleprestasjoner og livskvalitet.

Prosjektet er en prospektiv kohortstudie i overgangen fra ungdomsskolen til videregående skole. Det antas at dette er en utfordrende periode med hensyn til total belastning. Datamaterialet samles inn med standardiserte spørreskjema, fysiske prestasjonstester og en nettbasert treningsdagbok. I oppstarten av prosjektet samles bakgrunnsdata fra et spørreskjema.

Fire grupper sammenliknes; en gruppe er med i tiltaket "sterk og skadefri", en gruppe er fra Wang Ung idrettsungdomsskole, en gruppe kommer fra vanlig ungdomsskole til toppidrett og en gruppe er kontroll.

REKs vurdering

REK vest ba om tilbakemelding på følgende:

- Ny prosjektleder og CV må meldes til REK vest.

- Reviderte informasjonsskriv må sendes til REK vest.
- Det må forklares hva kontrollgruppen skal gjennomføre av tester/rapportering. Skal de gjennomføre det samme som utvalgsgruppen? REK vest ber om tilbakemelding.
- Kontrollgruppen må få et eget informasjonsskriv. Dette skrivet må sendes til REK vest.

Tilbakemelding
1. Prosjektleder vil være førsteamanuensis Shaher Shalfawi, Universitetet i Stavanger
2. - Alle informasjonsskrivene er reviderte.
3. Kontrollgruppe 1 - elever som driver med toppidrett, men som ikke har valgt programfaget toppidrett i videregående skole skal gjennomføre det samme som utvalgsgruppen:
- Ukentlig rapportering av sykdom og skade (OSTRQ)
- Fysisk treningsbelastning (nettbasert treningsdagbok)
- Livsbelastning (ASQ)
- Psykisk treningsbelastning (MTDS)
- Gjennomføring av to fysiske tester (MFT og SJ)
- Skoleprestasjoner
Kontrollgruppe 2 - elever som ikke driver med idrett skal gjennomføre følgende rapportering:
- Ukentlig rapportering av sykdom og skade (OSTRQ)
- Livsbelastning (ASQ)
- Psykisk treningsbelastning (MTDS) (vil formuleres til psykisk belastning)
- Kontrollgruppe 2 skal ikke gjennomføre fysiske tester
- Skoleprestasjoner
4. Det er utarbeidet et eget informasjonsskriv til hver av kontrollgruppene som er vedlagt.

Vurdering av tilbakemeldingen
REK vest ved komitéleder har vurdert tilbakemeldingen og godkjenner prosjeket.

Vi ber om at introduksjonen i informasjonsskrivene endres slik at formålet med studien presiseres bedre, f.eks.: "*Formålet med dette prosjektet er å kartlegge den totale treningsbelastningen hos unge utøvere som er tilknyttet programfaget toppidrett i videregående skoler i Rogaland fylke, og sammenlikne disse med ungdom som ikke driver toppidrett og elever som driver toppidrett, men som ikke er tilknyttet programfaget tooppidrett.*"

I skrivet til kontrollgruppe 1 må det i tillegg stå: "*Dette er et spørsmål til deg som elev på studiespesialiserende som ikke er tilknyttet programfaget toppidrett, men som driver med toppidrett. Vi ønsker å spørre om du ønsker å delta i et forskningsprosjekt som skal kartlegge unge utøveres treningsbelastning og livsbelastning på programfaget toppidrett.*"

Reviderte skriv sendes til REK vest.

Vedtak

Alle skriftlige henvendelser om saken må sendes via REK-portalen
Du finner informasjon om REK på våre hjemmesider rekportalen.no

Godkjent med vilkår

Vilkår
Informasjonsskrivene må revideres.

REK vest har gjort en helhetlig forskningsetisk vurdering av alle prosjektets sider. Prosjektet godkjennes på betingelse av ovennevte vilkår, med hjemmel i helseforskningsloven § 10.

Med vennlig hilsen

Marit Grønning
Professor dr.med.
komiteleder REK vest

Camilla Gjerstad
rådgiver

Sluttmelding
Søker skal sende sluttmelding til REK vest på eget skjema senest seks måneder etter godkjenningsperioden er utløpt, jf. hfl. § 12.

Søknad om å foreta vesentlige endringer
Dersom man ønsker å foreta vesentlige endringer i forhold til formål, metode, tidsløp eller organisering, skal søknad sendes til den regionale komiteen for medisinsk og helsefaglig forskningsetikk som har gitt forhåndsgodkjenning. Søknaden skal beskrive hvilke endringer som ønskes foretatt og begrunnelsen for disse, jf. hfl. § 11.

Klageadgang
Du kan klage på komiteens vedtak, jf. forvaltningsloven § 28 flg. Klagen sendes til REK vest. Klagefristen er tre uker fra du mottar dette brevet. Dersom vedtaket opprettholdes av REK vest, sendes klagen videre til Den nasjonale forskningsetiske komité for medisin og helsefag (NEM) for endelig vurdering.

Appendix 9 – Informed consent Study I

Vil du delta i studien *«Treningsbelastning og livsbelastning hos unge utøvere på programfaget toppidrett»?*

Dette er et spørsmål til deg om å delta i en studie hvor formålet er å kartlegge psykisk treningsbelastning hos unge utøvere på toppidrett i videregående skole. I dette skrivet gir vi deg informasjon om målene for prosjektet og hva deltakelse vil innebære for deg.

Formål
Hensikten med studien er å undersøke om den norske versjonen av spørreskjemaet «Multicomponent Training Distress Scale» (MTDS) kan benyttes for å beskrive psykisk treningsbelastning hos unge utøvere. Et ytterligere formål er å beskrive opplevd psykisk treningsbelastning hos unge utøvere tilknyttet toppidrett i videregående skoler i Norge. Forskningsspørsmålene som skal besvares er:

1. Er den norske versjonen av MTDS et valid mål for å avdekke psykisk treningsbelastning hos unge utøvere tilknyttet toppidrett i Norge?
2. Hvordan oppleves psykisk treningsbelastning hos unge utøvere på programfaget toppidrett? Er det ulikheter mellom kjønn, alder, idrett og fylke?

Denne studien er en del av et større doktorgradsprosjekt. Hovedformålet med doktorgradsprosjektet er å utvikle mer dyptgående og nyansert kunnskap vedrørende unge utøveres tilknytning til programfaget toppidrett i videregående skoler. Et ytterligere mål er å innhente informasjon som skal kunne bidra til at programfaget skal få en enda større effekt på utøveres prestasjonsutvikling, skoleprestasjoner og livskvalitet.

Hvem er ansvarlig for forskningsprosjektet?
Universitetet i Stavanger er ansvarlig for prosjektet.

Hvorfor får du spørsmål om å delta?
Alle utøvere som er tilknyttet programfaget toppidrett i videregående skoler i Norge får henvendelse om å delta i prosjektet.

Dine kontaktopplysninger er mottatt av skolens ledelse på bakgrunn av at de har gitt aksept for prosjektet.

Hva innebærer det for deg å delta?
Hvis du velger å delta i prosjektet, innebærer det at du fyller ut et spørreskjema som består av 22 spørsmål. Dette vil ta deg omtrent 4-5 minutter. Spørreskjemaet inneholder spørsmål knyttet til energi, tretthet, stress, fysiske symptomer, søvnforstyrrelser og depresjon. Dine svar fra spørreskjemaet blir registrert elektronisk.

Det er frivillig å delta
Det er frivillig å delta i studien. Hvis du velger å delta, kan du når som helst trekke samtykke tilbake uten å oppgi noen grunn. Alle opplysninger om deg vil da bli anonymisert. Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller senere velger å trekke deg.

Ditt personvern – hvordan vi oppbevarer og bruker dine opplysninger
Vi vil bare bruke opplysningene om deg til formålene vi har fortalt om i dette skrivet. Vi behandler opplysningene konfidensielt og i samsvar med personvernregelverket. Det er kun personer tilknyttet doktorgradsprosjektet og som har signert taushetserklæring som har tilgang til opplysningene fra studien.

For å sikre at ingen uvedkommende får tilgang til personopplysningene vil datamaterialet lagres gjennom Universitetet i Stavanger sitt IKT-system. IT-utstyret skal være passord-beskyttet. Avidentifiserte data som skal oppbevares på bærbar enheter skal være kryptert og enheten skal være sikret med passord. Navnet og kontaktopplysningene dine vil erstattes med en kode som lagres på egen navneliste adskilt fra øvrige data. Opplysningene om deg skal ikke overføres til land utenfor EØS.

Du vil ikke kunne gjenkjennes i publikasjoner i forbindelse med doktorgradsprosjektet.

Hva skjer med opplysningene dine når vi avslutter forskningsprosjektet?
Prosjektet skal etter planen avsluttes i desember 2025. Opplysningene om deg vil bli anonymisert eller slettet fem år etter prosjektslutt. Formålet med videre oppbevaring etter prosjektslutt er mulige oppfølgingsstudier.

Dine rettigheter
Så lenge du kan identifiseres i datamaterialet, har du rett til:
- innsyn i hvilke personopplysninger som er registrert om deg,
- å få rettet personopplysninger om deg,
- få slettet personopplysninger om deg,
- få utlevert en kopi av dine personopplysninger (dataportabilitet), og
- å sende klage til personvernombudet eller Datatilsynet om behandlingen av dine personopplysninger.

Hva gir oss rett til å behandle personopplysninger om deg?
Vi behandler opplysninger om deg basert på ditt samtykke.
På oppdrag fra Universitetet i Stavanger har NSD – Norsk senter for forskningsdata AS vurdert at behandlingen av personopplysninger i dette prosjektet er i samsvar med personvernregelverket.

Hvor kan jeg finne ut mer?
Hvis du har spørsmål til studien, eller ønsker å benytte deg av dine rettigheter, ta kontakt med:

- Universitetet i Stavanger ved Cathrine Nyhus Hagum (prosjektansvarlig), på telefon: 94 15 01 90 eller e-post: cathrine.n.hagum@uis.no.
- Universitet i Stavanger ved Hovedveileder for doktorgradsprosjekter er Shaher Shalfawi (hovedveileder), på telefon: 51 83 34 88 eller e-post shaher.shalfawi@uis.no.
- Vårt personvernombud: Kjetil Dalseth, på e-post personvernombud@uis.no.
- NSD – Norsk senter for forskningsdata AS, på epost (personverntjenester@nsd.no) eller telefon: 55 58 21 17.

Med vennlig hilsen
Prosjektansvarlig   Hovedveileder

Cathrine Nyhus Hagum Shaher Shalfawi

Samtykkeerklæring

Jeg har mottatt og forstått informasjon om prosjektet «*Treningsbelastning og livsbelastning hos unge utøvere på programfaget toppidret*t» og har fått anledning til å stille spørsmål. Jeg samtykker til:

- å delta på spørreskjemaet
- at mine personopplysninger lagres etter prosjektslutt til eventuelle oppfølgingsstudier

Ved å besvare spørreskjemaet samtykker du til at opplysningene dine behandles frem til prosjektet er avsluttet, desember 2025.

Appendix 10 – Informed consent Study II

Vil du delta i forskningsprosjektet *«Treningsbelastning og livsbelastning hos unge utøvere på programfaget toppidrett»*?

Dette er et spørsmål til deg om å delta i en studie hvor formålet er å undersøke opplevd koordinasjon mellom utøvere, skoletrenere, klubbtrenere, kontaklærere, støttepersonell og foreldre i forhold til treningsbelastning og prestasjonsutvikling. I dette skrivet gir vi deg informasjon om målene for studien og hva deltakelse vil innebære for deg.

Formål
Hensikten med studien er todelt; 1) å undersøke opplevd koordinasjon mellom utøvere, skoletrenere, klubbtrenere, kontaklærere, støttepersonell og foreldre i forhold til treningsbelastning og prestasjonsutvikling, 2) å undersøke miljøene som opplever en velfungerende praksis med hensyn til kommunikasjon og koordinering rundt treningsbelastning og prestasjonsutvikling. Studien skal bidra til at ulike strategier som skal kunne forbedre praksis belyses. Forskningsspørsmålene som skal besvares er:

1. Hvordan oppleves koordinasjonen mellom utøvere, foreldre, lærere, klubbtrenere og støttepersonell med hensyn til treningsbelastning og prestasjonsutvikling?
2. Hva karakteriserer et miljø med en velfungerende koordinering? Hva oppleves som de store utfordringene?

Denne studien er en del av et større doktorgradsprosjekt. Hovedformålet med doktorgradsprosjektet er å utvikle mer dyptgående og nyansert kunnskap vedrørende unge utøveres tilknytning til programfaget toppidrett i videregående skoler. Et ytterligere mål er å innhente informasjon som skal kunne bidra til at programfaget skal få en enda større effekt på utøveres prestasjonsutvikling, skoleprestasjoner og livskvalitet.

Hvem er ansvarlig for forskningsprosjektet?
Universitetet i Stavanger er ansvarlig for prosjektet.

Hvorfor får du spørsmål om å delta?
Du får spørsmål om å delta i prosjektet fordi du har valgt programfaget toppidrett på en videregående skole i Rogaland. Alle som er tilknyttet toppidrett i Rogaland får henvendelse om å delta i studien.Vi har mottatt kontaktopplysninger om deg i forbindelse med at ledelsen på skolen du går på ønsker å være med på studien.

Hva innebærer det for deg å delta?
Hvis du velger å delta i prosjektet, innebærer det at du besvarer et spørreskjema på syv spørsmål. Dette vil ta deg omtrent 10 minutter. Spørreskjemaet inneholder spørsmål om hvordan du kommuniserer og samarbeider med foreldrene dine, lærerne dine, klubbtrenerne dine og støttepersonell i forhold til treningsbelastning og prestasjonsutvikling. Dine svar fra spørreskjemaet blir registrert elektronisk.

Et fåtall av de som besvarer spørreskjemaet vil også bli forespurt om å delta i et individuelt intervju. Intervjuet vil ta utgangspunkt i spørsmålene som er besvart i spørreskjemaet. Intervjuet vil hente mer detaljert informasjon rundt hvordan du kommuniserer og samarbeider med foreldrene dine, lærerne dine, klubbtrenerne dine og støttepersonell i forhold til treningsbelastning og prestasjonsutvikling. Ved å besvare spørreskjemaet er det en mulighet for at du blir kontaktet for å delta på et individuelt intervju. Dette vil ta deg ca. 20-30 minutter.

Dersom du er under 16 år kan foreldre se spørreskjemaet eller intervjuguiden på forhånd ved å ta kontakt med prosjektansvarlig Cathrine Nyhus Hagum.

Det er frivillig å delta
Det er frivillig å delta i prosjektet. Hvis du velger å delta, kan du når som helst trekke samtykke tilbake uten å oppgi noen grunn. Alle opplysninger om deg vil da bli anonymisert. Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller senere velger å trekke deg.

Ditt personvern – hvordan vi oppbevarer og bruker dine opplysninger
Vi vil bare bruke opplysningene om deg til formålene vi har fortalt om i dette skrivet. Vi behandler opplysningene konfidensielt og i samsvar med personvernregelverket. Det er kun personer tilknyttet doktorgradsprosjektet og som har signert taushetserklæring som har tilgang til opplysningene fra studien. For å sikre at ingen uvedkommende får tilgang til personopplysningene vil datamaterialet lagres gjennom Universitetet i Stavanger sitt IKT-system. IT-utstyret skal være passord-beskyttet. Avidentifiserte data som skal oppbevares på bærbar enheter skal være kryptert og enheten skal være
sikret med passord. Navnet og kontaktopplysningene dine vil erstattes med en kode som lagres på egen navneliste adskilt fra øvrige data. Opplysningene om deg skal ikke overføres til land utenfor EØS.

Du vil ikke kunne gjenkjennes i publikasjoner i forbindelse med doktorgradsprosjektet.

Hva skjer med opplysningene dine når vi avslutter forskningsprosjektet?
Prosjektet skal etter planen avsluttes i desember 2025. Opplysningene om deg vil bli anonymisert eller slettet fem år etter prosjektslutt. Formålet med videre oppbevaring etter prosjektslutt er mulige oppfølgingsstudier.

Dine rettigheter
Så lenge du kan identifiseres i datamaterialet, har du rett til:
- innsyn i hvilke personopplysninger som er registrert om deg,
- å få rettet personopplysninger om deg,
- få slettet personopplysninger om deg,
- få utlevert en kopi av dine personopplysninger (dataportabilitet), og
- å sende klage til personvernombudet eller Datatilsynet om behandlingen av dine personopplysninger.

Hva gir oss rett til å behandle personopplysninger om deg?
Vi behandler opplysninger om deg basert på ditt samtykke.
På oppdrag fra Universitetet i Stavanger har NSD – Norsk senter for forskningsdata AS vurdert at behandlingen av personopplysninger i dette prosjektet er i samsvar med personvernregelverket.

Hvor kan jeg finne ut mer?
Hvis du har spørsmål til studien, eller ønsker å benytte deg av dine rettigheter, ta kontakt med:

- Universitetet i Stavanger ved Cathrine Nyhus Hagum (prosjektansvarlig), på telefon: 94 15 01 90 eller e-post: cathrine.n.hagum@uis.no.
- Universitet i Stavanger ved Hovedveileder for doktorgradsprosjekter er Shaher Shalfawi (hovedveileder), på telefon: 51 83 34 88 eller e-post shaher.shalfawi@uis.no.
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Med vennlig hilsen

Prosjektansvarlig	Hovedveileder
Cathrine Nyhus Hagum	Shaher Shalfawi

Samtykkeerklæring

Jeg har mottatt og forstått informasjon om prosjektet «*Treningsbelastning og livsbelastning hos unge utøvere på programfaget toppidrett*», og har fått anledning til å stille spørsmål. Jeg samtykker til:

- å delta i spørreundersøkelsen
- å delta i et intervju
- at lærer kan gi opplysninger om meg til prosjektet
- at mine personopplysninger lagres etter prosjektslutt, til eventuelle oppfølgingsstudier

Ved å besvare denne spørreundersøkelsen samtykker du til at opplysninger om deg behandles frem til prosjektet er avsluttet, desember 2025

Appendix 11 – Informed consent Study II

Vil du delta i forskningsprosjektet *«Treningsbelastning og livsbelastning hos unge utøvere på programfaget toppidrett»*?

Dette er et spørsmål til deg om å delta i en studie hvor formålet er å undersøke opplevd koordinering vedrørende treningsbelastning og prestasjonsutvikling mellom utøvere, lærere, klubbtrenere, støttepersonell og foreldre. I dette skrivet gir vi deg informasjon om målene for studien og hva deltakelse vil innebære for deg.

Formål
Hensikten med studien er todelt; 1) å undersøke opplevd koordinasjon mellom utøvere, foreldre, lærere, klubbtrener og støttepersonell vedrørende treningsbelastning og prestasjonsutvikling, 2) å undersøke miljøene som opplever en velfungerende praksis med hensyn til kommunikasjon og koordinering. Ulike strategier som skal kunne bidra til å forbedre praksis vil belyses. Forskningsspørsmålene som skal besvares er:

1. Hvordan oppleves koordinasjonen mellom utøvere, foreldre, lærere, klubbtrenere og støttepersonell med hensyn til treningsbelastning og prestasjonsutvikling?
2. Hva karakteriserer et miljø med et velfungerende samspill? Hva oppleves som de store utfordringene?

Denne studien er en del av et større doktorgradsprosjekt. Hovedformålet med doktorgradsprosjektet er å utvikle mer dyptgående og nyansert kunnskap vedrørende unge utøveres tilknytning til programfaget toppidrett i videregående skoler. Et ytterligere mål er å innhente informasjon som skal kunne bidra til at programfaget skal få en enda større effekt på utøveres prestasjonsutvikling, skoleprestasjoner og livskvalitet.

Hvem er ansvarlig for forskningsprosjektet?
Universitetet i Stavanger er ansvarlig for prosjektet.

Hvorfor får du spørsmål om å delta?
Du får spørsmål om å delta i prosjektet fordi du har en form for tilknytning til programfaget toppidrett på en videregående skole i Rogaland. Alle som er tilknyttet toppidrett i Rogaland får henvendelse om å delta i studien.
Vi har mottatt kontaktopplysninger om deg i forbindelse med at ledelsen på skolen du er tilknyttet til ønsker å være med på studien.

Hva innebærer det for deg å delta?
Hvis du velger å delta i prosjektet, innebærer det at du besvarer et spørreskjema på syv spørsmål. Dette vil ta deg omtrent 10 minutter. Spørreskjemaet inneholder spørsmål om hvordan du kommuniserer og samarbeider med utøvere, foreldre, lærere, klubbtrenere og støttepersonell i forhold til treningsbelastning og prestasjonsutvikling. Dine svar fra spørreskjemaet blir registrert elektronisk.

Et fåtall av de som besvarer spørreskjemaet vil også bli forespurt om å delta i et individuelt intervju. Intervjuet vil ta utgangspunkt i spørsmålene som er besvart i spørreskjemaet. Intervjuet vil hente mer detaljert informasjon rundt hvordan du kommuniserer og samarbeider med utøvere, foreldrene, lærere, klubbtrenerne og støttepersonell i forhold til utøveres treningsbelastning og prestasjonsutvikling. Ved å besvare spørreskjemaet er det en mulighet for at du blir kontaktet for å delta på et individuelt intervju. Dette vil ta deg ca. 20-30 minutter. Intervjueren vil ta lydopptak og notater fra intervjuet.

Det er frivillig å delta
Det er frivillig å delta i prosjektet. Hvis du velger å delta, kan du når som helst trekke samtykke tilbake uten å oppgi noen grunn. Alle opplysninger om deg vil da bli anonymisert. Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller senere velger å trekke deg.

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Dine rettigheter
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- Universitet i Stavanger ved Hovedveileder for doktorgradsprosjekter er Shaher Shalfawi (hovedveileder), på telefon: 51 83 34 88 eller e-post shaher.shalfawi@uis.no.
- Vårt personvernombud: Kjetil Dalseth, på e-post personvernombud@uis.no.

- NSD – Norsk senter for forskningsdata AS, på epost (personverntjenester@nsd.no) eller telefon: 55 58 21 17.

Med vennlig hilsen

Prosjektansvarlig	Hovedveileder
Cathrine Nyhus Hagum	Shaher Shalfawi

Samtykkeerklæring

Jeg har mottatt og forstått informasjon om prosjektet «*Treningsbelastning og livsbelastning hos unge utøvere på programfaget toppidrett*» og har fått anledning til å stille spørsmål. Jeg samtykker til:

- å delta i spørreundersøkelsen
- å delta i et intervju
- at elever kan gi opplysninger om meg til prosjektet
- at mine personopplysninger lagres etter prosjektslutt, til eventuelle oppfølgingsstudier

Ved å gjennomføre denne spørreundersøkelsen samtykker du til at opplysninger om deg behandles frem til prosjektet er avsluttet, desember 2025

Universitetet
i Stavanger

University of
Stavanger

Forespørsel om deltakelse i forskningsprosjektet:

"Treningsbelastning og livsbelastning på toppidrett"

Bakgrunn og hensikt

Dette er et spørsmål til deg som skal starte på toppidrettslinje i videregående skole om å samtykke til å delta i et forskningsprosjekt som skal undersøke effekten av et tilvenningsprogram i løpet av sommerferien med hensyn til forekomsten av sykdom og skade. Om du er under 18 år, må du og foresatte samtykke.

Høsten 2021 skal du følge drømmen, og starte på Wang Toppidrett eller Talenter mot toppen. Tidligere forskning viser at mange unge lovende toppidrettselever får skade de første månedene, da de ikke er trent opp til å tåle den belastningen som kreves for å trene som en fremtidig toppidrettsutøver. Utfordringen skyldes spesielt at det fra skoleslutt på ungdomsskolen til skolestart på toppidrettsgymnas ikke finnes en individuell oppfølging, med en målrettet treningsplan som skal gjøre deg i stand til å tåle all den gode treningen på toppidrettsgymnaset. Formålet med prosjektet er således å undersøke hvilken effekt et tilvenningsprogram kan ha på unge utøvere som skal begynne på toppidrettslinje i videregående skole med hensyn til forekomsten av skade og sykdom, fysisk- og psykisk treningsbelastning og generell livsbelastning. En gruppe vil motta et tilvenningsprogram i løpet av sommerferien, mens den andre gruppen vil trene som normalt. For å oppnå dette ønsker vi ditt samtykke til å delta. Prosjektansvarlig er Institutt for grunnskolelærerutdanning, idrett og spesialpedagogikk, Universitetet i Stavanger med prosjektleder stipendiat Cathrine Nyhus Hagum. Hovedveileder er førsteamanuensis Shaher A. I. Shalfawi, mens biveiledere er professor Espen Tønnessen ved Høyskolen Kristiania og professor Jonny Hisdal ved Oslo universitetssykehus.

Gjennom dette prosjektet kommer det til å produseres vitenskapelig publikasjoner og en Ph.D.-avhandling.

Hva innebærer studien?

Oppstart av forskningsprosjektet vil være i mai 2021, når du fortsatt går på ungdomsskolen. Prosjektet avsluttes ved utgangen av november 2021, tre måneder etter at du har startet på videregående skole. Sommerferien inkluderes i prosjektperioden. Alle elevene som driver med fotball og håndball i klassen du skal starte i, vil bli spurt om å delta i forskningsprosjektet.

I prosjektet vil vi innhente og registrere opplysninger om deg. Deltakelse i prosjektet innebærer:

1. Daglig rapportering av trening i Bestr treningsdagbok. Rapporteringen tar 3-5 minutter.
2. Ukentlig besvarelse av to spørreskjemaer i Bestr treningsdagbok. Bestr behandler informasjon om deg kun i henhold til ditt samtykke, personopplysningsloven og GDPR. Spørreskjemaene fanger spørsmål vedrørende:
    a. Sykdom og skade den siste uken, og hvordan det eventuelt har påvirket deltakelse på trening eller konkurranse. Dersom du har opplevd sykdom eller skade blir du bedt om å gi detaljer vedrørende skaden/ sykdommen.
    b. Spørsmål knyttet til fysisk- og psykisk treningsbelastning (2-3 minutter).
3. Rapportering av generell livsbelastning ved starten av prosjektet, etter oppstart på videregående skole og ved prosjektets slutt (2-3 minutter).
4. Utførelse av fysiske tester i starten av prosjektet, etter oppstart på videregående skole og ved prosjektets slutt. Testingen tar 60 minutter og følgende tester gjennomføres:

a. Vekt og høyde
b. Counter Movement Jump (spenst)
c. 30 meter løp (hurtighet)
d. 7×34,2 meter løp (anaerob utholdenhet)
e. Brutalbenk (kjernemuskulatur)
f. Skuddhastighet
g. Beep-test (aerob utholdenhet)

Personene knyttet til prosjektet vil ha tilgang til informasjonen som registreres om deg gjennom prosjektperioden. Når du starter på skolen etter sommerferien vil all datainnsamling foregå i skoletiden, slik at du får avsatt tid til å rapportere trening, besvare spørreskjema og utføre testbatteri.
Ta gjerne kontakt dersom du ønsker en detaljert gjennomgang av spørreskjemaet eller testbatteriet.

Mulige fordeler og ulemper

En fordel med at du deltar i prosjektet er at vi kan utvikle mer kunnskap om hvilken belastning unge utøvere møter i overgangen fra ungdomsskolen til programfaget toppidrett i videregående skole. Videre vil du lære å følge med på din egen trening, samt bli bevisst over den totale belastningen som er av betydning for prestasjonsutvikling i både idrett- og skolesammenheng.
En mulig ulempe med prosjektet er at det krever en viss tid å rapportere treningen din, besvare spørreskjemaene, samt å utføre de fysiske testene.

Hva skjer med informasjonen om deg?

Informasjonen som registreres om deg skal kun brukes slik som beskrevet i formålet med prosjektet. Du har rett til innsyn i hvilken informasjon som er registrert om deg og rett til å få korrigert eventuelle feil i informasjonen vi har. Du har også rett til å få innsyn i sikkerhetstiltakene ved behandling av informasjonen.
All informasjon vil bli behandlet uten navn og fødselsnummer eller annen direkte gjenkjennende informasjon. En kode knytter deg til informasjonen din gjennom en navneliste. Det er kun personer som er tilknyttet prosjektet som har tilgang til informasjonen som registreres om deg.
Prosjektet skal etter planen avsluttes i desember 2025. Informasjonen om deg vil bli anonymisert eller slettet fem år etter prosjektslutt. Formålet med videre oppbevaring etter prosjektslutt er mulige oppfølgingsstudier.

Deltakelse

Det er frivillig å delta i prosjektet. Du kan når som helst og uten å oppgi noen grunn trekke deg fra deltakelse. Dette vil ikke få konsekvenser for deg som elev, utøver eller i videre samhandling med personer som er tilknyttet prosjektet. Dersom du trekker deg fra prosjektet kan du kreve å få slettet innsamlet informasjon, med mindre informasjonen om deg allerede er inngått i analyser eller brukt i vitenskapelige publikasjoner. Dersom du senere ønsker å trekke deg eller har spørsmål til prosjektet, kan du kontakte:

Stipendiat: Cathrine Nyhus Hagum, tlf: 94 150 190, e-post: cathrine.n.hagum@uis.no
Hovedveileder: Shaher A. I. Shalfawi, tlf: 51 833 448, e-post: shaher.shalfawi@uis.no
Vårt personvernombud: Universitetet i Stavanger ved (personvernombud@uis.no).

Med vennlig hilsen

Prosjektansvarlig	**Hovedveileder**
Cathrine Nyhus Hagum	Shaher Shalfawi

FORRIGE NESTE 11%

Appendix 13 – MTDS-N

Multicomponent Training Distress Scale - MTDS

Navn: ________________________ Dato: ____________

Spørsmålene i skalaen nedenfor spør deg om følelsene og tankene dine i løpet av den siste uken. I begge tilfeller vil du bli bedt om å indikere hvor ofte du følte eller tenkte på en bestemt måte. Selv om noen av spørsmålene likner, er det forskjeller mellom dem, og du bør behandle hver og en som et eget spørsmål. Den beste tilnærmingen er å svare på hvert spørsmål ganske raskt. Det vil si, ikke prøv å telle opp antall ganger du følte noe på en spesiell måte, men snarere angi alternativet som virker som et rimelig estimat. For hvert spørsmål, sett ring rundt ett av de følgende alternativene:

0. Aldri
1. Nesten aldri
2. Noen ganger
3. Ganske ofte
4. Veldig ofte

	Aldri	Nesten aldri	Noen ganger	Ganske ofte	Veldig ofte
1. I løpet av den siste uken, hvor ofte har du følt at du ikke har klart å håndtere alt du måtte gjøre?	0	1	2	3	4
2. I løpet av den siste uken, hvor ofte har du følt at vanskeligheter har blitt så store at du ikke kunne overvinne dem?	0	1	2	3	4
3. I løpet av den siste uken, hvor ofte har du følt deg nervøs?	0	1	2	3	4
4. I løpet av den siste uken, hvor ofte har du følt deg stresset?	0	1	2	3	4

Nedenfor er en liste over ord som beskriver følelser som mennesker har. Les hvert ord nøye. Sett så ring rundt svaret som best beskriver hvordan du føler deg akkurat nå. Sørg for at du svarer på alle ordene.

	Ikke i det hele tatt	Litt	Moderat	Ganske mye	Ekstremt
1. Trøtt	0	1	2	3	4
2. Trist	0	1	2	3	4
3. Livlig	0	1	2	3	4
4. Energisk	0	1	2	3	4
5. Deprimert	0	1	2	3	4
6. Ulykkelig	0	1	2	3	4
7. Fortvilet	0	1	2	3	4
8. Bitter	0	1	2	3	4
9. Utslitt	0	1	2	3	4
10. Oppmerksom	0	1	2	3	4
11. Mentalt aktiv	0	1	2	3	4
12. Søvnig	0	1	2	3	4

Sett ring rundt tallet som nøyaktig reflekterer hvor mye du har erfart hvert av de følgende symptomene i nyere tid.

I løpet av den siste uken

I hvilken grad har du opplevd:	Ikke i det hele tatt	Litt	Moderat mengde	Ganske mye	Ekstrem mengde
1. Muskelømhet/ gangsperre	0	1	2	3	4
2. Tunge følelser i armene og bena	0	1	2	3	4
3. Stive eller ømme ledd	0	1	2	3	4
4. Urolig søvn	0	1	2	3	4
5. Søvnløshet	0	1	2	3	4
6. Vanskeligheter med å sovne	0	1	2	3	4

Appendix 14 – RCS – Student atheltes

RCS – idrettselever

Kjønn

(1) ❑ Jente
(2) ❑ Gutt

Hvor gammel er du?

______

Hvilken studieretning tar du?

(1) ❑ Studiespesialiserende med valgfag toppidrett
(2) ❑ Idrettsfag med valgfag toppidrett

Hvilken idrett/idretter driver du med?

_____

Hvor mange år har du drevet med idrett?

______

Etter din mening, hvordan vil du rangere ditt eget prestasjonsnivå, sammenliknet med andre jevnaldrende utøvere i samme idrett i <u>Norge</u>?

(1) ❑ Topp 1%
(2) ❑ Topp 5%
(3) ❑ Topp 10%
(4) ❑ Topp 25%
(5) ❑ Topp 50%
(6) ❑ Under 50%

Hvor mange timer trener du totalt i uken?

______

Kryss av for hvilken rolle du har

(1) ❑ Utøver
(2) ❑ Klubbtrener
(3) ❑ Skoletrener
(4) ❑ Støtteapparat
(5) ❑ Foreldre
(6) ❑ Kontaktlærer

1. Hvor ofte kommuniserer personene i hver av disse gruppene med deg om utøverens totalbelastning (treningsbelastning og livsbelastning)

	Alt for lite	For lite	Akkurat passe	For mye	Alt for mye	Ikke aktuelt
Utøvere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Klubbtrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Skoletrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Kontaktlærere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Foreldre	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Støtteapparat	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

2. Kommuniserer personer i disse gruppene med deg i rett tid (i tide) om utøverens totalbelastning?

	Aldri	Sjelden	Av og til	Ofte	Alltid	Ikke aktuelt
Utøvere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Klubbtrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Skoletrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Kontaktlærere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Foreldre	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Støtteapparat	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

3. Kommuniserer personene i disse gruppene nøyaktig (på en presis måte) om utøverens totalbelastning?

	Aldri	Sjelden	Av og til	Ofte	Alltid	Ikke aktuelt
Utøvere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Klubbtrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Skoletrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Kontaktlærere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Foreldre	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Støtteapparat	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

4. Når det oppstår problemer angående utøverens totalbelastning i idrett/skole, samarbeider disse personene med deg for å løse problemet?

	Aldri	Sjelden	Av og til	Ofte	Alltid	Ikke aktuelt
Utøvere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Klubbtrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Skoletrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Kontaktlærere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Foreldre	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Støtteapparat	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

5. I hvor stor grad har personer i disse gruppene samme mål som deg i forhold til utøverens totalbelastning?

	Ikke i det hele tatt	Lite	En del	Mye	Fullt og helt	Ikke aktuelt
Utøvere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Klubbtrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Skoletrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Kontaktlærere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Foreldre	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Støtteapparat	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

6. Hvor mye vet personer i disse gruppene om arbeidet utøveren gjør som inngår i totalbelastning?

	Ingenting	Lite	En del	Mye	Alt	Ikke aktuelt
Utøvere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Klubbtrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Skoletrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Kontaktlærere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Foreldre	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Støtteapparat	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

7. I hvor stor grad respekterer personer i disse gruppene arbeidet som utøveren gjør i idrett/skole med hensyn til totalbelastning?

	Ikke i det hele tatt	Lite	En del	Mye	Fullt og helt	Ikke aktuelt
Utøvere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Klubbtrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Skoletrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Kontaktlærere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Foreldre	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Støtteapparat	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

Takk for at du deltok i denne undersøkelsen!

Appendix 15 – RCS – School coaches

RCS – Skoletrenere

Kjønn

(1) ❑ Kvinne

(2) ❑ Mann

Hvor gammel er du?

_____

Lærer på studieretning

(1) ❑ Studiespesialiserende med valgfag toppidrett

(2) ❑ Idrettsfag med valgfag toppidrett

Har du en idrettslig bakgrunn? Hvis ja, hvilke(n)?

_____

Hvilken utdannelse har du tatt?

_____

Hvor mange skoletimer har du sammen med utøverne/utøveren i løpet av en uke?

_____

Kryss av for hvilken rolle du har

(1) ❑ Skoletrener

(2) ❑ Kontaktlærer

(3) ❑ Klubbtrener

(4) ❑ Støtteapparat

(5) ❑ Foreldre

(6) ❑ Utøver

1. Hvor ofte kommuniserer personer i hver av disse gruppene med deg om utøvernes/utøverens totalbelastning (treningsbelastning og livsbelastning)?

	Alt for lite	For lite	Akkurat passe	For mye	Alt for mye	Ikke aktuelt
Skoletrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Kontaktlærere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Utøvere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Klubbtrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Foreldre	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Støtteapparat	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

2. Kommuniserer personer i disse gruppene med deg i rett tid (i tide) om utøvernes/utøverens totalbelastning?

	Aldri	Sjelden	Av og til	Ofte	Alltid	Ikke aktuelt
Skoletrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Kontaktlærere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Utøvere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Klubbtrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Foreldre	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Støtteapparat	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

3. Kommuniserer personene i disse gruppene nøyaktig (på en presis måte) om utøvernes/utøverens totalbelastning?

	Aldri	Sjelden	Av og til	Ofte	Alltid	Ikke aktuelt
Skoletrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Kontaktlærere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Utøvere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Klubbtrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Foreldre	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Støtteapparat	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

4. Når det oppstår problemer angående utøvernes/ utøverens totalbelastning i idrett/skole, samarbeider disse personene med deg for å løse problemet?

	Aldri	Sjelden	Av og til	Ofte	Alltid	Ikke aktuelt
Skoletrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Kontaktlærere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Utøvere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Klubbtrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Foreldre	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Støtteapparat	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

5. I hvor stor grad har personer i gruppene samme mål som deg i forhold utøvernes/utøverens totalbelastning?

	Ikke i det hele tatt	Lite	En del	Mye	Fullt og helt	Ikke aktuelt
Skoletrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Kontaktlærere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Utøvere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Klubbtrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Foreldre	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Støtteapparat	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

6. Hvor mye vet personer i disse gruppene om arbeidet utøverne/utøveren gjør som inngår i totalbelastning?

	Ingenting	Lite	En del	Mye	Alt	Ikke aktuelt
Skoletrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Kontaktlærere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Utøvere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Klubbtrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Foreldre	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Støtteapparat	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

7. I hvor stor grad respekterer personer i disse gruppene arbeidet som utøverne/utøveren gjør i idrett/skole med hensyn til totalbelastning?

	Ikke i det hele tatt	Lite	En del	Mye	Fullt og helt	Ikke aktuelt
Skoletrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Kontaktlærere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Utøvere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Klubbtrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Foreldre	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Støtteapparat	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

Takk for at du deltok i denne undersøkelsen!

Appendix 16 – RCS – Club coaches

RCS – Klubbtrenere

Kjønn

(1) ❑ Kvinne

(2) ❑ Mann

Hvor gammel er du?

______

Hvilken utdannelse har du tatt?

______

Hvem er du trener for?

(1) ❑ Individuell idrett

(2) ❑ Lagidrett

Har du en idrettslig bakgrunn? Hvis ja, hvilken?

______

Etter din mening, hvordan vil du rangere utøvernes/utøverens prestasjonsnivå, sammenliknet med andre jevnaldrende utøvere i samme idrett i Norge?

(1) ❑ Topp 1%

(2) ❑ Topp 5%

(3) ❑ Topp 10%

(4) ❑ Topp 25%

(5) ❑ Topp 50%

(6) ❑ Under 50%

Kryss av for hvilken rolle du har

(1) ❑ Klubbtrener

(2) ❑ Skoletrener

(3) ❑ Foreldre

(4) ❑ Støtteapparat

(5) ❑ Kontaktlærer

(6) ❑ Utøver

1. Hvor ofte kommuniserer personer i hver av disse gruppene med deg om utøvernes/utøverens totalbelastning (treningsbelastning og livsbelastning)?

	Alt for lite	For lite	Akkurat passe	For mye	Alt for mye	Ikke aktuelt
Klubbtrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Utøvere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Skoletrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Kontaktlærere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Foreldre	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Støtteapparat	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

2. Kommuniserer personer i disse gruppene med deg i rett tid (i tide) om utøvernes/utøverens totalbelastning?

	Aldri	Sjelden	Av og til	Ofte	Alltid	Ikke aktuelt
Klubbtrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Utøvere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Skoletrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Kontaktlærere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Foreldre	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Støtteapparat	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

3. Kommuniserer personer i disse gruppene nøyaktig (på en presis måte) om utøvernes/utøverens totalbelastning?

	Aldri	Sjelden	Av og til	Ofte	Alltid	Ikke aktuelt
Klubbtrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Utøvere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Skoletrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Kontaktlærere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Foreldre	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Støtteapparat	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

4. Når det oppstår problemer angående utøvernes/utøverens totalbelastning i idrett/skole, samarbeider disse personene med deg for å løse problemet?

	Aldri	Sjelden	Av og til	Ofte	Alltid	Ikke aktuelt
Klubbtrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Utøvere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Skoletrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Kontaktlærere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Foreldre	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Støtteapparat	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

5. I hvor stor grad har personer i disse gruppene samme mål som deg i forhold til utøvernes/utøverens totalbelastning?

	Ikke i det hele tatt	Lite	En del	Mye	Fullt og helt	Ikke aktuelt
Klubbtrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Utøvere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Skoletrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Kontaktlærere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Foreldre	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Støtteapparat	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

6. Hvor mye vet personer i disse gruppene om arbeidet utøverne/utøver gjør som inngår i totalbelastningen?

	Ingenting	Lite	En del	Mye	Alt	Ikke aktuelt
Klubbtrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Utøvere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Skoletrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Kontaktlærere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Foreldre	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Støtteapparat	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

7. I hvor stor grad respekterer personer i disse gruppene arbeidet som utøverne/utøveren gjør i idrett/skole med hensyn til totalbelastning?

	Ikke i det hele tatt	Lite	En del	Mye	Fullt og helt	Ikke aktuelt
Klubbtrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Utøvere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Skoletrenere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Kontaktlærere	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Foreldre	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Støtteapparat	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

Takk for at du deltok i denne undersøkelsen!

Appendix 17 – ASQ-N

SPØRSMÅL OM STRESS (ASQ-N)

Her kommer en liste med ting eller situasjoner som du kan oppleve som stressende. Vær snill og fortell oss hvor stressende hver av disse tingene eller situasjonene har vært for deg i løpet av den siste måneden. Vennligst svar på alle utsagnene/spørsmålene. Sett bare ett kryss i sirkelen som passer for hvert utsagn.

NB: Hvis det noe du ikke har opplevd, krysser du i sirkel nr. 1 (Ikke stressende).

Hvor stressende er …	*Ikke stressende* 1	*Litt stressende* 2	*Moderat stressende* 3	*Ganske stressende* 4	*Svært stressende* 5
1. … uenigheter mellom deg og faren din?					
2. … å stå opp tidlig om morgenen?					
3. … å være nødt til å lære ting du ikke forstår?					
4. … å ha lærere som forventer for mye av deg?					
5. … å bli ertet?					
6. … å ha vanskeligheter med noen skolefag?					
7. … å følge regler du er uenig i hjemme?					
8. … å måtte lese ting du ikke er interessert i?					
9. … å bli oversett eller avvist av en person du er interessert i?					
10. … å ikke ha nok tid til å ha det gøy?					
11. … uenigheter med søsknene dine?					
12. … å ikke ha nok tid til å drive med fritidsaktiviteter?					
13. … å ha for mye hjemmelekser?					
14. … å ikke få nok tilbakemelding på skolearbeidet tidsnok til at det er hjelp i det?					
15. … å få forholdet til kjæresten til å fungere?					
16. … å bli nedvurdert av vennene dine?					
17. … uenigheter mellom foreldrene dine?					
18. … å ha for mye fravær fra skolen?					
19. … hvordan du ser ut?					
20. … uenigheter mellom deg og mora di?					
21. … å gå på skolen?					
22. … å ikke ha nok tid til kjæresten din?					
23. … lærere som erter deg?					
24. … å adlyde regler du er uenig i på skolen?					
25. … å ikke bli hørt på av lærere?					
26. … å ikke komme overens med kjæresten din?					
27. … mangel på respekt fra lærere?					
28. … uenigheter mellom deg og dine venner?					
29. … å ikke komme overens med lærerne dine?					
30. … å slå opp med kjæresten?					

Appendix 18 – OSTRC-H2

Norsk versjon av OSTRC on Health problems (OSTRC-H2)

Spørsmål

1. Deltakelse i vanlig trening og konkurranse

Har du hatt problemer med å delta i din idrett på grunn av skader, sykdom eller andre helseproblemer i løpet av den siste uken?

- Deltar for fullt uten problemer
- Deltar for fullt, men med skade-/sykdomsproblemer
- Redusert deltagelse, på grunn av skade/sykdom
- Har ikke kunnet delta på grunn av skade/sykdom

2. Redusert treningsmengde

I hvilken grad har du redusert treningsmengden på grunn av skader, sykdom eller andre helseproblemer i løpet av den siste uken?

- Ingen reduksjon
- I liten grad
- I moderat grad
- I stor grad

3. Redusert prestasjon

I hvilken grad opplever du at skader, sykdom eller andre helseproblemer har påvirket prestasjonsevnen i din idrett i løpet av den siste uken?

- Ingen påvirkning
- I liten grad
- I moderat grad
- I stor grad

4. Symptomer på skade eller sykdom

I hvilken grad har du opplevd symptomer/helseplager i løpet av den siste uken?

- Ingen symptomer/helseplager
- I liten grad
- I moderat grad
- I stor grad

5. Er helseproblemet som det er referert til i de fire spørsmålene ovenfor en skade eller sykdom?

- Skade
- Sykdom

6. Skadeområde

Vennligst kryss av for hvilket område som best beskriver plasseringen av skaden din. Dersom skaden involverer flere områder, vennligst velg hovedområdet. Dersom du har flere skader fullføres en separat registrering for hver enkelt.

- Hode/ansikt
- Nakke/hals
- Skulder (inkludert kragebein)
- Overarm
- Albue
- Underarm
- Håndledd
- Hånd/ fingre
- Brystkasse inkl. indre organer
- Mageregion inkl. indre organer
- Øvre del av ryggen (Brystrygg)
- Nedre del av ryggen (Lumbalrygg)
- Bekken
- Hofte/lysk
- Lår
- Kne
- Legg
- Ankel
- Fot/tær
- Annen kroppsdel

7. Sykdomssymptomer

Vennligst merk av i sirklene som tilsvarer de viktigste symptomene du har opplevd den siste uken. Du kan velge flere alternativer, men dersom du har flere sykdommer som ikke er relaterte til hverandre må du imidlertid fullføre en egen registrering av hver enkelt.

- Feber
- Slapphet/tretthet
- Hovne lymfeknuter
- Sår hals
- Tett nese/snørrete/nysing
- Hoste
- Tungpustethet/tetthet
- Hodepine
- Kvalme/uvelhet
- Oppkast/brekninger
- Diare
- Forstoppelse
- Besvimelse
- Kløe/utslett
- Uregelmessig puls/hjertebank
- Brystsmerter

- o Magesmerter
- o Smerte andre steder
- o Nummenhet/prikking
- o Angst/uro
- o Tristhet/depresjon
- o Irritabilitet
- o Symptomer fra øye
- o Symptomer fra øre
- o Symptomer fra urinveier eller kjønnsorganer
- o Annet, spesifiser [___tekstboks___]

8. Fravær

Hvor mange dager i løpet av den siste uken har du måttet stå over trening eller konkurranse på grunn av dette problemet?

- Velg alternativ [0-7]

9. Rapportering

Er dette første gang du har registrert dette problemet i helseappen?

- Ja, dette er den første gangen
- Nei, jeg har rapportert det samme problemet i en av de fire siste ukene
- Nei, jeg har rapportert det samme problemet tidligere, men det var mer enn fire uker siden

10. Har du hatt noen andre skader, sykdommer eller andre helseproblemer i løpet av den siste uken?

- Ja
- Nei

Om du har flere skade- eller sykdomsproblemer, vennligst referer til ditt nest alvorligste problem denne uken [spørreskjema starter på ny].