Torstein Dalen-Lorentsen // Training load and health problems in football – More complex than we first thought?

DISSERTATION FROM THE
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Torstein Dalen-Lorentsen

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List of papers

This dissertation is based on the following original research papers, which are referred to in the text by their Roman numerals:

I. Dalen-Lorentsen T, Bjørneboe J, Clarsen B, Vagle M, Fagerland MW, Andersen, TE. Does load management using the acute:chronic workload ratio prevent health problems? A cluster randomised trial of 482 elite youth footballers of both sexes *Br J Sports Med Med* 2021;55:108-114

II. Dalen-Lorentsen T, Andersen TE, Bjørneboe J, Vagle M, Martin KN, Kleppen M, Fagerland MW, Clarsen B. A cherry, ripe for picking: The relationship between the acute:chronic workload ratio and health problems J Orthop Sports Phys Ther 2021;51(4):162–173. Epub 20 Jan 2021. doi:10.2519/jospt.2021.9893

III. Dalen-Lorentsen T, Ranvik A, Bjørneboe J, Clarsen B, Andersen TE. Facilitators and barriers for implementation of a load management intervention in football. *BMJ Open Sports and Exercise Medicine.* 2021;7:e001046. doi:10.1136/bmjsem-2021-001046

IV. Dalen-Lorentsen T, Andersen TE, Thorbjørnsen C, Brown M, Tovi D, Braastad A, Lindinger TG, Williams C, Moen E, Clarsen B, Bjørneboe J. Injury characteristics in Norwegian male professional football: a comparison between a regular season and a season in the pandemic. *In review, Science and Medicine in Football*

Abbreviations

ACL	Anterior Cruciate Ligament
ACWR	Acute:chronic Workload Ratio
AMS	Athlete Management System
CI	Confidence Interval
CR	Category Scale
FIFA	Fédération Internationale de Football Association
GEE	Generalised Estimated Equations
GPS	Global Positioning Systems
IOC	International Olympic Committee
IQR	Interquartile Range
IRR	Incidence Rate Ratio
LPS	Local Positioning Systems
M-FASIS	Framework for the Analysis of Subsequent Injury in Sport
OR	Odds Ratio
OSTRC	Oslo Sports Trauma Research Center
OSTRC-H	Oslo Sports Trauma Research Center Questionnaire on Health Problems
RE-AIM	Reach Effectiveness Adoption Implementation and Maintenance
RPE	Rating of Perceived Exertion
SD	Standard Deviation
SMS	Short Message Service
TRIPP	Translating Research Into Injury Prevention Practise
UEFA	Union of football associations

Summary

Background

Health problems are prevalent in football, and in both elite youth and professional football, players are expected to sustain several health problems per season. Also, at any given time of the season, the prevalence of health problems (both injuries and illnesses) exceeds 40% among elite youth players. Training load has recently emerged as a potential risk factor for health problems in football; subsequently, many teams, particularly those at an elite level, attempt to manage players' training loads as a preventative measure to mitigate health problem risk. However, the evidence supporting this practice is limited, and its effectiveness is never tested. Therefore, this dissertation aims to improve our understanding of the relationship between training load and health problems and to guide preventative efforts.

Methods

All studies were performed on Norwegian football players and coahces, Papers I, II and III in elite youth (U19 age category) and Paper IV in professional football. In the first study (*Paper I*), we registered daily training load and health data to assess methodological issues in the relationship between the Acute:chronic workload ratio (ACWR) and health problems. The second study (*Paper II*) was a cluster-randomised trial that assessed the effectiveness of a load management programme on health problem prevention. We followed 482 players for a full season, registering their monthly health problem prevalence. In Paper III, we surveyed 250 of the players included in Paper II about their attitudes, beliefs and experiences of load management and health problems. In Paper IV, we assessed the injury characteristics of two different football seasons in the Norwegian premier league. This explorative descriptive study collected injury data from eight teams participating in the 2019 and 2020 seasons.

Main results

In Paper I, we found 24 (22%) significant associations between ACWR and health problems among the 108 analyses performed. These were spread across various methodological combinations. We did not observe any patterns of combinations that substantially increased the chance of a significant association. There was a considerable variation in the size and precision of the estimated strength of the association. In *Paper II,* the average prevalence of health problems was 65.7% (61.1% to 70.2%) in the intervention group and 63.8% (60.0% to 67.7%) in the control group. The prevalence was 1.8%-points (-4.1 to 7.7%-points; P=0.55) higher in the intervention group, and there was no reduction in the likelihood of reporting a health problem in the intervention group (Relative Risk, RR 1.01 (95% CI 0.91 to 1.12); P=0.84). In *Paper III,* we found that most players (88%) think scientific evidence for improved performance is a key facilitator to implementation. Similarly, the coaches reported that the most crucial facilitator was scientific evidence that the preventive measures were effective (100%). Players reported that the coach's attitude to preventive measures was important (86%), and similarly, 88% of coaches reported that the player's attitude was important. In Paper IV, the match incidence was 7.23 per 1000h lower in 2020 (22.82 per 1000h; CI 18.07 to 28.44; Incidence Rate Ratio; IRR 0.76) than in 2019 (30.05 per 1000h; CI 24.55 to 36.41); however, this was not a significant difference. There were no differences in either availability, severity or injury burden across the two seasons.

Conclusion

Based on our findings, we conclude that the relationship between ACWR and health problems is highly affected by the methodological approach, which can lead to p-hacking and cherry-picking of results. Future training load studies should pre-register their definitions, hypotheses, models and report all performed analyses' results. Furthermore, managing training loads using ACWR in a one-size-fits-all approach does not appear to prevent health problems in elite youth football. When implementing future health problem preventive measures, practitioners and researchers should focus on time-efficient interventions and create buy-in from club and federation stakeholders as well as coaches and players by focusing on both performance and prevention. Finally, we found no differences in injuries comparing a match-congested season with a regular one, suggesting a congested season can be a safe alternative.

Sammendrag på norsk (Summary in Norwegian)

Bakgrunn

Helseproblemer er vanlig blant fotballspillere på både elite-junior- og profesjonelt nivå. Spillere på disse nivåene må forvente rundt to skader per sesong. Studier på norsk elite-juniorfotball har også vist at prevalensen av helseproblemer er over 40%, som betyr at åtte spillere per lag vil til enhver tid oppleve et helseproblem. Treningsbelastning har nylig blitt foreslått som en risikofaktor for helseproblemer. Dette har ført til at trenere, medisinsk personale og forskere har tatt i bruk styring av treningsbelastning for å redusere risikoen for helseproblemer i fotball. Dette på tross av manglende evidens for at treningsbelastning kan øke risikoen for helseproblemer, og at den forebyggende effekten ikke er testet overhodet. Hovedformålet med dette doktorgradsprosjektet er å øke vår forståelse rundt forholdet mellom treningsbelastning og helseproblemer, for å kunne utvikle fremtidige preventive tiltak.

Metode

Alle studiene inkludert i denne avhandlingen ble utført i norsk fotball. Artiklene I, II og III ble utført blant elite-juniorspillere og trenere, mens Artikkel IV er utført blant profesjonelle spillere. I Artikkel I registrerte vi spillernes daglige treningsbelastning og helsestatus. Dette for å kunne vurdere den metodologiske kvaliteten til analysene og konklusjonene tidligere studier på Acute:Chronic Workload Ratio (ACWR) og helseproblemer. Artikkel II var en kluster-randomisert kontrollert studie der vi undersøkte effekten av å styre treningsbelastningen med ACWR på prevelansen av helseproblemer. Her fulgte vi 482 spillere gjennom en full sesong med månedlige registreringer av helseproblemer. I Artikkel III inkluderte vi 250 av spillerne og trenerne fra Artikkel II til en spørreundersøkelse om deres holdninger, tanker og erfaringer om treningsbelastning og helseproblemer. I Artikkel IV brukte vi data fra åtte lag som hadde deltatt i Eliteserien i 2019 og 2020 for å undersøke om det var forskjeller i skader.

Resultater

I artikkel I fant vi at 24 av 108 (22%) analyser var signifikante assosiasjoner mellom ACWR og helseproblemer som var spredd utover mange forskjellige metodologiske kombinasjoner. Vi fant ingen mønster av kombinasjoner som vesentlig økte sannsynligheten for en signifikant assosiasjon. Det var svært stor spredning i størrelsen og presisjonen for det estimerte forholdet mellom ACWR og helseproblemer. I Artikkel II var gjennomsnittlig prevalens av helseproblemer var 65,7% (61,1% to 70,2%) i intervensjonsgruppen og 63,8% (60,0% to 67,7%) i kontrollgruppen. Prevalensen var 1,8 prosentpoeng (-4,1 to 7,7%-poeng; P=0,55) høyere i intervensjonsgruppen, og det var ingen reduksjon i sannsynligheten for å rapportere et helseproblem. (Relativ risiko 1,01 (95% Konfidensintervall; KI; 0.91 to 1,12); P=0,84). I Artikkel III, fant vi at de fleste spillerne (88%) mener vitenskapelig bevis for økt prestasjon er den viktigste fasilitatoren for implementering. For trenerne var den viktigste fasilitatoren at tiltakene hadde vitenskapelig bevis for å kunne redusere helseproblemer. Både spillere (86%) og trenere (88%) mente hverandres holdning til en intervensjon var svært viktig for deres motivasjon. I Artikkel IV fant vi at kampinsidensen var 7,23 per 1000 time lavere i 2020 (22,82 per 1000t; KI 18,07 til 28,44; Insidensrate ratio 0.76) sammenlignet med 2019 (30,05 per 1000t; KI 24,55 til 36,41), noe som ikke var signifikant forskjellig. Det var ingen forskjell mellom sesongene i tilgjengelighet, alvorlighetsgrad eller skadebyrde mellom de to sesongene.

Konklusjon

Forholdet mellom ACWR of helseproblemer er avhengig av hvilken metode man velger. Dette muliggjør «p-hacking» og «cherry-picking» av analyser og resultater i studier som undersøker ACWR og helseproblemer. Fremtidige studier bør pre-registrere definisjoner, hypoteser og antagelser, samt presentere alle resultater når man undersøker forholdet mellom treningsbelastning og helseproblemer. Det ser ikke ut som at man kan redusere helseproblemer ved å styre treningsbelastningen med AWCR i en «one-size-fits-all» approach blant elite-juniorspillere. Når man skal implementere forebyggende tiltak, fokuser på tidseffektive løsninger og involver beslutningstagere fra alle nivåer, men spesielt trenere og spillere. Vi fant ingen forskjell i skadestistikk ved å spille en sesong med tett kampprogram og foreslår at dette kan være et trygt alternativ for fremtidige sesonger.

Introduction

Football is one of the most popular sports in the world. Fédération Internationale de Football Association (FIFA) has 208 member associations and about 270 million registered football players.[1] In Norway, football is the most popular sport with almost 400 000 registered players, of whom almost 300 000 are under 19 years old.[2] Football is a complex sport with random transitions between rest, sub-maximal and maximal efforts.[3] Professional players play 30 to 70 competitive matches per season and have large expectations and stresses attached to their profession.[4] Dependent on playing position, players must typically cover 10-13 km per match, including 800-1200 meters of high speed running and 200-400 meters of sprinting.[5,6] The professional game is evolving, and recent studies are reporting that the physical demands of the game are increasing.[6,7] Elite youth players (16-19 years old) have similar physical demands for total distance and low-intensity work but lower for high speed running and sprinting.[8]

Health problems are prevalent in football, and in both elite youth and professional football, players are expected to sustain several health problems per season.[9-11] Health problems have a significant impact on player and team performance,[12,13] and pose a large financial burden on professional clubs and organizations.[14,15] To prevent injuries and increase performance, teams and practitioners are interested in knowing what measures they should employ.[16]

The potential risk factors for injuries in football have been studied extensively, and studies have reported associations between risk factors for different injury types and locations.[17-19] Recently, researchers and practitioners have increased their interest in training load as a risk factor for health problems in football,[20-22] with numerous studies reporting an association between training load and health problems.[23] Although the proposed relationship between training load and health problem was hypothesized already in 1992,[24] there has been an increase in published articles on the subject. Advancements in technology and the creation and endorsement of the Acute:chronic Workload Ratio (ACWR),[25-27] is likely to be two of the reasons behind the sudden increase.

Following the increase in publications, training load monitoring and management has gained widespread popularity as a preventive measure in professional and elite youth football.[21,22,28]

However, the research underpinning the suggestions that load management can prevent injuries is scrutinized for having a high risk of bias,[29,30] and have resulted in conflicting and inconclusive outcomes. Therefore, prospective studies investigating the methodological quality are needed to fill the knowledge gaps in this field of research. Furthermore, the effect of training load management on injury prevention is previously not tested and represents a considerable knowledge gap.

Prevention of health problems

The sequence of injury prevention, described by Van Mechelen et al.. in 1992,[31] is often used to guide research in sports medicine. The first step is to establish the magnitude of the problem. The second step is to establish the cause and mechanisms of the problem. The third step is to develop and introduce preventive measure based on the first two steps. The fourth finishing step is to repeat step one to investigate the effectiveness of the preventive measure (Figure 1).

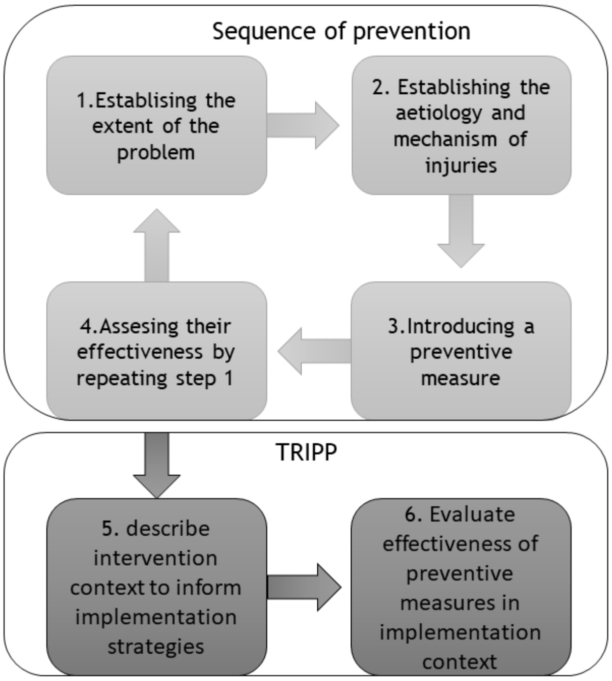

Figure 1 Overview of van Mechelens Sequence of Prevention and Finch's TRIPP-model. Adapted from van Mechelen et al..[31] and Finch et al..[32]

In 2006, Finch introduced the Translating Research into Injury Prevention Practise (TRIPP) framework to highlight the need for implementation thinking in health problem prevention research.[32] This framework consists of the same four first steps as the sequence of prevention but adds two additional steps. First, describe intervention context to inform implementation strategies, and second, evaluate the effectiveness of preventive measures in an implementation context (Figure 1).

When reviewing the current literature through the lens of these frameworks, there are some obvious knowledge gaps. The first step, however, has been extensively studied. The extent of the problem is usually established through systematic injury surveillance.[31] Many high-quality papers account for this,[10,11] providing a solid foundation for the subsequent steps. For step 2, many publications have aimed to investigate the relationship between training load and health problems.[23,33,34] In *Paper I*, we aimed to improve the understanding of the relationship between training load and health problems by investigating these studies' methodology. Furthermore, *Paper IV* was an explorative, descriptive study that could lead to further hypotheses and studies regarding aetiology and mechanisms, thus improving the knowledge in step 2.

As there were no studies investigating steps 3 through 6, we aimed to fill these knowledge gaps. *Paper II* aimed to introduce a preventive measure and to test its effectiveness. In P*aper III*, we aimed to investigate the facilitators and barriers to implementing load management interventions.

The overall aim of the dissertation is to improve our understanding of the relationship between training load and health problems and to use this to guide future preventative measures.

Theoretical framework and background

Health problem surveillance methodology

How health problems are defined, recorded and collected is essential to the interpretation and findings in sports injury research. There are many ways to perform surveillance of health problems. In a systematic review from Ekegren et al..[35] they reported that most ongoing surveillance systems (e.g., in professional sporting leagues) had not assessed the quality of their data. Also, they described that there was a large variance in the methodology and that most of the surveillance systems appeared to be sport specific. Thus, there seems to be an understanding that the methods had to be sports specific. However, there was not a consideration of how variations in methodology would affect the health problem outcomes. This underlines the need to understand how methodological differences can affect outcomes and how sources of errors must be acknowledged.[36] To limit biases and improve the validity of surveillance methodology, several consensus statements have been published.[37,38] These have either been general[37] or football-specific,[38] and provide guidelines for recording, defining and reporting health problems. Methodological considerations when defining, recording and reporting health problems will be discussed in this section.

Defining health problems

Clarsen et al..[39] defined an athletic health problem as any condition that reduces an athlete's normal state of full health, irrespective of its consequences on the athlete's sports participation or performance or whether the athlete sought medical attention. This is wide term that included but is not limited to injuries (i.e. both acute and overuse injuries) and all illness (i.e. physical, mental or social wellbeing). However, in this dissertation, the term is used as a description of all health-related problems that is conceptually linked to training load. This includes acute and overuse non-contact injuries as well as physical illness.

What constitutes a 'recordable event' is arguably one of the most critical methodological factors in sports injury and illness surveillance studies.[40] When there are clear-cut incidents (i.e. tibial fracture), this is straightforward, but with cases of mild symptoms (i.e. hamstring tightness) and without impact on participation, this becomes more difficult. The three most common health problem definitions are 1) 'time-loss', 2) 'medical attention' and 3) 'all complaints'.[41] Time-loss is the most used definition in sports medicine research and is considered a narrow and reliable definition, as participation is relatively easy to measure.[41] However, many health problems do not lead to decreased participation and are thus overlooked using the 'time-loss' definition.[40,42,43] Furthermore, the frequency of training and matches can weaken the precision of the 'time-loss' definition when recording injuries in amateur and youth sports. The 'medical attention' definition is broader and can capture non-time-loss health problems where a player is experiencing, e.g., pain or soreness, but is still participating in sports. One of the disadvantages of the 'medical attention' definition is that its dependent on the access to medical personnel and the players' threshold for seeking help.[44] 'All complaints' is the broadest definition and is a good way of capturing all health problems, regardless of participation or the need for medical consideration. However, as with 'medical attention', 'all complaints' can be suspect to systematic bias due to each collector's interpretation of what constitutes a recordable complaint.[40,44,45] Furthermore, even though recommended, few studies use its true form.[40] This is likely because most studies use medical staff to register the health problems, and they are unlikely to be aware of complaints not leading to medical attention.

When selecting a definition, a one-size-fits-all approach is not suitable, and the definition must be tailored to the research question and context. If the research question is surrounding overuse injuries, using only the time-loss definition is insufficient. If the population is youth footballers, the access to medical definition might be a limiting factor, ruling out the medical attention definition.

Recording health problems

When selecting how to record health problems, one must consider the context, definition and research question. The main emphasis when considering the recording of health problems is *who* records and *how* problems are recorded. Most studies have used medical staff.[40] The medical staff's knowledge of the participants' problems is limited compared to the players themselves. Consequently, player-based methods have been suggested.[37,46] When compared, medical staff and player-based reporting do not overlap with each other, and it seems that they both have strengths and weaknesses.[47-49] Using medical staff could provide more detailed health problem data (e.g.

diagnosis, mechanisms), but it might overlook many health problems.[48,49] Player-based reporting can capture all problems but can be limited by the players' interpretation of what constitutes a recordable health problem, and it will lack diagnostic detail. The strengths and weaknesses of both approaches have led researchers to combine the two methods to have a more comprehensive recording of health problems.[50,51]

Reporting health problems

After choosing the appropriate definition and method of recording, the final step is to decide how to report the health problems. The most used approach is incidence which is a measure of how many times a specific health problem occurs in a time period.[37] The time period could be a general duration (e.g., player years) or an actual exposure to an activity (match exposure minutes). As sporting injuries happen during sports activity, it is recommended to report them as relative to time spent participating in sports.[37] Using exposure to an activity allows for more direct comparisons as it takes differences in time periods into account (e.g. duration, number and duration of sessions and absences).[37,52] The most common health problem incidence in sports medicine research is to report the number of new incidences per 1000 hours of exposure. One challenge with using incidence measures is that it only counts *new* health problems. Especially problems with a gradual onset (e.g. overuse groin injuries) are either underestimated as only one problem, or it can be counted as numerous problems as it can fluctuate between being a problem and not.[46,53,54] Furthermore, existing problems will not be counted when using incidence measures, which can exclude important information. Another weakness with incidence measures is that it only reports how many new health problems happened, but not how long they lasted and how severe they were. This would give a non-complete view of the real scope of health problems. Using only incidence measures, a season-ending knee injury would be counted as the same as a mild muscular problem and would not provide us with enough information to target interventions. Health problem burden, expressed as days lost per 1000hours, is suggested as an approach that includes both the incidence (how *often)* and severity (how *severe)* health problems are.[37,55] Injury burden could also be expressed as the number of days lost to injury (*incidence x severity*), or in a more functional way, the number of matches missed to injury.

Prevalence methods have been suggested as an alternative to the typically used incidence methods.[46] Prevalence is the number of athletes experiencing a health problem at a specific time. Thus, it can handle both fluctuating health problems (e.g. overuse injuries) and health problems that existed upon study start.[56] When examining health problems in relation to training load, overuse injuries are of particular interest, and prevalence methods could be helpful in this setting. Prevalence measures also provide a better understanding on the magnitude of the health problems as it also contains information on the severity of the health problems. Different from using incidence measure with a 'time-loss' definition, prevalence measures using an all complaints definition can detect pain and symptoms below the time-loss threshold.[37] One tool for measuring health problem prevalence is the Oslo Sports Trauma Research Center Questionnaire on Health Problems (OSTRC- H). This questionnaire consists of four questions surrounding participation, training modification, performance reductions and symptoms, and can thus capture both symptoms and functional consequences of both injury and illness.[39,46,57] One weakness with prevalence methods is the lack of diagnostic detail and can be limited in examining injury aetiology.[56] This can, however, be accounted for by including follow-up questions and examinations by sports-medicine practitioners.[39]

When working on research questions with time-varying variables, one must record data in a method that can capture their fluctuation. In training load and health problem research, data on exposure and outcomes are needed on a more granular level than weekly questionnaires. Based on the work of Andersen & Keiding,[58] Shrier et al.[59] suggested the multistate framework for the analysis of subsequent injury in sport (M-FASIS) where participants are divided into individual states. These states could be diversified into detailed diagnostic states or just as a dichotomised *healthy* or *injured* state. The definition of an injury in the two-state model is the transition from the healthy state to the injured state.

Health problems can also be reported more functionally. Player availability, expressed as the percentage of available players to training or matches, is an easy way to communicate the scope of health problems to players and coaches.[37] Player availability is a direct measure of the consequences of health problems and should be reported when examining the scope of health problems in a team- or league setting.[37]

Health problems in football

To accurately prescribe measures that can reduce health problems, we need to understand the scope of health problems (Figure 1).[31] To improve comparability and quality of epidemiological studies in football, one consensus-statement has been published.[38] This consensus statement is from 2007 and is not aligned with the newer International Olympic Committee (IOC)-consensus statement regarding where increased attention to injury burden is highlighted.[37] Most studies have mainly reported the injury incidence and have not included measures of burden or prevalence, reducing the ability of these studies to target preventive measures.

To summarise the existing literature, two systematic searches were performed in the PubMed database (Tables 1 and 3) on the 18th of May 2021.

Table 1: Search strategy for the literature review on injuries in elite youth football

Inclusion criteria	**Exclusion criteria**
✓ Football (soccer) players	✓ Mixed sport
✓ Population 15 years to 19 years	✓ Children and adults
✓ High-level, elite or academy players	✓ Non-elite youth players
✓ Prospective data collection	✓ Cross-sectional, retrospective, case-series or intervention studies
✓ Minimum duration of 1 season/year	✓ Duration <1 season/year
✓ Overall injury outcome with prevalence, incidence or burden	✓ Studies on specific injury types
✓ Full article available in a peer-reviewed journal	✓ Abstract, conference paper, review, letter or chapter
✓ English language	✓ Non-English language
✓ Article published in or after 2011	✓ Article older than 10 years

Domain (combined with AND)	**Keywords (combined with OR within each domain)**
Sport	football, soccer
Population	young, youth, elite, male, female, professional
Outcome	injur*, illness*, health problem*
Analysis	incidence, prevalence, burden, surveillance, audit
Initial search results (PubMed 18.05.2021): 730	
Included studies after screening titles, abstracts and reference lists: 6	

Table 2 Prospective studies reporting overall, training and match incidence relative to exposure hours in elite youth football

1st author (year) Duration	Level Country	Players	Age	Health problem definition	Health problem recorder	Incidents	Exposure	Incidence (per 1000 hours) Overall	Training	Match
Ergün (2013)[60] 3 seasons	National team Turkey	52	U17-19	Medical attention & time loss injuries	Medical staff	44	Individual	MA: 18.4 TL: 12.1	MA: 10.5 TL: 7.4	MA: 48.7 TL: 30.4
Nilsson (2016)[61] 2 seasons	Elite team Sweden	43	15-19 yr.	Time-loss injuries	Medical staff	61	Individual	6.8	5.6	15.5
Bacon (2017)[62] 2 seasons	Academy England	41	U18-21	Unclear	Medical staff	85	Individual	10.6	3.7	5.8
Bowen (2017)[63] 2 seasons	Academy England	32	U18-21	Time-loss injuries	Medical staff	138	Individual	12.1	7.9	33.5
Delecroix (2019)[64] 4 seasons	Academy France	52	U19	Time-loss injuries	Unclear	182	Individual	7.6	N/A	N/A
Loose (2019)[65] 1 season	Elite division Germany	Unclear	U19	Time loss & non-time loss injuries	Player/ Medical staff	Unclear	Individual	10.4	N/A	N/A

MA: Medical attention. TL: Time loss

Table 3 Search strategy for the literature review on injuries in professional football

Inclusion criteria	**Exclusion criteria**
✓ Football (soccer) players	✓ Mixed sport
✓ Population 16 years and older	✓ Children
✓ High-level, elite or academy players	✓ Non-elite and amateur players
✓ Prospective data collection	✓ Cross-sectional, retrospective, case-series or intervention studies
✓ Minimum duration of 1 season/year	✓ Duration <1 season/year
✓ Overall injury outcome with incidence and burden	✓ Studies on specific injury types
✓ Full article available in a peer-reviewed journal	✓ Abstract, conference paper, review, letter or chapter
✓ English language	✓ Non-English language
✓ Article published in or after 2011	✓ Article older than 10 years
✓ Minimum 200 player-seasons included	✓ Less than 200 player-seasons included
Domain (combined with AND)	**Keywords (combined with OR within each domain)**
Sport	football, soccer
Population	young, youth, elite, male, female, professional
Outcome	injur*, illness*, health problem*
Analysis	incidence, prevalence, burden, surveillance, audit
Initial search results (PubMed 18.05.2021): 1497	
Included studies after screening titles, abstracts and reference lists: 12	

Table 4 Prospective studies reporting overall, training and match incidence relative to exposure hours in elite football

1st author (year) Duration	Level Country	Sex	Players	Health problem definition	Health problem recorder	Incidents	Exposure	Incidence (per 1000 hours) Overall	Training	Match
Dauty (2011)[66] 15 seasons	Elite France	Male	173	Time-loss injuries	Medical staff	903	Individual	4.7		
Kristenson (2013)[67]	Elite Sweden & Norway	Male	32 teams	Time-loss injuries	Medical staff	2 241	Individual		3.7	21.7
Bjørneboe (2014)[68] 6 seasons	Elite Norway	Male	14 teams	Time-loss injuries	Medical staff	2365	Individual	4.8	1.9	15.9
Salces (2014)[69] 1 season	Elite Spain	Male	427	Time-loss injuries	Medical staff	1293	Estimated	5.7	3.5	43.5
Stubbe (2015)[70] 1 season	Elite Netherlands	Male	217	Time-loss injuries	Medical staff	286	Individual	6.2	2.8	32.8
Bjørneboe (2016)[71] 4 seasons	Elite Europe	Male	18 teams	Time-loss Illness	Medical staff	1914	Individual	1.5		
Smpokos (2018) 3 seasons	Elite Greece	Male	123	Time-loss injuries	Medical staff	93	Individual			55
Jones (2019)[72] 1 season	Professional England	Male	243	Time-loss injuries	Medical staff	473	Individual	9.1	6.8	24.30
Sprouse (2020)[73] 8 seasons	International teams England	Male & Female	8 teams	Time-loss injuries Time-loss illness	Medical staff	216	Individual	Illness: Combined: 0.58	Injury: Male: 3.8 Female: 5.0	Injury Male: 31.8 Female: 18.5
Klein (2020)[74] 3 seasons	Professional Germany	Male	1449	Time-loss and medical attention[a]	Medical staff	7493	Estimated	12.5	47.0	8.0

Lu (2020)[75] 6 seasons	Elite Australia	Male	421	Time-loss injuries	Medical staff	917	Estimated	4.8-6.7[b]		
Ekstrand (2021)[76] 18 seasons	Top-elite Europe	Male	3302	Time-loss injuries	Medical staff	11820	Individual	6.6	3.3	23.8

[a] Employed a hybrid definition where both time-loss and/or medical attention would be counted as an incident.

[b] Range across the six seasons.

The systematic searches yielded six articles on elite youth football and 12 articles on elite football. All articles focused solely on incidence and did not report any measure of prevalence. Furthermore, none of the elite youth articles included or focused solely on girls/female players. Only Sprouse et al.[73] included female professional players in their study.

Incidence

For elite youth football, using the time-loss definition, the injury incidence ranged from 6.8 to 18.4 overall, 3.7 to 7.9 for training injuries and 5.8 to 30.4 for match injuries (Table 2). Only Ergün et al.[60] reported incidence using the medical attention definition, which was 18.4 overall, 10.5 for training injuries and 48.7 for match injuries. In elite football, all studies used a time-loss definition, and the health problem incidence ranged from 4.7 to 9.1 overall, 1.9 to 6.8 for training injuries and 15.9 to 55.0 match injuries (Table 4).

Sprouse et al.[73] found an illness incidence of 0.58 per 1000h. Using a different time period to calculate illness incidence, Bjørneboe et al.[71] reported an illness incidence of 1.5 per 1000 player-days for professional players.

Burden

Only two studies included a measure of injury burden. For elite males, Ekstrand et al.[76] found a burden of 60.5 days per 1000h and 504.6 per 1000h. Sprouse et al..[73] reported a burden for female and male professional players combined, of 36.2 per 1000h for training and 455.7 per 1000h for matches. For female and male youth players from the under 15 to 19 categories, the training injury burden was 60.2 per 1000h and 450.0 per 1000h for match injury burden. Lu et al.[75] reported an average of 44 missed matches per team across a six-season.

There are also two studies reporting illness burden. Sprouse et al.[73] reported an illness burden for male and female professional football of 2.5 absent days per 1000h, and Bjørneboe et al.[71] reported illness burden to be 7.0 absence days per 1000 player-days.

Severity

There are considerable differences in how the severity of injuries has been classified. Most studies have reported by the recommendation of the previous consensus statement, using the categories mild (1-3 days), minor (4-7 days), moderate (8-28 days) and severe (>28 days).[38] Using this categorisation, Jones et al.[72] reported that almost half of the injuries were in the moderate category. Both Kristenson et al.[67] and Stubbe et al.[70] found that the category with the most injuries was the moderate category with more than 1/3 of the injuries. Klein et al.[74] reported that one of four injuries were in the moderate or severe category. Salces et al.[69] reported somewhat less severe injuries and had more than one-third of injuries in the mild category. Using a categorisation with the categories mild (1-7), moderate (8-28), severe (29-89) and major (≥90). Lu et al.[75] found two-thirds of all injuries in the mild category. Bjørneboe et al.[68] used three categories (mild, 1-7days; moderate, 8-21 days and severe >21 days) and reported that every second injury was in the mild category. Ekstrand et al.[77] reported severity as the average number of absences, and found 18 and 21 for training injuries and match injuries, respectively.

Sprouse et al.[73] reported the median severity of an illness to be two days. Bjørneboe et al.[71] reported that most (91%) illnesses had minimal (0-days) or mild (1-3 days) severity.

Training load

Training load is defined as any stimulus placed on a human biological system from training or competition.[27] All physical activity elicits training load, and training load will always give a physiological response from the activity performed.[27,78] Although it has recently been massively investigated in relation to injury (Table 7), the use of training load stems from the prescription and evaluation of training.[79,80] Using a more practical approach, training load can be seen as the input variable to elicit a training response.[81]

Training load can be divided into different dimensions. The most common way to group training loads is the constructs external and internal training load.[82,83] External training load is the amount of work performed by an athlete at any given time period (e.g., minutes of football play, total distance, sprint distance, number of accelerations). Internal load is the players' psychophysiological response to the external load. The most common way of measuring internal training loads are through heart rate monitors and rating of perceived exertion (RPE; Table 6).[84] Vanrentghem et al.[85] proposed an extension of this framework where two main groups of load-adaptation pathways are included. Physiological loads are the training loads that mainly affects metabolic systems (e.g. oxygen uptake, heart rate, kinetic energy). Biomechanical loads predominantly lead to stresses in the musculoskeletal system (e.g. cartilage, bone, tendons and muscle tissue). Altogether, these different groups of training load provide us with a framework for choosing the appropriate parameters, both in practice and research settings. The training load cycle consists of three steps that must be performed when prescribing training and returning to play loads (Figure 2). These three steps will be discussed in this section.

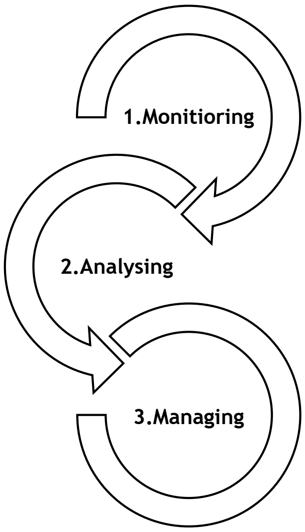

Figure 2 The training load management cycle

Monitoring training load

The process of collecting training load data is often referred to as training load monitoring. How these parameters are collected is context specific. The amount of data collected each day is massive in professional teams, whereas semi-professional and amateur teams typically collect a significantly smaller amount. The most considerable difference in the amount of data is whether teams are using microtechnology or not. Advances in player tracking technology can provide accurate and valid data on players' training load in training and match.[86,87] Local or Global Positioning Systems (LPS; GPS), and accelerometer devices are typically worn every training and match and provide positional and physical data sampled at 10-100Hz.[88] These microdevices gives us an objective measure of training load, and it does not consider the players' perceptions. Subjective measures, like perceived physical and psychological well-being questionnaires and RPE, have been recommended over objective markers, as they can also reflect players mental fatigue.[89,90] Originally proposed by Foster et al.,[84] sRPE consists of quantifying the players perceived exertion of a session using a category scale (CR10-Scale) and multiplying it with the session duration.[84] It is considered a reliable and valid measure of internal training load,[91,92] and several studies have established its construct validity by comparing it to reference measures of internal load.[93-96] sRPE is the most used training load variable in both practise and research.[97] Presumably due to its ease of use, little cost and ability to quantify loads across many activity forms (e.g. football, strength training, running, etc.).

Although there are different groups of training load, a mix between subjective and objective, internal and external, and biomechanical and physiological is typically monitored and recommended in football.[20,22,97] In the training process framework proposed by Impellizzeri et al.,[82] one should include measures of external load, internal load and the training outcome. Monitoring these components can provide an understanding of whether the prescribed training (external load) has induced the planned response (internal load) and finally if that response has induced the expected training adaptations (training outcomes).[98]

Analysing training load

After the training load data is collected through the monitoring phase, the next step is to transform it into meaningful insights. There are many ways to analyse training load data, and it can broadly be divided into two categories, absolute and relative.[99,100] Absolute loads are simply the amount of load performed through the course of a time period (e.g. cumulative or average loads from training sessions or matches, days, weeks). Shorter periods (i.e.1-9 days) are typically called acute periods, and more extended periods (i.e.>9 days) are called chronic periods. Absolute loads can also be analysed as the number of matches during a time period, often referred to as match congestion.[4] Furthermore, pre-season participation has also been used to measure absolute loads in recent training load and injury research.[101]

Relative loads are the absolute loads but in relation to a reference. The most used references are the competition demand and training load history. When using game demands as a reference, the absolute training load is divided by the game demand (i.e. the player has this week performed 500m of sprinting, or 1.2 times the game demand), and is contextualised practically for players and coaches.[20,102] The game demand reference is most often used as a whole game average[102], but it can also be a "worst case" period (e.g. the most demanding 60s period),[103], although its usefulness is debated.[104]

Many different approaches are possible when using load history as a reference (also referred to as change-in-load). One option is to analyse strain and monotony.[105] Monotony is the daily training load average divided by the standard deviation, and strain is the average weekly training load multiplied by monotony. Another alternative is to calculate basic differences between periods, such as the week to week change. This can be done as the absolute change in load (e.g. the increase from week 4 to week 5 was 200m) or the percentage change in load (i.e. 100% increase).[99]

Another concept is the acute-chronic workload ratio (ACWR). ACWR was introduced by Hulin et al. in 2014[25] as a modification of Banister's fitness-fatigue model.[80]

$$\frac{Acute\ load\ (Week\ 1)}{Chronic\ load\ ((Week\ 1 \times 0.25) + (Week\ 2\ \times 0.25) + (Week\ 3\ \times 0.25) + (Week\ 4\ \times 0.25))}$$

It is calculated by dividing the total amount of training an athlete has recently completed (i.e. 3-9 days) by the amount they have completed over a more extended time period (i.e. 14-28 days). ACWR intends to reflect athletes' preparedness for training by accounting for both positive and negative training effects (i.e., fitness and fatigue). There are, however, many different possible ways of calculating this metric, and it is unclear whether the calculation approach can affect the relationship between ACWR and injuries. This knowledge gap is addressed in *Paper II.*

Managing training load

After monitoring and analysing the training load, the next step is to use the data in an informed decision on training prescription. The training load data can help inform decisions related to 1) the load athletes need to be prepared for in competition, 2) the load they are prescribed, and 3) their subsequent response to that load.[106]

Impellizzeri et al.[82] proposed a framework where both external and internal load is used to link the data and the performance construct. The first step is to identify the key determinants of performance, before setting training goals and prescribing training. External training load is used to ensure that the training went as planned, and internal training load is used to ensure that the players psychophysiological response to the training was as planned. In a recent editorial by West et al.,[106] the authors propose five overarching levels for training load management decisions. From long to short term, the levels include 1) long-term use (e.g. managing players across several seasons), 2) season planning (e.g. prepare for game demands), 3) day-to-day planning (e.g. plan and perform training session to fit the weekly periodisation), 4) in-session adjustment (e.g. live evaluation and intervention on players physical outputs) and 5) feedback (e.g. how can we learn from this training session for the next session?).[106]

Training load and health problems

When performing training or match play, training load will elicit a psychophysiological stimulus. The physiological systems will then either go through a recovery period and adapt to the increased demand (i.e. increase its capacity) or undergo maladaptation if the stimulus was excessive (i.e. tissue damage).[78,107]

Creating an accurate framework of the relationship between load and injury is difficult. Injury is a complex and dynamic outcome influenced by a multitude of factors, often without a predictable pattern. Bittencourt et al.[108] exemplified this by their complex model for sports injury, which outlines a web of determinants that display a dynamic and open structure with inherent nonlinearity due to recursive loops and interactions between risk factors. While the complex nature of injury makes prediction extremely difficult, recognising and measuring known risk factors may help determine specific periods when players may be at an increased risk of injuries.[106] Meeuwisse et al.[109] demonstrate how intrinsic and extrinsic risk factors influence risk and are dynamic. For non-modifiable risk factors (e.g. age, sex), single baseline values can be enough. On the other hand, for modifiable risk factors that change over time, one must use repeated measures that coincide with the change. Some modifiable risk factors are relatively slowly changing, such as player strength, muscle balance, and fitness level can be measured over a longer time (e.g. every three months).

Contrary to the slowly changing factors, training load is a rapidly evolving risk factors and must be updated daily.[106] In an attempt to include training load in an injury aetiology model, Windt and Gabbet[110] describe how loads expose can contribute to injury in three ways: 1) exposure to external risk factors and potential inciting events, 2) fatigue, or negative physiological effects, and 3) fitness, or positive physiological adaptations. However, this framework does not establish a clear causal relationship between load and injury. How and if training load is causally related to injury risk is an area of an ongoing investigation and discussion.[111-113]

The relationship between ACWR and health problems

After investigating the scope of health problems in football, the next step in the sequence of prevention is to establish the cause and mechanisms of the problems (Figure 1). Developing interventions that eventually can prevent health problems and understanding the relationship between specific training load metrics and health problems is essential. As many training load metrics have been investigated in their relation to health problems, I have narrowed the literature to the most relevant metric in this dissertation, the ACWR. This literature will assess the relationship between ACWR and health problems and the methodological quality in this field of research.

To summarise the existing literature, a systematic search was performed in the PubMed database (Table 5) on June 3Rd 2021.

Table 5 Search strategy for the literature review on ACWR and health problem studies in football

Inclusion criteria	Exclusion criteria
✓ Football (soccer) players	✓ Mixed sport and gender samples
✓ Full article available in a peer-reviewed journal	✓ Abstract, conference paper, review, letter or chapter
✓ English language	✓ Non-English language
Domain (combined with AND)	**Keywords (combined with OR within each domain)**
Sport / population	football, soccer
Outcome	injur*, illness*, health problem*
Exposure	Acute**chronic workload ratio*, ACWR
Initial search results (PubMed 06.06.2021): 76	
Included studies after screening titles, abstracts and reference lists: 17	

Table 6 The methodology used to calculate and analyse ACWR in articles investigating ACWR and health problems in football

1st author (year)	Load variable	Average	Acute time-period	Chronic time-period	Coupling	Analysis type	Categorisation	Number of categories	Reference category
Bowen (2017)[63]	GPS: TD, HSD (>20 km/h), TL (Total of the forces on the player over the entire session based on accelerometer data alone), ACC (change in GPS speed data for at least half a second with maximum acceleration in the period of at least 0.5 m/s)	RA	7	28	Coupled	Categorical	Z-score	5	N/A
Jaspers (2017)[114]	sRPE, GPS: TD, HSD (>20 km/h), ACC (N efforts >1ms^{-2}), DECC (N efforts <-1ms^{-2})	RA	7	28	Coupled	Categorical	Tertiles	3	Low
Lu (2017)[115]	sRPE, GPS: TD, LSD (<14.5 km/h), HSD (>14.5 km/h), WHSD (>20 km/h)	RA	7	21	Coupled	Categorical	Mean ± SD	N/A	Mean
Malone (2017)[116]	sRPE	RA	7	28	Coupled	Categorical	Quartiles	4	Low
McCall (2017)[117]	sRPE, number of sessions	RA	7	28	Coupled	Categorical	N/A	N/A	N/A
Watson (2017)[118]	sRPE	RA	7	28	Coupled	Categorical	z-score	N/A	N/A
Delecroix (2018)[119]	sRPE	RA	7	14,21,28	Coupled	Categorical	Z-score	3	Moderate
Fanchini (2018)[120]	sRPE	RA	7	14,21,28	Coupled	Categorical	Percentile	4	Low
Malone (2018)[121]	sRPE	RA	3	21	Coupled	Categorical	Quartiles	4	Low
McCall (2018)[122]	sRPE	RA	7	14,21,28	Coupled	Categorical	Centiles	4	extremely low, moderately low, moderately high

1st author (year)	Load variable	Average	Acute time-period	Chronic time-period	Coupling	Analysis type	Categorisation	Number of categories	Reference category
Bowen (2019)[123]	GPS: TD, LSD (<14.4 km/h), HSD (19.8-25.2 km/h), SD (>25.2km/h), ACC (An increase in GPS speed data for at least half a second with maximum acceleration in the period at least 0.5 m/s/s), DECC (A decrease in GPS speed data for at least half a second with maximum deceleration in the period at least 0.5 m/s/s.)	RA	7	28	Uncoupled	Categorical	Z-score	6	N/A
Delecroix (2019)[64]	sRPE	RA	7	14,21,28	Coupled	Categorical	N/A	N/A	N/A
Raya-González (2019)[124]	sRPE	RA	7	28	Coupled	Continuous	N/A	N/A	N/A
Arazi (2020)[125]	sRPE	RA, EWMA	7	28	Coupled	Continuous	N/A	N/A	N/A
Enright (2020)[126]	GPS: TD, HSD (>19.8 km/h), SD (>25.2 km/h)	RA, EWMA	7	21,28	Coupled and uncoupled	Continuous	N/A	N/A	N/A
Sedeaud (2020)[127]§	Session rating of observed exertion (sROE)	RA	7	28	Coupled	Categorical	Pre-defined	4	Medium
Suarez-Arrones (2020)[128]	GPS: TD, MSC (>14.4 km/h), HSD (>18 km/h), WHSD (>21 km/h), SD (>24 km/h)	RA	7	28	Uncoupled	Categorical	Pre-defined	2	N/A

§ Sedeaud included both football players and pentathletes. The data presented in the table is from the football players only

TD, Total Distance: LSD, Low-speed distance; MSD, Moderate speed distance; HSD, High-speed distance; SD, Sprint Distance; ACC, Acceleration; DECC, Deceleration; TL, Total load; sROE, session rating of observed exertion; RA, Rolling average; EWMA, Exponentially weighted moving average

Table 7 The study characteristics, injury methodology, statistical approaches and conclusions for studies examining ACWR and health problems in football

1st author (year)	N	Sex	Age	Study approach	Latent period	Health problem definition	N Incidents	Statistical method	N Association ACWR-Injury Analyses	Conclusion ACWR and injury
Bowen (2017)[63]	32	M	17.3	Descriptive	Subsequent week	Time-loss, non-contact and contact	138	Binary logistic regression	240	↑ Risk for contact injury when ACWR TD >1.76, ACC >1.77 and TL between 0.44-0.88. ↑ Risk for non-contact injury when ACWR HSD was 1.41-1.96 combined with low chronic load, HSD 0.91.1.34 combined with high chronic load and TL 0.88–1.32 ↓ Risk for overall injury when ACWR HSD <0.36, for TD <0.32 combined with low chronic load and when ACC <0.33 combined with low chronic load. *213 analyses not significant
Jaspers (2017)[114]	35	M	23.2	Descriptive	Subsequent week	Time-loss, overuse	64	Generalised estimating equations, Magnitude-Based Inference	10	↑ Injury risk when ACWR HSD was >1.18 ↓ injury risk when ACWR ACC, DEC, and sRPE was medium *8 analyses were either beneficial or neutral
Lu (2017)[115]	45	M	26.4	Descriptive	Subsequent week	Time-loss, non-contact	39	One-way ANOVA	8	*No statistically significant associations with ACWR.
Malone (2017)[116]	48	M	25.3	Descriptive	Subsequent week	Time-loss, overall	75	Logistic regression	10	↓ Injury risk of moderate 1.00-1.25 ACWR during pre-season and in-season. ↓ Injury risk for players with greater aerobic fitness when ACWR was >1.25 compared with the other players
McCall (2017)[117]	33	M	26.6	Descriptive	N/A	Time-loss, non-contact	7	Magnitude-Based Inference of Cohen's d	6	* Small to moderate effect sizes were evident for a higher sRPE ACWR (ES = 0.45; 90% CI: 0.31–0.87) for sRPE load in injured compared to non-injured players. * Moderate-large effect sizes for increased ACWR for the number of sessions (training and matched combined) in injured compared to non-injured players. *4 analyses were not significant

1st author (year)	N	Sex	Age	Study approach	Latent period	Health problem definition	N Incidents	Statistical method	N Association ACWR-Injury Analyses	Conclusion ACWR and injury
Watson (2017)[118]	75	F	15.5	Descriptive /Predictive	Daily	Time-loss, overall	36	univariable Poisson regression models		* ACWR was found to be a significant predictor of injury *No association between ACWR and illness
Delecroix (2018)[119]	130	M	N/A	Descriptive /Predictive	Daily	Time-loss, non-contact	237	Relative Risk, ROC curves	n/a	↑ Non-contact injury risk when ACWR was distant from 1.0 using chronic 2-, 3- and 4-weeks loadings. *ACWR could not predict injury. *only reported significant findings
Fanchini (2018)[120]	34	M	26	Descriptive /Predictive	Subsequent week	Time-loss, non-contact	72	Generalised estimating equations, Magnitude-Based Inference, ROC curves	18	*ACWR of 2, 3 and 4 weeks all showed a significant association with non-contact injury. * Injury risk increased (OR >1) as ACWR values increased. *No predictive power. *12 analyses not significant
Malone (2018) [121]	37	M	25	Descriptive	Subsequent week	Time-loss, soft tissue, lower limb	75	Logistic regression	8	↑ Injury risk when ACWR HSD 3:21 >1.25 and a 3:21 day SR distance ACWR of >1.35. * Aerobic fitness had a protective effect for players who have an ACWR HSD>1.25, while players with lower aerobic fitness were at increased risk at the same ACWR. *6 results were non-significant
McCall (2018)[122]	171	M	25.1	Descriptive /Predictive	Subsequent week	Time-loss, non-contact	123	Generalised estimating equations, Roc Curves, Magnitude-Based Inference	24	* ACWR 1:3 and 1:4 showed significant associations with non-contact injuries * An ACWR 1:4 of 0.97 to 1.38 and >1.38 compared with 0.60 to 0.97 showed an increased risk of non-contact injury * An ACWR 1:3 of >1.42 compared with 0.59 to 0.97 displayed a 1.94 times higher risk of injury *No predictive power. *17 analyses not significant

1st author (year)	N	Sex	Age	Study approach	Latent period	Health problem definition	N Incidents	Statistical method	N Association between ACWR-Injury Analyses	Conclusion ACWR and injury
Bowen (2019)[123]	33	M	25.4	Descriptive	Subsequent week	Time-loss, non-contact and contact	132	Binary logistic regression	206	↑ Contact injury risk when TD, LID and DECC ACWR was moderate to high ↑ Contact injury risk with high ACWR TD, LSD and ACC. ↑ Contact injury risk when a low chronic load was combined with high ACWR TD, LSD and ACC. ↑ Overall injury risk with high ACWR High ACWR TD, DECC and LID. ↑ Overall injury risk with high ACWR ACC, DECC and LID with both low chronic loads. ↓ Injury risk with low ACWR TD. *184 analyses not significant
Delecroix (2019)[64]	122	M	18.7	Descriptive	Daily	Time-loss	489	Poisson regression analysis	9	* No association was found between none of the ACWR and 1) overall 2) non-contact or 3) contact injuries.
Raya-González (2019)[124]	22	M	18.6	Descriptive /Predictive	Subsequent week	Time-loss, non-contact	27	Generalised estimating equation, Magnitude-Based Inference	N/A	*No significant associations were found. *No predictive power
Arazi (2020)[125]	22	M	17.1	Descriptive	Weekly	Medical attention contact and non-contact	19	Kernel regression analysis	2	*Small to moderate correlations between ACWR and non-contact injury using both RA and EWMA.
Enright (2020)[126]	192	M	N/A	Descriptive	N/A	Time-loss	264	ANOVA and Pearson's R	81	*No differences in any of the workload variables and each injury tissue type.
Sedeaud (2020)[127] §	24	F	17.1	Descriptive	N/A	Time-loss	57	chi-squared test	18	*Significantly more injuries and more days lost to injury in the high group than low and medium-low. *Significantly greater chance of being absent due to injury in the medium-low and high category. *14 analyses were not significant
Suarez-Arrones (2020)[128]	15	M	18.6	Descriptive	N/A	Time-loss	2	Linear mixed model	N/A	*No difference in injured and uninjured players

§ Sedeaud included both football players and pentathletes. The data presented in the table is from the football players only

Study characteristics

Seventeen studies were included and are summarised in Tables 6 and 7. Most of the sample included only male players (n=15; 88%), except Sedeau et al.[127] and Watson et al.[118] that had female participants. Twelve of the studies were solely descriptive (n=12; 70%), whereas the remaining five were descriptive and predictive.[118-120,122,124] The median number of participants was 35 (Interquartile range; IQR; 43), and the median age was 23.2 (IQR 7.4).

The number of incidents varied across the studies and ranged from two to 489, with a median of 72 (IQR 87). As most studies used a combination of methods to analyse ACWR and health problems, the number of analyses also performed varied, from Arazi et al.[125] who performed two analyses, to Bowen et al.[63] that did 240. The median was 10 (IQR 10). In four studies,[118,119,124,128] the number of analyses was either not reported or possible to calculate.

Study methodology

Of the 17 articles included, no two studies used the same methodological approach (Table 6). The most common training load variable was sRPE which 14 of the studies used. All studies used the rolling average, but Arazi et al.[125] and Enright et al.[126] also used the exponentially weighted moving average. Seven-day acute period was used by all studies, except for Malone et al.[121] that used a 3-day acute period. Most studies used only a 28-day chronic period, Lu et al.[115] and Malone et al.[121] used only a 21-day period, Enright et al.[126] used both 21 and 28-day periods, Delecoix et al.,[119] Fanchini et al.[120] and McCall et al.[122] used both 14, 21 and 28-days. Most studies used a coupled approach for the ACWR calculation, except for Bowen et al.[123] and Suarez-Arrones[128] that used the uncoupled option, and Enright et al.[126] that used both.

Most commonly, ACWR was analysed as a categorical variable. Only Raya-Gonzales,[124] Enright et al.[126] and Arazi[125] analysed ACWR as a continuous variable. The studies that discretised the data into categories, used on average, four categories. Most used distribution-based categorisation methods, and the most frequent reference category was the medium category. Only Watson et al.[118] included illness in their study, and the rest investigated injuries only. The time-loss definition was used in all studies, except Arazi et al.[125] that used medical attention.

The statistical approach was also varying (Table 7). Only seven studies reported how they handled missing data; four used mean imputation methods[63,114,122,123], and three used listwise deletion.[115,121,126] The most frequently used analysis methods were regression models, including logistic regression (n=6), Poisson regression (n=4), generalised estimated equations (GEE; n=4) and linear regression (n=1). Other analyses included ANOVA (n=4), chi-squared test (n=3), Cohens D (n=1), Spearman's Rho (n=2) and Fisher's exact test (n=1).

Study conclusions

For studies examining health problem prediction, three reports no predictive power[119,120,122] and one report ACWR to be a significant predictor of injuries.[118] All studies investigated the association between ACWR and health problems. Most studies (n=11; 65%) report one or more associations found among their analyses, the remaining six (35%)[64,115,118,124,126,128] reported no associations. As no study has performed the same analyses using the same calculation of ACWR, same analysis approach and statistical methods, comparison and summation of the studies are difficult. In addition to the methodological issues, several conceptual issues affect the relationship between ACWR and health problems. These issues are addressed in the results and discussion section.

Prevention of injuries and illnesses in football

Several types of injury reducing protocols have been successful in football. The Fédération Internationale de Football Association (FIFA) 11+ program where players undergo a systematic warm-up has been very effective.[129-131] Another successful injury preventive measure has been introducing the Nordic hamstring strength exercise,[132] which halves the risk of hamstring injuries[133] Furthermore, Mohammadi et al.[134] introduced a proprioceptive training program that reduced the risk of ankle sprains. Hägglund et al.[135] also reduced injury risk by teaching team coaches' rehabilitation principles and a 10-step progressive rehabilitation program including return-to-play criteria. Harøy et al.[136] reported a decrease in the prevalence of groin injuries in footballers using an adductor strengthening programme. Despite an increase in game demands,[7] training and match injuries have decreased by 3% annually.[76] The reason for the decline is currently unclear, but it might be due to advances in sports medicine practice and research.[76] Altogether, these successful preventive measures show us that reducing injuries in football is possible, and further measures should be developed. If load management can be an injury preventive measure is not tested. This gap in research is addressed in *Paper II*.

Implementation of health problem preventions

Previous studies have shown that the higher the compliance, the better the effectiveness of an intervention.[137-139] Consequently, a focus on increasing compliance is vital in health problem prevention research. While the TRIPP framework suggests how research should be prioritised and what kind of studies are needed within the different steps (Figure 1), The Reach, Effectiveness, Adoption, Implementation and Maintenance (RE-AIM)[140] framework is used to determine the feasibility of interventions. RE-AIM was first introduced in sports medicine research by Finch and Donaldson,[141] to help researchers better understand the real-world implementation challenges. In this framework, an intervention can be seen through the lens of five different dimensions to determine whether the intervention is feasible in a real-world setting. Suppose an intervention that has been deemed effective in controlled settings is not adopted, complied with, and sustained. In that case, it is not likely to mitigate health problems.[141] The RE-AIM framework has been used to guide injury prevention in football.[142,143] The implementation of load management has not been investigated with an RE-AIM approach and thus is addressed in *Paper III*.

Aims of the dissertation

The overall aim of the dissertation is to improve our understanding of the relationship between training load and health problems and to use this to guide preventative efforts. We planned three projects to achieve these aims—first, methodological challenges on the current literature on ACWR and health problems (*Paper I).* Second, a cluster randomised controlled trial and a post-study survey (*Papers II and III).* Finally, an investigation on match congestion in Norwegian professional football players (*Paper IV*).

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

1. To investigate whether the relationship between ACWR and health problems varies when different methodological approaches are used to quantify it (*Paper I*).

2. To evaluate the effectiveness of a load management intervention designed to reduce the prevalence of health problems among elite youth football players of both sexes (*Paper II*).

3. To investigate players' and coaches' barriers and facilitators to a load management approach to prevent injuries and illnesses and their attitudes and beliefs of load management and injuries and illnesses in general. (*Paper III*).

4. To investigate seasonal differences in injury characteristics between a regular and match-congested season (*Paper IV*).

Methods

Context and study design

The four papers included in this dissertation were all conducted on Norwegian football players and coaches (Figure 3). *Paper I, II and III* investigated elite youth teams that compete in one of the two highest divisions in the U19-category. This cohort of players were chosen as they typically train with and play for several different teams, making their load management challenging. Furthermore, this was deemed one of few cohorts where coaches systematically plan their training and, at the same time, where we would be allowed to influence their training content. *Paper I* was conducted from July to October 2017, including the summer-break, transition into completive season and competitive season. *Paper II* was conducted from February to November 2018, following players a full season. *Paper III* was performed when teams finished their 2018 season.

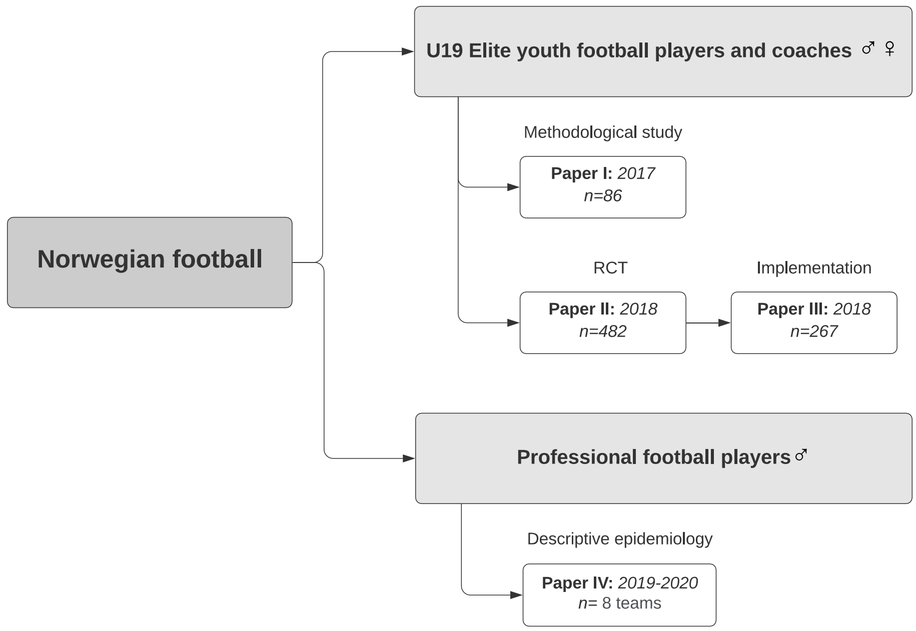

Figure 3 Overview of the papers and participants in the dissertation

In both projects, players were identified as potential participants based on their membership in a team. For the second project, we also included the coaches of the same teams, who also were identified based on their team membership. We excluded teams that already used a load management system and players that were likely to be absent from football training and match play for the study period due to severe health problems at baseline.

The last project was conducted on Norwegian professional football players, competing in the Norwegian premier league (Eliteserien; *Paper IV*). The Norwegian premier league consist of 16 teams spread across the country and is currently number 22 in the Union of Football Associations (UEFA) country coefficient.[144] In this paper, we invited all teams that had participated in both the 2019 and 2020-seasons, and that had used the same medical staff to register injuries in both seasons.

Paper I was a descriptive study that used a prospective cohort design to assess methodological issues in the relationship between ACWR and health problems. *Paper II* was a cluster-randomised trial that assessed the effectiveness of a load management programme on health problem prevention. *Paper III* was a cross-sectional study that investigated implementation issues for load management. *Paper IV* was an explorative descriptive study that used a prospective cohort design to assess the injury characteristics of two football seasons.

Participants and ethics

Participants included in the papers are 1) elite youth football players *(Papers I, II* and *III)* 2) elite youth football coaches *(Paper III)* and 3) professional football players (*Paper IV*; Figure 3).

Study samples

Paper I included 86 elite youth footballers from six teams (three girls' and three boys' teams), and we recorded 6250 player-days. *Paper II* consisted of 482 players from 25 teams (12 girls' and 13 boys' teams), and we recorded 394 player-seasons. *Paper III* included 250 players and 17 coaches. *Paper IV* included eight teams and we collected approximately 400 player seasons.

Ethics

We obtained written informed consent from all participants. *Paper I* was reviewed by the South-Eastern Norway Regional Committee for Medical and Health Research Ethics (2017/1015) and approved by the Norwegian Center for Research Data (5487) before starting the study. *Papers II* and *III* were reviewed by the South- Eastern Norway Regional Committee for Medical and Health Research Ethics (2017/2232) and approved by the ethics board of The Norwegian School of Sports Sciences (39–1 91 217) and the Norwegian Center for Research Data (56935). As we did not collect any new health data in Paper IV, we did need ethical approval. The Norwegian Centre for Research Data approved the paper (896416).

Health problem surveillance (Papers I, II and IV)

For the three papers that included surveillance of health problems, we chose three different approaches. In *Paper I*, to link daily training load to health problems, we needed a method that could capture the players' daily health status.

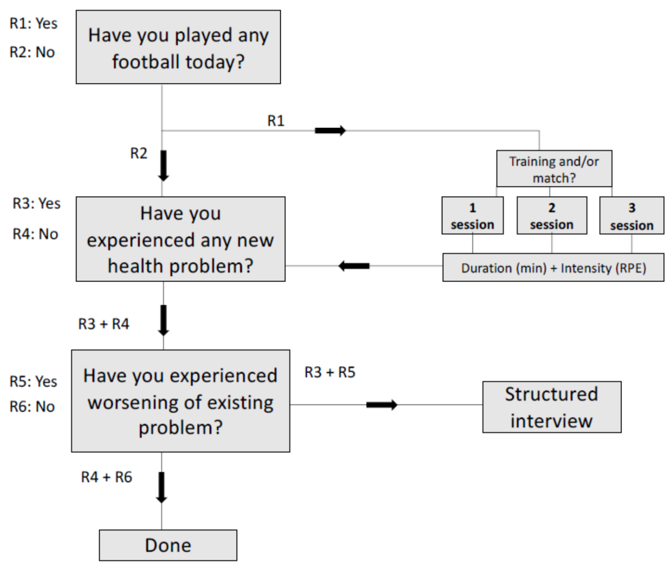

Figure 4 Daily training load and health problem questionnaire structure in Paper I

We asked the players to record their health status in the daily questionnaire by answering two questions (Question 2 and 3; Figure 4). Players were categorised into one of the following four "states", 1) 'healthy', 2) 'new health problem', 3) 'existing health problem' or 4) 'worsening of an existing health problem'. Players were asked to report all complaints, irrespective of their consequences on football participation or their need to seek medical attention. If the player reported any new health problems or a worsening of an existing problem, a sports medicine clinician (physiotherapist or chiropractor) contacted them by telephone the following day to conduct a structured interview. During this interview, we classified health problems according to the UEFA guidelines as injury or illness, acute or overuse, contact or non-contact, injury mechanism, tissue and body part.[145] A health problem was defined as a change from the healthy state to the new health problem state, or as a change from existing health problem to worsening of an existing health problem. As we collected health problems with a broad health problem definition and had diagnosed the health problems via interviews, we could use several definitions of health problems in our analyses. We chose three definitions, 1) 'all health problems', 2) 'all injuries' and 3) 'new non-contact injuries'.

In *Paper II*, we followed players for a full season using the OSTRC-H2 questionnaire to record health data.[146] Players responded to the questionnaire in the last week of each month and were instructed to report health problems for the previous 7-days only, giving us weekly prevalence of 10 intervals at approximately 1-month apart. Players were asked to report all complaints, irrespective of their consequences on football participation or their need to seek medical attention, including illness and injury.[38] If players answered anything but the lowest score ("no problem") on either of the questions, a health problem was registered. If a player registered alternative two or higher (i.e., moderate or severe reduction, or inability to participate) in question 2 (training volume) or 3 (performance), the health problem was registered as substantial. Each month, we calculated prevalence of both outcomes by dividing the number of players reporting either a health problem or a substantial health problem to the total number of respondents in each group. To ensure consistent reporting of all health problems, we familiarised players with the definitions in the pre-study meeting, and repeatedly emphasized the importance of reporting all health problems during the study period, irrespective of their consequences. We informed the players that the coaches and other club staff members did not have access to any health data.

In both *Paper I* and *Paper II*, the questionnaire was distributed using an online survey software (Briteback AB, version 2.5.3.1; Norrköping, Sweden) via short message service (SMS) Sunday at 9 PM. Non-responders received an SMS-reminder the following morning at 8 AM.

In *Paper IV*, we used data gathered by the teams participating in the study. Six teams manually extracted injury data from the medical records and/or their data records, whereas two teams exported data directly from their Athlete Monitoring System (AMS). When organising the data into comparable spreadsheets, we had video or telephone consultations with each of the teams' medical coordinators to ensure that all data were comparable across the two seasons and to exclude any data recording errors. An injury was defined using a time-loss definition.[37,38] We ensured that all team's had used the same interpretation. All reported that they used the same criteria for return to play, i.e. when a player was cleared for full participation in either team training or match play. The number of days injured starting from the day after the onset of the injury (i.e. the first potential absence from team training activity) until the return to full participation was considered days lost to injury and used to calculate injury incidence and injury burden. When analysing the injury burden, all days lost to injury were assigned to the month the injury was registered (e.g. an Anterior Cruciate Ligament; ACL injury in January 2019 would be attributed 300 days lost to injury and 30 matches missed in January). Injury severity was calculated based on the number of days lost per injury and categorised as recommended in the IOC consensus statement.[37] Availability was calculated as the average percentage of players available for match selection. If a player was absent due to a reason other than an injury, the player was removed from the available player's calculation.

Training load monitoring (Papers I and II)

In *Paper I*, we used a short online questionnaire to monitor daily training load. A link to the questionnaire was distributed by an automated SMS at 9 p.m. every evening. If players had not replied to the questionnaire before 8 a.m. the following morning, they received an SMS reminder. The questionnaire included questions with structured response options on training load data for all football activity, including organized training and matches, as well as non-organized football play (Figure 4).

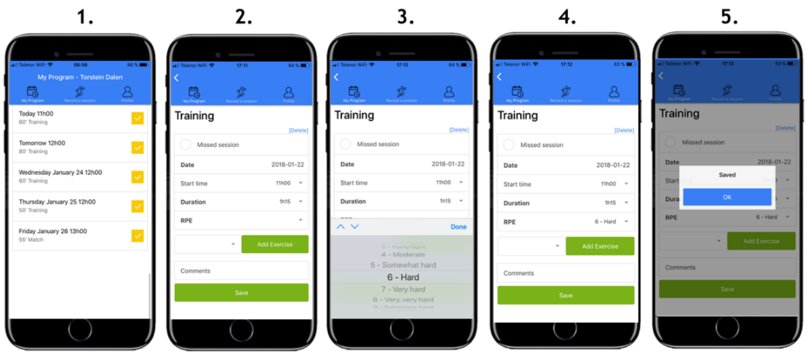

Figure 5 An overview of the training load recording process for the players in the intervention group

In *Paper II*, the intervention group players recorded their training load ten minutes after each training session was planned to be completed. A link to a questionnaire (Figure 5) in the AMS smartphone app was sent to the players via an automated short message service. If players had not replied to the questionnaire 12 h post activity, they received a second SMS, reminding them to complete the questionnaire. If players failed to complete the session questionnaire, the AMS treated the player as not being a part of the training and leaving a session-value of nil in the calculations (and falsely decreasing the load of the player).

In both papers, players were asked to record the duration in minutes and their sRPE using the modified Borg CR-10 scale.[84] We calculated an arbitrary training load unit (au) by multiplying the duration and the sRPE[84] for all footballing activity. Players were familiarized with the collection method as well as the Borg scale before study start.

Training load management (Paper II)

The intervention consisted of individualised load management of every player in the intervention group. Intervention group-coaches planned the weekly training plan (micro-cycle) based on each player's training load history. A commercially-available AMS assisted coaches in planning player micro-cycles, based on ACWR theory.[147] ACWR was calculated as the coupled 7- to 28-day ratio using a rolling average. We instructed the intervention group-coaches on training load management theory and how to use the AMS to plan training content, duration and intensity. Each coach received a one-hour introductory session and a follow-up session two weeks later if necessary. Coaches were instructed to follow a periodization model based on the "optimal range" concept described by Hulin et al.[147,148] where the aim was to progress or maintain player load while ensuring they remained within the desired ACWR range of 0.8 to 1.5.

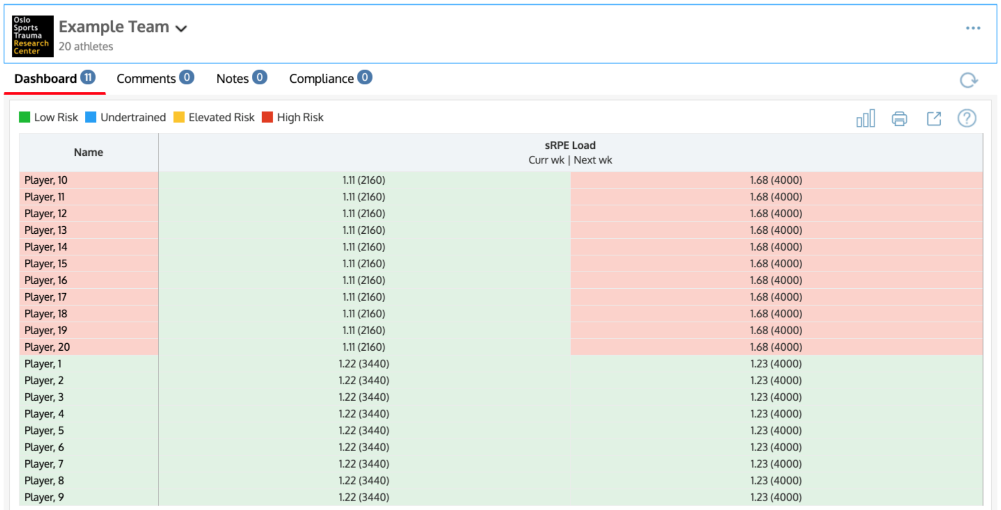

Figure 6 Coaches dashboard in the AMS after next week's training load is planned (Paper II)

All training load data reported by the players were instantly available on the coach dashboard in the AMS (Figure 6). After finishing all weekly football activity every Sunday evening, coaches reviewed and arranged the individual training plans for the following week. The coaches were expected to have detailed insight into all their players' planned training and match activities (including activities outside the club team, e.g. high-school training, regional team, national team). The AMS combined the subsequent week's (7-days) planned training load with the training load from the past 21-days (a rolling average of 28-days) and calculated the planned ACWR for the subsequent week.

If the planned training activity in the subsequent week led to players having an ACWR below 0.8, the AMS alerted the coach with a suggestion to increase the load accordingly. Conversely, if the planned activity led to an ACWR above 1.5 for, the AMS alerted the coach and suggested that they decrease the planned load.

Recording of attitudes and beliefs (Paper III)

In *Paper III,* we used questionnaires to investigate players' and coaches' experiences from a load management intervention and their attitudes and beliefs to load management and injuries and illnesses in general. The questionnaires were influenced by the reach, adoption and implementation pillars of the RE-AIM framework[149] and two similar questionnaires used to examine the implementation of the OSTRC Shoulder Injury Prevention Programme in handball players[150] and the Adductor Strengthening Programme in football players.[143] The overall theme of the questionnaires was player's and coach's barriers and facilitators for implementation of load management to prevent injuries and illnesses and their attitudes and beliefs of load management and injury and illness in general. The questionnaires differed in two ways. 1. Coaches were asked specific questions on their role in the intervention and their perception of the players and vice versa. 2. The players and coaches in the intervention group were asked additional questions regarding their experiences of the intervention. We conducted a pilot test with two players and one coach from a similar youth elite football setting to test their understanding of the questions, the length of the questionnaire and the technical procedures. The questionnaires that were tested were the intervention group player and coach questionnaires, as they include all the questions from the control group questionnaires, in addition to the specific intervention questions. A research staff member interviewed the players and coaches. All agreed that the questions were clear and relevant, the overall length of the questionnaire acceptable, and the technical solutions suitable. No changes were made based on the pilot study, as we considered the face validity of the study to be strong. Four versions of the questionnaires were developed; one for the intervention group players, one for the intervention group coaches, and one for the control group players and the control group coaches. The questionnaires were in Norwegian, as all players and coaches participating were familiar with the Norwegian language.

Teams that agreed to participate received a questionnaire distributed using online survey software (Briteback AB, version 2.5.3.1; Norrköping, Sweden). The data collection started as soon as the teams completed their competitive season, and hence, were finished as participants in *Paper II* The questionnaires were distributed at 9 PM on a weekday when all other activities (e.g. schoolwork and training) were likely to be completed. Players who did not respond to the initial questionnaire received a reminder 24h after the first distribution. Two weeks after the initial round of distribution, all non-respondents were sent the questionnaire again, as well as the 24h post reminders.

Data management and statistical analyses

Paper I

The aim of *Paper I* was to investigate whether the relationship between the acute:chronic workload ratio (ACWR) and health problems varies when different methodological approaches are used. With this in mind, we used a random-effects logistic regression model analyse all combinations of the 12 independent and 3 dependent variables, comparing the medium ACWR group to the low and high groups and the low group to the high group. We performed a total of 108 (all combinations X comparisons) separate analyses using Stata software (version 15.3 StataCorp LLC, College Station, TX), with the xtlogit command. A random-intercept model was used, and the random error term was assumed normal distributed (with mean 0). We did not adjust the regression models for confounding by sex, age or for the effect of clustering by individuals and teams. The incidence rate was calculated by dividing the total number of cases satisfying each health problem definition by the total exposure time and multiplying by 1000 hours. We calculated the absolute daily risk of health problems by dividing the number of cases satisfying each health problem definition by the total number of athlete days in the study.

When athletes' training load data were incomplete, either due to missing session duration or RPE, we replaced the missing values of individual players with the team average for that session. If an entire session was unreported, we did not attempt to estimate missing data. Instead, we defined a minimum amount of information necessary to make an ACWR calculation (5 days for a 7-day acute period, 14 days for a 21-day chronic period and 21 days for a 28-day chronic period) and used a statistical model (random-effects logistic regression) capable of handling incomplete datasets.

Paper II

In *Paper II,* we aimed to investigate the effectiveness of load management on health problems in elite youth football. We defined the primary effect measure as the between-group difference in prevalence (intervention – control), and the secondary effect measure as the relative risk ratio (intervention/control). To evaluate the effectiveness of the intervention, we fitted generalized estimating equations panel-data models to the two outcomes: all health problems and substantial health problems. The models were defined with a binomial family, a log-link function, and an exchangeable correlation matrix. The estimated standard errors were adjusted for clustering, and a Kauermann and Carroll bias-corrected variance estimator,[151] which is specifically recommended for cluster randomized trials, was used. The models included terms for group (intervention vs control) and time, and we report the results for group as the relative risk of intervention vs control. Initial models also included a term for group x time interaction; however, this term did not impact the models (P=0.44 for all health problems; P=0.34 for substantial health problems), and we removed the interaction term to obtain a simple and easily-interpretable estimate of the intervention effect. We used the xtgeebcv command[152] in Stata (version 15.3 StataCorp LLC, College Station, TX). No attempt to impute missing training or health data was performed. All analyses were performed according to the intention-to-treat principle, using a full analysis set-definition; that is, we included all available data and analysed the teams as randomised. Teams that withdrew from the study directly after randomisation were excluded, as were players who did not record any outcome data.

The sample size calculation was based on an average prevalence of health problems among elite youth footballers of 40%.[153] Based on an analysis of variance of within-subject and within-team prevalence, an inflation factor (DE) of 1.65 (to account for randomization at the cluster level), a cluster size of 20 players, a power of 80% and a 5% significance level (α), we estimated that a sample of 2 x 380 players would be needed to detect a 40% reduction in prevalence. This was based on previous studies with a similar design,[154,155] and on our estimation of what coaches would consider a worthwhile meaningful difference. To find the inflation factor, the following formula was used $DE = 1+(n-1)p$, where n is the number of individuals and p is the intra-cluster correlation coefficient.[156]

Paper III

The aim of *Paper III* was to investigate the players' and coaches' barriers and facilitators to a load management approach to prevent injuries and illnesses and their attitudes and beliefs of load management and injuries and illnesses in general. We included all returned questionnaires in the analysis regardless of missing items. All responses were exported into Microsoft Excel (Version 16, Microsoft Corp. Redmond, WA, United States) and analysed using descriptive statistics.

Paper IV

In *Paper IV,* we aimed to investigate the injury characteristics in Norwegian professional football across two seasons. We presented all continuous data as mean (standard deviation; SD). Incidence was calculated in R[157] using the *epiR*-package.[158] Incidence was expressed as the number of injuries per 1000 hours of exposure. Injury burden was expressed as the sum of all days off caused by injury. When analysing between season-difference in incidence and the number of injuries, a Poisson regression was used. The analysis was performed in R using the *sandwich* [159]and *msm* [160] packages and was reported with robust standard errors.[161] To analyse the difference in the number of days lost and matches missed due to injury, a one-sample t-test was used for the average of the team's seasonal difference in Stata (V.15.3- StataCorp LLC, College Station, Texas, USA) using the t-test-command. We did not analyse monthly seasonal differences on either injury parameter, as we considered the data insufficient for more detailed exploration.

Results and discussion

The following section will firstly present the main results and discuss specific aspects relevant to the specific papers before secondly, discussing overarching aspects relevant to several of the papers. Lastly, methodological considerations will be addressed.

A Cherry, Ripe for Picking: The Relationship Between the Acute-Chronic Workload Ratio and Health Problems (Paper I)

This methodological study analysed the relationship between the ACWR and health problems among elite youth football players using a wide range of methodological combinations defined before analysis. We considered the extent to which these methodological choices influenced the relationship between the ACWR and health problems. We followed 86 players for 105 days and recorded 6250 training days and 196 health problems. The health problem incidence was 42.0 (36.3 – 48.3) per 1000h (n=196) for the "all health problems" definition, 19.4 (15.6 – 23.9) per 1000h (n=91) using the "all injuries" definition and 9.6 (7.9 – 12.9) per 1000h (n=46) for the "new noncontact injuries" definition. Of the 108 analyses performed, we found 24 (22%) significant associations between ACWR and health problems, spread across various methodological combinations (Figure 7Figure 7). We did not observe any patterns of combinations that substantially increased the chance of a significant association.

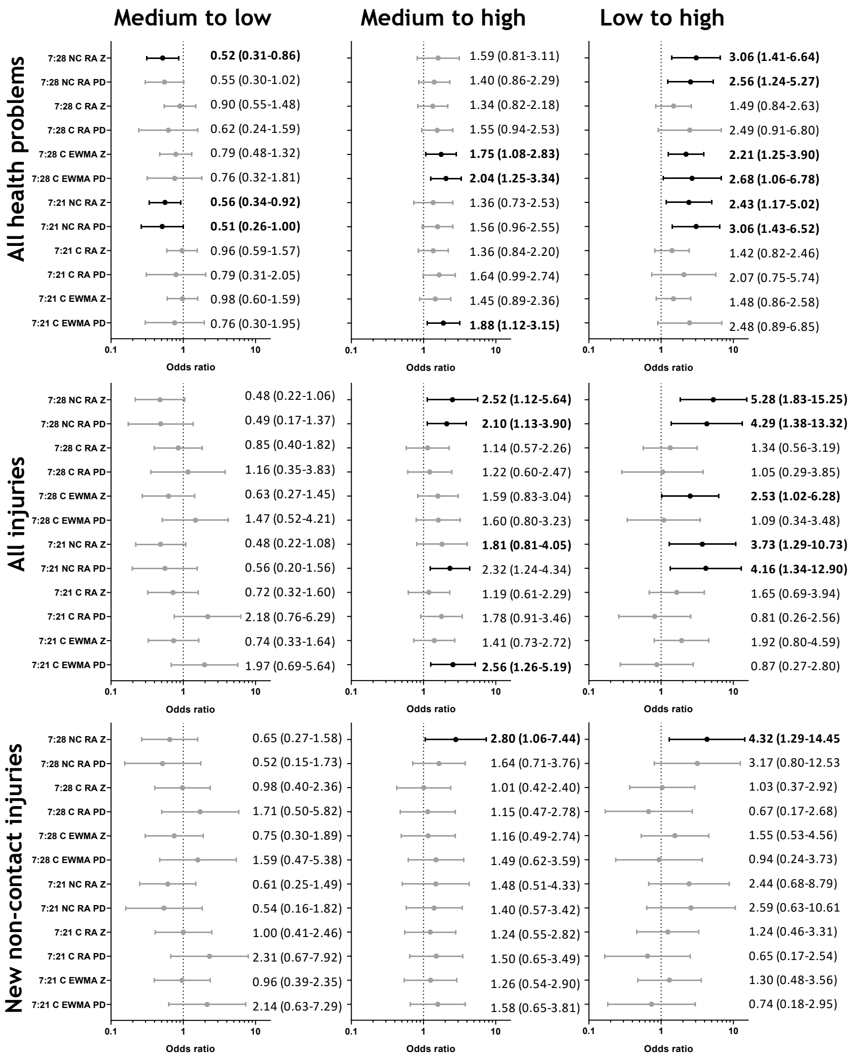

Figure 7 Analyses of the relationships between the acute-chronic workload ratio and all health problems, all injuries, and new noncontact injuries. Abbreviations: C, coupled; EWMA, exponentially weighted moving average; NC, noncoupled; PD, predefined category; RA, rolling average; z, z score–based category.

Does load management using the acute:chronic workload ratio prevent health problems? A cluster randomised trial of 482 elite youth footballers of both sexes (Paper II)

In this cluster-randomised controlled trial we aimed to evaluate the effectiveness of a load management intervention designed to reduce the prevalence of health problems among elite youth football players of both sexes. Eleven teams in the intervention group and 14 teams in the control group completed the study and the total number of players analysed was 394. We recorded a total of 2 475 health problems questionnaires and 15 253 training load responses.

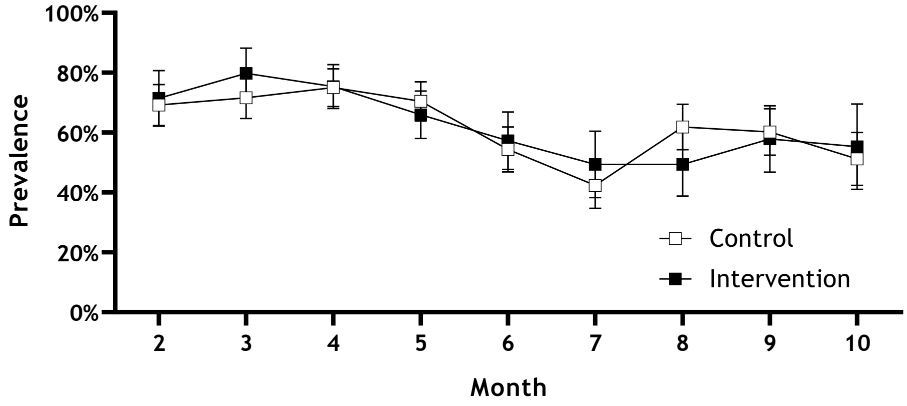

Figure 8 Prevalence of health problems in the control group and the intervention group throughout the season.

The average prevalence of health problems was 65.7% (61.1% to 70.2%) in the intervention group and 63.8% (60.0% to 67.7%) in the control group (Figure 8). The prevalence was 1.8%-points (-4.1 to 7.7%-points; P=0.55) higher in the intervention group, and there was no reduction in the likelihood of reporting a health problem in the intervention group (Relative Risk, RR 1.01; 95% CI 0.91 to 1.12; P=0.84) compared to the control group.

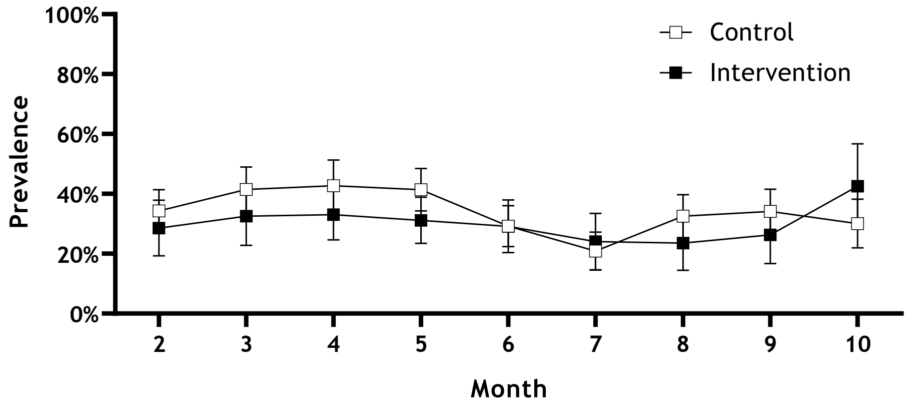

Figure 9 Prevalence of substantial health problems in the control group and the intervention group throughout the season.

The average prevalence of substantial health problems was 31.1% (26.7% to 35.5%) in the intervention group and 35.3% (31.6% to 39.1%) in the control group (Figure 9). The prevalence was 4.1%-points (-1.6 to 9.9; P=0.15) higher in the control group, and there was no reduction in the likelihood of reporting a substantial health problem (RR 0.88; 0.72 to 1.06; P=0.17) in the intervention group compared to the control group.

Adherence to the intervention

A major limitation of the study is the method used to assess the coaches' adherence to the intervention. Ideally, we would have logs or questionnaires describing the extent to which their training planning was influenced by the ACWR, and how often they intervened in their players' training plan based on feedback from the AMS. However, we asked the coaches in a post-study questionnaire where they indicated that, to a large extent, the intervention had been followed.

Facilitators and barriers for implementation of a load management intervention in football (Paper III)

This descriptive study aimed to investigate players' and coaches' barriers and facilitators to a load management approach to prevent injuries and illnesses and their attitudes and beliefs of load management and injuries and illnesses in general. We included 250 (51%) of the players enrolled at baseline in *Paper II*, 107 (46%) from the intervention group and 143 (58%) from the control group, respectively. Seventeen coaches (68%) were included, eight (73%) from the intervention group and seven (50%) from the control group, respectively.

The most important facilitators for players to implement a load management approach were scientific evidence for improved performance (88%) and mitigation of the injuries and illnesses (84%), as well as the coach being positive about it (86%; Figure 10). For coaches, the player's motivation to record training data (88%; Figure 10), scientific evidence of the preventative effect (100%) and scientific evidence of performance enhancement (71%) were considered most important.

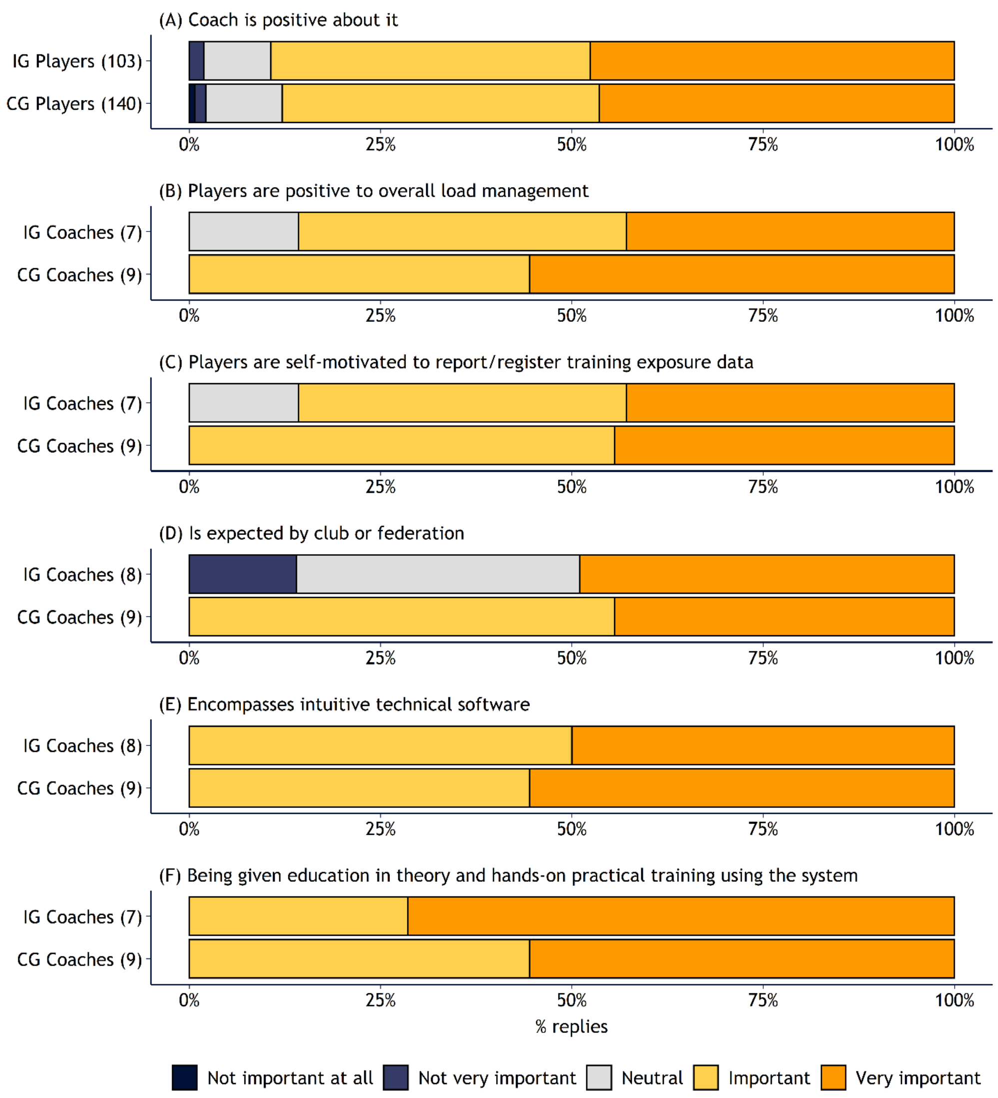

Figure 10 Players' and Coaches' response to How important are the following alternatives for your motivation to spend time on overall load management?

Of the players included in the study, half (48%) considered footballers to be at high risk of injuries in general, and 55 % considered footballers to be at high risk of overuse injuries. More than three-quarters of the coaches considered players to be at high risk of injuries in general (76%) and overuse injuries (76%) in particular. Furthermore, almost all players (90%) and all coaches strongly believed that load management could help reducing injury risk. Despite this, only 28% of players responded that they were willing to spend more than 10 minutes per week on a load management intervention, even if they thought the intervention could reduce injury. All coaches responded they were willing to spend more than 10 minutes per week on a load management measure to ensure both preventative and performance outcomes.

What to consider when implementing load management

To successfully implement load management measures, coaches and athletes have a symbiotic relationship.[162] Players considered their coach's attitude towards load management measures to be one of the most important facilitators, and coaches considered their players' attitudes equally important. Furthermore, the players' self-motivation to register training data is considered "important" by 81% of the coaches, highlighting the need for both player and coach engagement to implement a load management intervention successfully.

Finch suggested that an intervention must be easy to adopt, and coaches must be informed on why and how the intervention works.[32] This seems to be supported by our findings, where coaches considered intuitive software solutions and proper training in using them as important facilitators. Moreover, time constraints have been proposed to be one major barrier in implementing preventive interventions.[143,150,162] Despite the players' trust in the preventive effect of load management, only 57 % would spend more than 10 minutes, and less than one in three (28%) would want to spend more than 20 minutes weekly on injury and illness preventive measures. This reflects a reluctance among players to spend much time on preventive measures regardless of the invention's effectiveness. Only two-thirds of the coaches were willing to spend more than one hour per week if there were evidence for prevention (35%) or performance benefits (41%), which in our experience is a reasonable estimate of what would be needed for the coaches to perform the load management intervention. Similar to previous studies,[16, 25] time constraints seem to be a major barrier for the coaches, further highlighting the need for future studies considering the time efficiency of their intervention. However, there is likely a tradeoff between effectiveness, perceived benefit and time spent. Future studies may consider comparing the effect of more time-consuming interventions with interventions being time-efficient. Another aspect to consider when creating an understanding of the importance of implementing preventive measures is to bring on board and engage other stakeholders, such as representatives from federations, associations and clubs. Three quarters (76%) of the coaches replied that the expectations of the club or federation were "important" for their motivation, suggesting that high-level stakeholders should be targeted when introducing preventive measures.

Injury characteristics in Norwegian male professional football: a comparison between a regular season and a season in the pandemic (Paper IV)

We recorded 412-player seasons and 6 923 hours of match exposure from the 2019 and the 2020 seasons. A total of 506 injuries were recorded, of which 183 occurred during match play. Due to Covid-19 restrictions, the 2020-season was postponed from the scheduled start on the 5th of April until the 16th of June and ended on the 22nd of December, reducing the planned match period from 238 to 189 days.

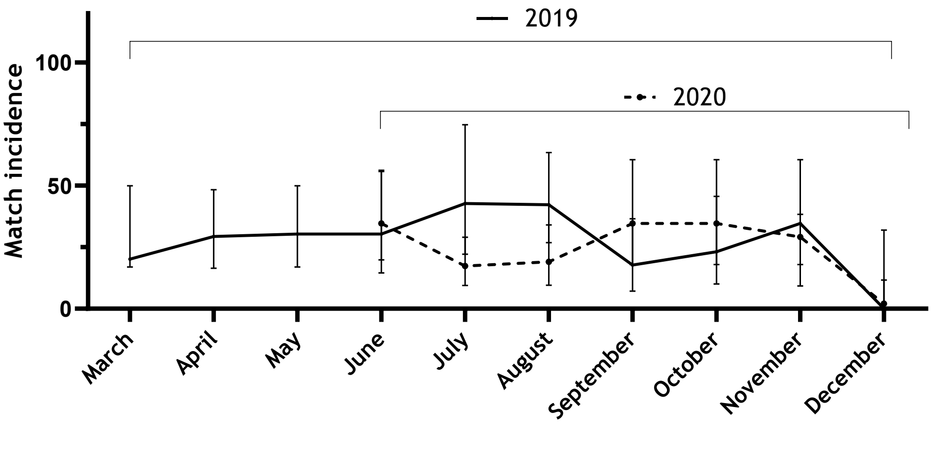

Figure 11 Timeline of monthly match injury incidence across the 2019 and the 2020 seasons

There was a large between-team discrepancy in match injury incidence, ranging from 4.04 per 1000h to 48.54 per 1000h. The total match incidence was 7.23 per 1000h lower in 2020 (22.82 per 1000h; CI 18.07 to 28.44; Incidence Rate Ratio; IRR 0.76) than in 2019 (30.05 per 1000h; CI 24.55 to

36.41), however, this was not a significant difference. The match incidence did not appear to follow a distinct pattern in either of the seasons (Figure 11). Furthermore, we found no difference in the number of injuries (0.94, CI- 0.49 to 1.8; p=0.84), days lost to injury (-15.57 (CI -273.49 to 242.35; p=0.89), or matches missed (4.28 (CI -32.26 to 40.83; p=0.78) between the two seasons. The average training availability was 84.1% and 85.9% in the 2019 and the 2020 seasons, respectively. The average match availability was 86.6% in the 2019 season and 88.2% in the 2020 seasons. Thus, we found no significant differences between the two seasons for neither training nor match availability.

Considerations about our findings

We did not observe a between-season difference, even though the 2020-season was played with an average of two fewer recovery days between matches. Previous studies examining the effect of a congested match calendar have reported increased[4,163-167] and unchanged[168,169] injury rates. Most of these studies have investigated whether shorter periods of matches congestion lead to increased injury risk compared to match periods with more recovery days in between.[4,163-166,168,169] We compared two complete seasons where one had 5.5 and the other had 7.5 average recovery days between matches, making a direct comparison to most previous study difficult. One exemption, however, is the study by Howle et al.,[167] which compared three full seasons and found that the season with congested match periods had higher injury rates. This was not in line with our findings.

The teams had four weeks of regular team training and training matches before the competitive season, which is likely to have mitigated some of the injury risk.[101] Furthermore, in an attempt to decrease the individual match load on the players', teams were permitted five substitutions in the 2020-season, compared to three in the 2019-season.[170] This affected the number of substitutions, as the average number of substitutions increased by 0.8 per match (2.8 in 2019, 3.6 in 2020) in the teams participating in this study. Moreover, this rule change has enabled teams rotating players to manage the load of players individually based on risk of injury, likely contributing to mitigating some of the injury risk in the 2020-season.

What is the relationship between ACWR and health problems? (Papers I and II)

In *Paper I,* we found that variations of the ACWR was associated with health problems. This aligns well with the conclusion for most studies examining ACWR and health problems in football (Table 7) and other sports.[23] However, the proposed relationship between ACWR and health problems is often based on descriptive studies reporting associations between various alterations of ACWR and health problems.

After the initial praise and endorsement,[27] there has been increased scrutiny of the ACWR-concept. This scrutiny can broadly be divided into two categories, studies highlighting methodological weaknesses and studies questioning the validity of the entire concept. The methodological criticism has focused on the calculation,[29,171-176] the statistical and analytical approaches[29,176-178] and other questionable research practises.[29,30,179]

Munafo et al.[180] outline six threats to reproducible science. These are 1) failure to control for biases, 2) low statistical power, 3) poor quality control, 4) P-hacking, 5) hypothesis after the results are known (HARKing) and 6) publication bias. In the ACWR and health problem space, many of these six threats have been violated. When preparing *Paper I*, we reviewed the methodology of all ACWR-health problem papers. We found that only six out of 43 studies had included more than 200 incidents, which is the recommended number to detect a small to moderate association.[181] Consequently, a large proportion of studies in this field appear to be underpowered.

P-hacking is when researchers perform several methodological approaches and analyses and selectively report those who produce positive results.[182] In *Paper I,* we reported how different methodological approaches affect the relationship between ACWR and health problems and that behind each association, there is likely to be many negative findings. This allows researchers to choose the approach that can produce the most favourable findings and highlight (or only report) these. Furthermore, the number of analyses performed varies but is not uncommonly in the hundreds (Table 6), which means that many positive findings will appear just by chance. In general, the conclusions of these studies have focused on significant findings. Additionally, many studies do not report the number of analyses performed and have not pre-registered any analytical approach.

Therefore, reporting bias is an important consideration when assessing the overall evidence for the relationship between ACWR and health problems.

The focus on conceptual problems has surrounded the lack of conceptual and theoretical models.[29,111] Perhaps the most significant limitation to the current scientific literature on ACWR and health problems is the study designs that have been used. Erroneous assumptions of causality is common in sports medicine research in general,[183] and the ACWR and health problem literature, particularly.[30] Grimes & Schulz proclaimed, "As in biology, anatomy dictates physiology. The anatomy of a study determines what it can and cannot do".[184] As most ACWR and health problems studies are descriptive (Table 7), they cannot make conclusions on causality.[184] In a descriptive study, an association between two variables (e.g. ACWR and noncontact injury) in an analysis can simply be due to a common cause (or chance). Consequently, without a causal relationship, changing a risk factor (e.g. ACWR) cannot modify the risk of an outcome occurring (e.g health problem).[29] As Impellizzeri et al.[29] exemplify, even though there is a correlation between ice cream sales and shark attacks, we cannot mitigate the risk of attacks by banning ice cream sales. Correlation does not equal causation, and thus, the majority of the ACWR literature is inadequate in evaluating the potential causal effect of ACWR on health problems. However, in *Paper II,* we used a randomised experimental design, which can help to draw causal inferences.[185] In our study, the intervention group did not have any reduction in the likelihood of reporting a health problem, and this finding further implies that there is no causal relationship.

Altogether, the evidence from the existing literature and the papers included in this dissertation indicates that the relationship between ACWR and health problem is not causal and that ACWR, using a one-size-fits-all approach, cannot prevent health problems in an elite youth football context.

Methodological considerations (Papers I, II, II and IV)

To fit the method to the study aim, we chose three vastly different approaches when defining, recording and reporting health problems in *Papers I, II* and *IV*.

Defining and recording health problems (Papers I, II and IV)

In *Papers I* and *II*, we aimed to investigate all health problems, but particularly overuse injuries. We recorded the prevalence of health problems directly from the players using an 'all complaints' definition to capture all health problems and overuse injuries.[40] Almost all studies examining ACWR and health problems have used a narrow definition (Table 7), which means they have been unable to capture most overuse injuries.[40,42,43] A limitation with our broad definition is that it can lead to systematic bias due to each collector's interpretation of what constitutes a recordable complaint.[40,44,45] Additionally, in our papers, health problems were not medically confirmed, lacked medical diagnostic details, and in many cases were not fully classified. Furthermore, players failed to respond to 31% of the daily questionnaires and, as illustrated by our post-study survey, did not always report every health problem or training session, a limitation potentially leading to selection bias. Moreover, our approach includes illness as a health problem without knowing more specifically whether or to what extent the illness is caused by training load. If illness is not affected by training load, it might result in a bias towards the null in our analyses. On the other hand, including illness is also a strength of the study as prevention of illness is a favourable potential outcome of load management.[186]

In *Paper I,* we aimed to analyse the relationship between training load and health problems. Training load is a fast-evolving factor that fluctuates from day to day,[106] and must be accompanied by a health problem surveillance method that can capture daily health status.[109] Therefore, we chose a daily recording of players' health state. In *Paper II,* we chose a different recording strategy. This paper aimed to assess the effectiveness of a load management programme on health problems across a complete season. To limit "questionnaire fatigue" and increase compliance, we had to balance the number of registrations of health problems. We chose a monthly registration of health problem prevalence using the OSTRC-H. This questionnaire is developed to measure the prevalence of health problems in the previous week. Asking players to report health status for the past week might be difficult when there are four weeks since the last registration. As the prevalence in our study was a lot higher than in previous studies, this could have been a sub-optimal method. Furthermore, capturing only one week of each month gives us only a snapshot of the status and not a complete picture compared to weekly questionnaires.

In *Paper IV*, we aimed to compare two seasons of injury characteristics collected from professional teams' medical staff. For this study aim, we needed to employ a definition that could be compared across multiple recorders. Using broad definitions where practitioners define a recordable complaint is not reliable, and only narrow time-loss-based definitions are recommended when using multiple recorders.[44] Despite using only narrow definitions, there was a considerable inter-team variation, meaning that the teams are not necessarily comparable. Bjørneboe et al.[47] reported that medical staff underestimated the incidence of all injuries by at least one-fifth. As this is likely similar for both seasons, we were able to compare the two seasons reliably. However, we are unable to detect differences in injuries that did not result in reduced participation. This group of potentially missed injures will typically include overuse injuries with mild symptoms. These injuries might be one of the most interesting type of injuries to investigate in relation to match congestion.

Reporting health problems (Papers I, II and IV)

As incidence-based methodology only counts *new* health problems, it is normally not optimal when examining fluctuating health problems (e.g. overuse injures). However, in *Paper I,* we recorded both new health problems and the worsening of an existing health problem daily, meaning we were likely to capture the full scope of health problems. For *Paper II,* we used a prevalence-based method that is likely to include a full scope of health problems. In *Paper IV*, we recorded only new injuries, and have likely overlooked many injuries using this approach.[40,42,43]

When choosing what methods to use in health problem surveillance studies, one must fit the methods to the study design. There is no perfect approach for all conditions, and a thorough assessment of the strength and limitations of each method should be considered when planning future studies.

Study design (Paper III)

Using survey-based methodology is limited because it only gives information in the specific areas assessed. Important components might have been missed, as they were not deemed as important when constructing the survey. We could have chosen a qualitative study design to achieve a deeper and more comprehensive understanding of the player's and coaches' perceptions. Furthermore, although the questionnaires were tested in a small pilot study, we cannot be sure all the participants understood the questions and similarly interpreted them similarly. The two questions surrounding the overall risk of injuries and overuse injures specifically is likely to have been somewhat misinterpreted as players considered footballers to have a higher risk of overuse injuries than injuries overall. Additionally, the terms "scientific evidence" and "performance" could have been more thoroughly refined in a focus group or pilot study as they are likely meaning different things to different participants.

Missing data (Papers I and II)

In *Papers I* and *II*, we asked players to register training load and/or health data daily across a long period of time. The players registered 69% of the daily questionnaires in *Paper I*. As illustrated by our post-study survey; they did not always report every health problem or training session, potentially leading to selection bias. Likewise, the players in *Paper II* registered 69% of all health problems questionnaires. An obvious limitation was that the players in the intervention group had a response rate of 62%. One reason why the intervention group had lower response rate might be "questionnaire fatigue", as they also reported training load after every football session. Moreover, as the AMS could not be used to collect the OSTRC-H2, the intervention group had to use two different systems to record training and health data, which is not optimal. Contrary to the health problem questionnaire, the training load questionnaire gave a reasonably good response rate of 74%, which might indicate that the AMS collected data were more feasibly.

Perspectives

Although many practitioners, researchers, and players consider training load an important risk factor for health problems, supporting evidence is currently lacking.

Future research

Future research should aim to establish casual frameworks to further our understanding of training load and health problems. Kalkhoven et al.[111] suggest that measures of psycho-physiological fatigue (e.g. RPE) are likely too far removed from injury causation and that the mechanical load-response pathways should be the future focus. Furthermore, to explore these pathways, greater consideration of tissue specificity when assessing injury risk is recommended.[187] Potential challenges with these recommendations is the lack of direct or proxy measures for mechanical load and tissue damage is problematic when assessing this relationship.[111] However, as microsensor and other technology are rapidly improving, this might be available in the future.[106] In sports that are dominated by one injury type (i.e. patellar tendinopathy in volleyball), inertial movement units (IMUs) could be one way of providing a proxy of tendon load and can be linked to narrow injury definitions or ideally, tissue damage. Studies examining this relationship are underway from our group. For sports with several injury types, however, the assumption of different relationships between load and different injury types would make prevention interventions in very complex.

High-quality and high-powered analytical studies using causal inference are one of two ways to move forward. These studies must use appropriate models that can handle non-linearity, have robust methods to handle missing data and use relevant and valid health problem definitions, recording and reporting. Studies to provide guidelines on how to handle non-linearity and missing data are warranted, and is currently being developed in our group.

Additionally, experimental studies can provide an understanding of the causal relationship between a specific training load variable and the likelihood of health problems. Studies using an experimental design must have an effective implementation strategy, as high compliance is necessary to investigate actual effectiveness. In *Paper III*, we give the following advice: (1) focus on the technical solutions for both coaches and players and make all participant involvement of an intervention time-efficient;

(2) create buy-in from club and federation stakeholders, as well as coaches and players; and (3) focus on both performance and prevention when communicating with all relevant stakeholders.

Load management in practise

In elite football, sports medicine and performance practitioners meticulously and continuously assess each player's training load together with numerous other factors, such as the history of previous injuries, injuries, player age, wellness, non-sporting load, communication with player, screening and strength test and the importance of next match. This information is used to inform subjective decisions that aim to increase performance and reduce the risk of health problems. Individual metrics of training load such as the ACWR are often used in this process. The extent to which these can help inform decisions on health problem prevention remains uncertain.

Regardless of the effect, to implement or test load management, players and coaches would still need to be engaged, and a re-calibration from a medical mindset to a performance mindset may help. Although recent research has overemphasised a medicalised rationale for load management (i.e health problem prevention), the role has historically been to improve performance. Players attend football to develop their game and to perform, not to avoid health problems.

The relationship between training load and health problems is indeed more complex than we first thought. However, until precise models can explain the relationship and experimental studies can document preventive effectiveness, practitioners must embrace uncertainty and move back to the basics. This should be done by trusting their expertise and use the skill and art of coaching to make decisions on training load management.

Conclusions

I. The potential association between ACWR and health problems is affected by methodological choices.

II. Load management using ACWR in a one-size-fits-all approach does not appear to prevent health problems among elite youth football players of both sexes.

III. Players and coaches could contribute to each other's attitude towards an intervention. We also found that players and coaches reported scientific evidence for injury preventive and performance-enhancing effect and time-efficiency as important facilitators. Furthermore, players and coaches believe that footballers are at high risk of sustaining injuries in general and overuse injuries specifically and think that load management could reduce injuries and illnesses.

IV. We could not detect any differences between the two seasons, suggesting the congested match calendar in the 2020 season is a safe alternative in future seasons.

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Paper I

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Paper II

Does load management using the acute:chronic workload ratio prevent health problems? A cluster randomised trial of 482 elite youth footballers of both sexes

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ABSTRACT

Background The acute:chronic workload ratio (ACWR) is commonly used to manage training load in sports, particularly to reduce injury risk. However, despite its extensive application as a prevention intervention, the effectiveness of load management using ACWR has never been evaluated in an experimental study.

Aim To evaluate the effectiveness of a load management intervention designed to reduce the prevalence of health problems among elite youth football players of both sexes.

Methods We cluster-randomised 34 elite youth football teams (16 females, 18 males) to an intervention group (18 teams) and a control group (16 teams). Intervention group coaches planned all training based on published ACWR load management principles using a commercially available athlete management system for a complete 10-month season. Control group coaches continued to plan training as normal. The prevalence of health problems was measured monthly in both groups using the Oslo Sports Trauma Research Centre Questionnaire on Health Problems.

Results The between-group difference in health problem prevalence (primary outcome) was 1.8%-points (−4.1 to 7.7 %-points; p=0.55) with no reduction in the likelihood of reporting a health problem in the intervention group (relative risk 1.01 (95% CI 0.91 to 1.12); p=0.84) compared with the control group.

Conclusions We observed no between-group difference, suggesting that this specific load management intervention was not successful in preventing health problems in elite youth footballers.

Trial registration number ISRCTN18177140.

INTRODUCTION

Health problems are common among elite youth footballers who experience similar injury and illness patterns and burden as senior professional players.[1–3]

Previous studies in elite youth football have found that at any given time of the season, the prevalence of health problems is over 40%.[3] Loss of participation due to health problems can negatively affect the players' performance,[4] their health later in their career[5 6] and, ultimately, their long-term development.[7] Therefore, preventive measures are important.

A range of general and specific exercise-based interventions have shown substantial efficacy.[8–15] In most cases, these interventions have been tested among elite adult male players[8–10 13 15] and recreational youth players[12 14 16]; only one study has been performed on elite youth players.[17]

Recently, researchers and practitioners have increased their interest in training load as a risk factor for health problems in football,[18] with numerous studies reporting an association between training load and injury.[19–22] Consequently, training load monitoring and management has gained widespread popularity as a preventive measure in professional and elite youth football.[18 23] There is currently no consensus on which training load parameters should be monitored, how their cut-off values should be set and how load progression should be evaluated. Moreover, load management is performed in numerous ways, is often dictated by the philosophy of the club staff or manager and has no consensus scientifically.[18 23] In 2014, Hulin *et al*[24] proposed the concept of the acute:chronic workload ratio (ACWR), whereby an athlete's recent training load (acute workload) is divided by their training load over a longer period of time (chronic workload). This metric is suggested to aid practitioners in managing training load within certain ranges.[25 26] The initial concept was based on avoiding sudden spikes in training load, trying to keep ACWR within an arbitrary 'optimal range' of 0.8–1.5.[25 26]

Observational evidence supporting an association between ACWR and injury is inconsistent and controversial,[27–30] and there are no experimental studies to determine whether using ACWR to manage training loads actually prevents injury or illness. Therefore, the aim of this cluster randomised controlled trial was to assess the effect of an ACWR-based load management intervention on health problem risk among elite youth footballers of both sexes.

METHODS

This study involved 482 Norwegian elite U-19 football players (178 females, 278 males), conducted during a complete season from February to November 2018.

Recruitment

We identified 78 teams from the vicinity of members in our research group and their participation in one

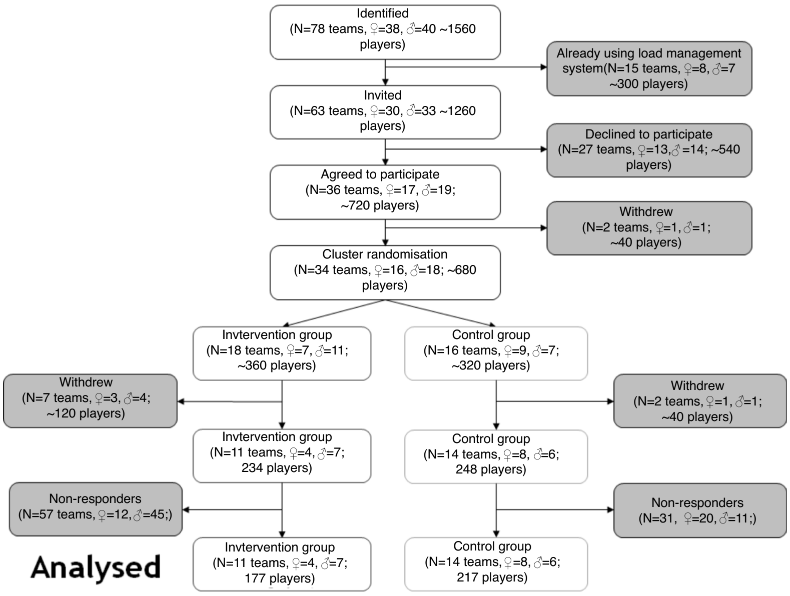

Figure 1 Flow of the teams and the players throughout the intervention.

of the top two tiers of Norwegian youth football. Of these, 15 teams that already used a training load management system were not invited, as this was likely to affect their adherence with the intervention. Sixty-three teams were invited and 27 declined to participate, 10 due to time constraints and 17 teams did not respond to the invitation or give any specific reason for why they declined (figure 1). Players who were permanent squad members were invited to participate in the study, with the exception of players who were likely to be absent from football training and match play for the study period due to severe health problems at baseline.

Participants

Thirty-six teams (15 females and 21 males) accepted the invitation to participate, and all players (or their guardian) on these teams gave their written consent to take part in the study (figure 1). The trail started for each team after all players had provided written consent, and the team had completed their introductory course to either the intervention group or the control group routines. Data collection was closed as each team finished their season.

Randomisation

We randomised on a team level to minimise the risk of contamination bias between players within the teams. A statistician, blinded to the study protocol, computer-generated blocks of 4 and 6 teams in random order. After a team and their players agreed to participate, the principal investigator opened a sealed envelope revealing the team's group assignment.

Blinding

It was impossible to blind players, coaches or the principal investigator to group allocation. However, a research assistant decoded the outcome measures during the data collection period, and outcome measures were not available to any of the members of the study group until all data had been collected.

Intervention

The intervention consisted of individualised load management of every player in the intervention group. Intervention group coaches planned the weekly training plan (microcycle) based on each player's training load history. A commercially available athlete monitoring system (AMS; Athlete Monitoring, Fitstats Inc, New Brunswick, Canada) assisted coaches in planning player microcycles, based on ACWR theory.[24] ACWR was calculated as the coupled 7–28 day ratio using a rolling average. We instructed the intervention group coaches on training load management theory and how to use the AMS to plan training content, duration and intensity. Each coach received a 1-hour introductory session and a follow-up session 2 weeks later if necessary. Coaches were instructed to follow a periodisation model based on the 'optimal range' concept described by Hulin *et al*,[24 31] where the aim was to progress or maintain player load while ensuring they remained within the desired ACWR range of 0.8–1.5.

All training load data reported by the players were instantly available on the coach dashboard in the AMS (figure 2). After finishing all weekly football activity every Sunday evening, coaches reviewed and arranged the individual training plans for the following week. The coaches were expected to have detailed insight into all their players' planned training and match activities (including activities outside the club team, ie, high-school training, regional team and national team). The AMS combined the subsequent week's (7 days) planned training load with the training load from the past 21 days (a rolling average of 28 days) and calculated the planned ACWR for the subsequent week.

If the planned training activity in the subsequent week led to players having an ACWR below 0.8, the AMS alerted the coach with a suggestion to increase the load accordingly. Conversely, if the planned activity led to an ACWR above 1.5, the AMS alerted the coach (figure 3) and suggested that they decrease the planned load. Additionally, during the week, coaches were expected to ensure that players completed their training as planned and, if

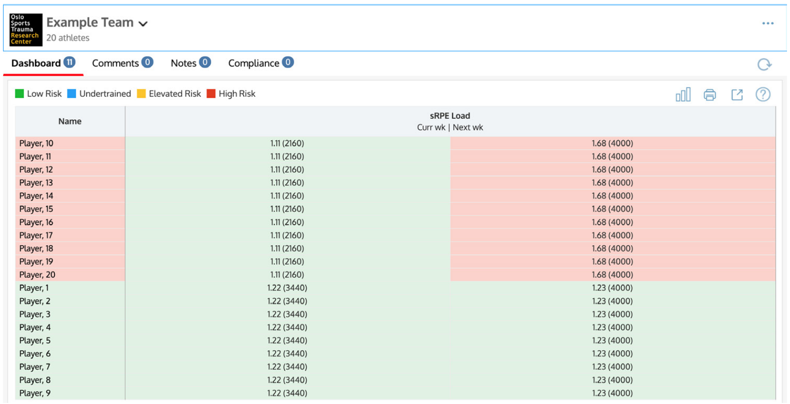

Figure 2 Coaches dashboard in the AMS after next week's training load is planned.

necessary, adjust the programme to keep them within the ACWR 'optimal range' (ie, if a player reported much higher loads than planned in the start of the week, the remainder of the weekly load could be reduced or vice versa).

We regularly contacted the coaches and sent supportive email each month to encourage them to continuing their training planning based on the intervention.

Collection of training load data

Intervention group players recorded the duration and their overall perceived rate of physical exertion (RPE) using the modified Borg CR-10 scale[32] after all footballing activity, including non-organised football play. Players were familiarised with the collection method as well as the Borg scale before study start. We calculated an arbitrary training load unit (AU) by multiplying the duration with the session RPE (sRPE)[32] for all football activities. Ten minutes after each training session was planned to be completed, a link to a questionnaire in the AMS smartphone app was sent to the players via an automated short message service (SMS; see online supplemental file 3 for details). If players had not replied to the questionnaire 12 hours postactivity, they received a second SMS, reminding them to complete the questionnaire. If players failed to complete the session questionnaire, the AMS treated the player as not being a part of the training and leaving a session value of nil in the calculations (and falsely decreasing the load of the player). The control group did not record any training load data.

Collection of health data

We used the Oslo Sports Trauma Research Centre Questionnaire on Health Problems (OSTRC-H2) Questionnaire (online supplemental file 1)[33] to record health data. Players responded to the questionnaire in the last week of each month and were instructed to report health problems for the previous 7 days only, giving us weekly prevalence of 10 intervals at approximately 1 month apart.

The questionnaire was distributed using an online survey software (Briteback AB, V.2.5.3.1; Norrköping, Sweden) via SMS on Sunday at 21:00. Non-responders received an SMS reminder the following morning at 08:00. Players were asked to report all complaints, irrespective of their consequences on football participation or their need to seek medical attention, including illness and injury.[34] If players answered anything but the lowest score (ie, 'no problem') on either of the questions, a health problem was registered. If a player registered alternative two or higher (ie, moderate or severe reduction, or inability to participate) in question 2 (training volume) or 3 (performance), the health problem was registered as substantial. Each month, we calculated

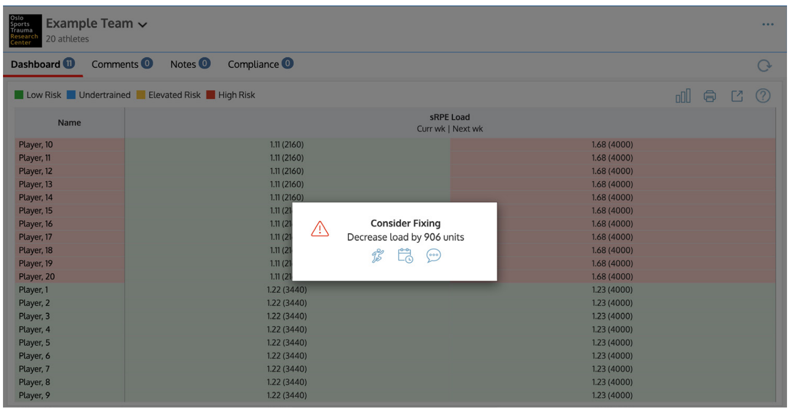

Figure 3 Coaches' dashboard in AMS suggesting a revision of planned load. AMS, athlete management system.

prevalence of both outcomes by dividing the number of players reporting either a health problem or a substantial health problem to the total number of respondents in each group. To ensure consistent reporting of all health problems, we familiarised players with the definitions in the prestudy meeting and repeatedly emphasised the importance of reporting all health problems during the study period, irrespective of their consequences. We informed the players that the coaches and other club staff members did not have access to any health data.

Outcome measures

The primary outcome measure was the occurrence of all health problems over the course of the season. The secondary outcome measure was occurrence of substantial health problems over the course of the season.

Statistical methods

The primary effect measure was the between-group difference in prevalence (intervention – control). The secondary effect measure was relative risk (RR) ratio (intervention/control). To evaluate the effectiveness of the intervention, we fitted generalised estimating equations panel data models to the two outcomes: all health problems and substantial health problems. The models were defined with a binomial family, a log-link function and an exchangeable correlation matrix. The estimated SEs were adjusted for clustering, and a Kauermann and Carroll bias-corrected variance estimator,[35] which is specifically recommended for cluster randomised trials, was used. The models included terms for group (intervention vs control) and time, and we report the results for group as the RR of intervention versus control. Initial models also included a term for group × time interaction; however, this term did not impact the models (p=0.44 for all health problems; p=0.34 for substantial health problems), and we removed the interaction term to obtain a simple and easily interpretable estimate of the intervention effect. We used the xtgeebcv command[36] in Stata (V.15.3 StataCorp LLC, College Station, Texas, USA; see online supplemental file 2 for script and results). No attempt to impute missing training or health data was performed. All analyses were performed according to the intention-to-treat (ITT) principle, using a full analysis set definition; that is, we included all available data and analysed the teams as randomised. Teams that withdrew from the study directly after randomisation were excluded, as were players who did not record any outcome data.

Sample size

The sample size calculation was based on an average prevalence of health problems among elite youth footballers of 40%.[3] Based on an analysis of variance of within-subject and within-team prevalence, an inflation factor (DE) of 1.65 (to account for randomisation at the cluster level), a cluster size of 20 players, a power of 80% and a 5% significance level (α), we estimated that a sample of 2×380 players would be needed to detect a 40% reduction in prevalence. This was based on previous studies with a similar design[8 37] and on our estimation of what coaches would consider a worthwhile meaningful difference. To find the inflation factor, the following formula was used DE=1+(n-1)p, where n is the number of individuals and p is the intracluster correlation coefficient.[38]

Ethics

The study was registered in the International Standard Randomised Controlled Trial Number Registry.

Table 1 Baseline characteristics of players included in the analyses

	Intervention group	Control group
N	177	217
Girls	57	107
Boys	120	110
Age	17.2 (1.2)	17.4 (1.1)

RESULTS

Participants

A total of 34 teams were enrolled in the study; nine teams withdrew shortly after randomisation, and 88 players did not respond to any of the health problems questionnaires. Eleven teams in the intervention group and 14 teams in the control group completed the study, and the total number of players analysed was 394 (table 1).

The flow of the teams and the number of players are shown in figure 1. Of the nine teams that withdrew after randomisation, seven teams were randomised to the intervention group and two teams to the control group. The reasons stated for withdrawal from the intervention group were: wanted to be in the control group (n=4), wanted to implement a different load management routine (n=2) and change of coaching staff (n=1). The two teams that withdrew from the control group indicated that they would rather be in the intervention group.

Questionnaire response rate

We recorded a total of 2475 health problems questionnaires. The compliance to the OSTRC-H2 questionnaire was 62% (range 10%–100%) in the intervention group and 76% (range 10%–100%) in the control group, which amounts to an average of 69%. The intervention group coaches planned a total of 25 004 player sessions and received 15 253 player responses, which amounts to an overall response of 74% (range 0%–100.0%) to the post-training questionnaire.

Training data

The intervention group players' median weekly sRPE was 1470 (IQR 750) AU.

Adherence with the intervention

In a poststudy survey, the intervention group coaches replied to the following question describing their compliance with the intervention: did you use the AMS to plan training every week throughout the season? Eight out of 11 coaches responded and five replied 'yes, every week', two replied 'no, every other week' and one replied 'no, every month'.

Primary outcome: all health problems

The average prevalence of health problems was 65.7% (61.1%–70.2%) in the intervention group and 63.8% (60.0%–67.7%) in the control group (figure 4). The prevalence was 1.8%-points (−4.1 to 7.7%-points; p=0.55) higher in the intervention group, and there was no reduction in the likelihood of reporting a health problem in the intervention group (RR 1.01 (95% CI 0.91 to 1.12); p=0.84) compared with the control group.

Secondary outcome: substantial health problems

The average prevalence of substantial health problems was 31.1% (26.7%–35.5%) in the intervention group and 35.3% (31.6%–39.1%) in the control group (figure 5). The prevalence was 4.1%-points (−1.6 to 9.9; p=0.15) higher in the control

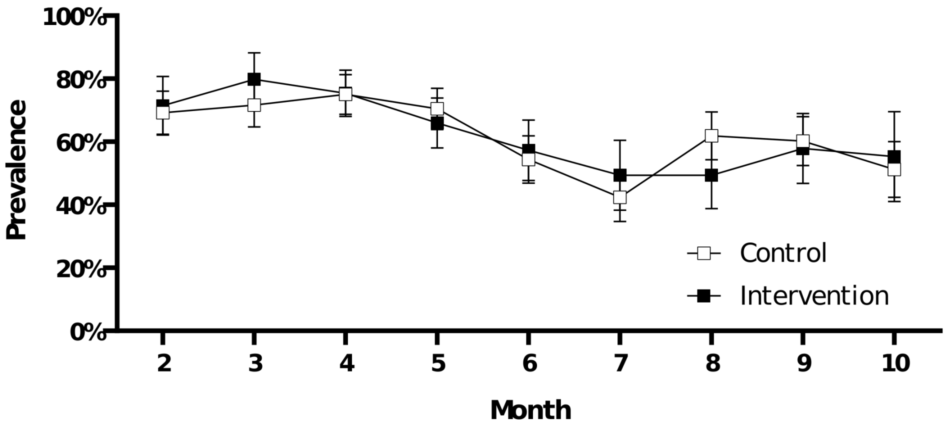

Figure 4 Prevalence of health problems in the control group and the intervention group throughout the season.

group, and there was no reduction in the likelihood of reporting a substantial health problem (RR 0.88 (0.72 to 1.06); p=0.17) in the intervention group compared with the control group.

DISCUSSION

This is the first randomised controlled trial investigating the effect of individual management of training loads on the risk of health problems in any sport. We did not identify any significant differences in either outcome between the intervention group and the control group.

Intervention

When planning this study, choosing the exact mode of intervention represented a major challenge. We were guided by the literature at the time, as well as the recommendations from the group that developed the ACWR approach.[24 26 39] Also, we considered what was commonly used in the field and therefore had the most practical relevance.

Since then, there has been increased scrutiny of the ACWR concept, with several papers highlighting methodological challenges[30 40–45] and some authors questioning the validity of the entire concept.[27–29] Despite many studies showing an association, no study has yet managed to predict health problems based on ACWR,[20] indicating that a meaningful and pronounced relationship between ACWR and health problems is unlikely.

We tested the preventive effect on health problems by using one particular approach of load management. However, there is no consensus on which load management concept should be used or, if using ACWR, how it should be calculated.[30] Our intervention was a one-size-fits-all approach, as we considered it to be the most feasible method for the coaches and because a structured individual protocol remains in a conceptual phase.[46] Moreover, at the time we planned the study, the available literature recommended that a similar threshold should be used for all players.[24] This one-size-fits-all approach has recently been challenged by both scientists and practitioners, as the relationship between ACWR and health problems is affected by a large number of individual moderating factors.[46]

Our training load parameter was sRPE. We chose sRPE as it is considered a valid method for measuring training load across various sports[47] and for elite youth footballers specifically.[48] Moreover, sRPE was the most practical way to quantify load in 25 non-professional youth football teams, and the majority of previous ACWR studies have used sRPE as their primary measure of load.[19 20 22 49–67]

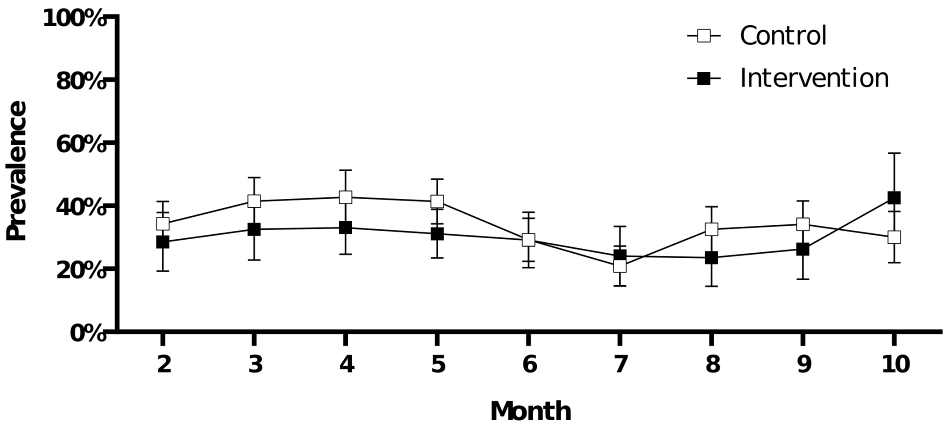

Figure 5 Prevalence of substantial health problems in the control group and the intervention group throughout the season.

Methodological considerations

This study involved an intervention that was arguably more technically demanding and time-consuming for coaches and players than previous prevention studies in sports.[8 37] These challenges may have led to reduced adherence to the intervention by the coaches and to reduced questionnaire response rates by the players.

A major limitation of the study is the method used to assess the coaches' adherence to the intervention. Ideally, we would have logs or questionnaires describing the extent to which their training planning was influenced by the ACWR, and how often they intervened in their players' training plan based on feedback from the AMS. However, we asked the coaches in a poststudy questionnaire where they indicated that, to a large extent, the intervention had been followed.

Another problem we faced was the health problem questionnaire average response rate of 69% and specifically the intervention group response rate of 62%. One reason that the intervention group had lower response rate might be questionnaire fatigue, as they also reported training load after every football session. Moreover, as the AMS could not be used to collect the OSTRC-H2 at the time, the intervention group had to use two different systems to record training and health data, which is not optimal. Contrary to the health problem questionnaire, the training load questionnaire had a reasonably good response rate of 74%, which might indicate that the AMS collected data in a more feasible way. Non-responders and non-compliances will introduce selection and measurement bias in our analyses and should be taken into consideration when interpreting our results. Despite some of the challenges with this method, using athlete-recorded health problems allowed us to use a broad health problem definition and thereby gain a more complete understanding of the range of health problems affecting the players.[68 69] In particular, this broader approach was specifically designed to record overuse injuries, which are presumably the most preventable type of injury from a load management intervention. Nevertheless, this approach also has limitations.[70] Health problems were not confirmed by a sports medicine practitioner or by diagnostic imaging, making our data less secure and detailed. Moreover, our approach includes illness as a health problem without knowing more specifically whether or to what extent the illness is caused by training load. If illness is not affected by training load, it might result a bias towards the null in our analyses. However, including illness is also a strength of the study as illness prevention is a favourable potential outcome of load management.[71]

The average prevalence of both health problems and substantial health problems are higher in our study than in previous studies.[3 8] The reason for this is unknown. However, as this finding was the same in both groups, we believe a between-group comparison is appropriate.

Choosing a suitable population is key when performing experimental research; elite youth players have previously been targeted in injury prevention research.[17] We chose this cohort of athletes since many elite youth players in Norway train with and play for several different teams, making their load management challenging. Furthermore, this was deemed one of few cohorts where coaches systematically plan their training and, at the same time, where we would be allowed to influence their training content.

The modified ITT analysis could introduce selection bias due to the withdrawals postrandomisation and should be acknowledged as a limitation of the study.

We were unable to identify statistically significant differences between groups, a larger study with higher statistical powere might have found otherwise. In this case, and based on our CIs, the effect of the intervention would nonetheless be small to moderate.

Perspectives

Although many practitioners, researchers and players consider training load to be an important risk factor for health problems in football, supporting evidence is currently conflicting. To date, studies examining the relationship between training load and health problems have largely been descriptive studies.

This trial—the first randomised study in the field—demonstrates that, although difficult to conduct, it is not impossible. We hope, despite this study's methodological limitations, it will pave the way for future training load studies using a similar design.

In elite football, sports medicine and performance practitioners meticulously and continuously assess each player's training load together with numerous other factors, such as history of previous injuries, injuries, player age, wellness, non-sporting load, communication with player, screening and strength test and the importance of next match. This is done to inform subjective decisions that aim to increase performance and reduce risk of health problems. Providing coaches with a one-size-fits-all metric does not seem to add much value to this process. We believe that, given the results of this study and the current state of knowledge in the field, load management remains just as much an art as a science.

CONCLUSION

We provided coaches of teams in the intervention group with tools and knowledge to manage their players' training load using a common form of ACWR. This did not lead to a reduction in the prevalence of health problems, compared with teams in the control group. Managing training loads using ACWR does not appear to represent an effective prevention intervention in elite youth football.

Patient and public involvement statement

Coaches were involved in the design of the intervention and recruitment of teams and players to the study. Coaches and

Key messages

What are the findings?

- Load management using acute:chronic workload ratio (ACWR) in a one-size-fits-all approach does not appear to prevent health problems among elite youth football players of both sexes.

How might it impact on clinical practice in the future?

- The lack of a clear relationship between training load and health problems does not mean practitioners should abandon training load management. Its primary role has always been performance enhancement and not health problem prediction or prevention.
- With a lack of models linking training load and health problems, practitioners should follow the general training principles such as the principle of progressive overload.
- Alternative models of load management should be developed and their preventative effect tested.

players were not involved in the design of the research questions, the outcome measures or the analyses. The results from the study will be disseminated to all teams that were included in the project.

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Contributors TD-L, BC, TEA, JB and MWF planned the study. The data collection was done by TD-L and MV. All authors have been involved in the data analyses, drafting and revision of the manuscript, and all have approved the final version.

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Competing interests The Oslo Sports Trauma Research Centre has a research partnership together with Fitstats Inc. This partnership is based on the development of injury surveillance tools, which were not used in this study. Fitstats provided the use of athlete management system free for this study.

Patient and public involvement Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

Patient consent for publication Not required.

Ethics approval The study was reviewed by the South-Eastern Norway Regional Committee for Medical and Health Research Ethics (2017/2232) and approved by the ethics board of The Norwegian School of Sports Sciences (39–1 91 217) and the Norwegian Center for Research Data (56935).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement All data relevant to the study are included in the article or uploaded as supplementary information. All data are available as supplementary files.

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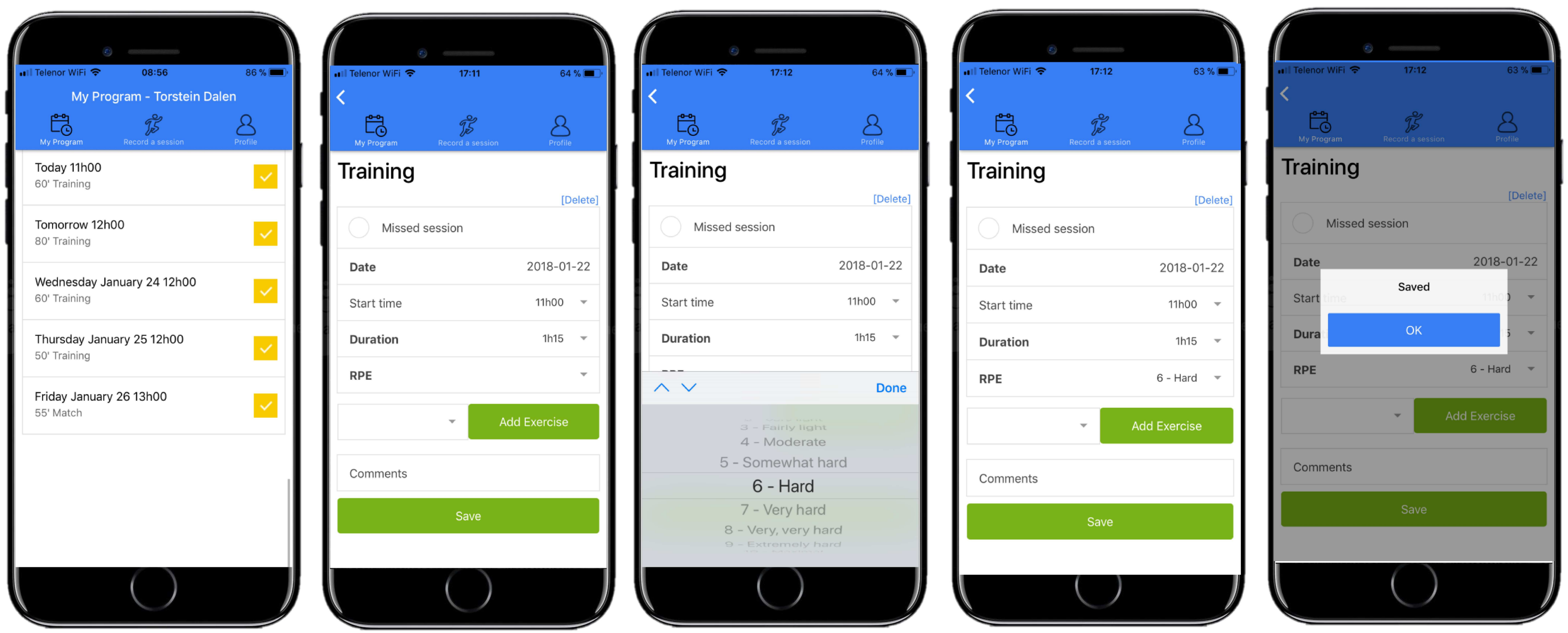

My Program - Torstein Dalen
My Program
Record a session
Profile
Today 11h00
60' Training
Tomorrow 12h00
80' Training
Wednesday January 24 12h00
60' Training
Thursday January 25 12h00
50' Training
Friday January 26 13h00
55' Match
Training
[Delete]
Missed session
Date
2018-01-22
Start time
11h00
Duration
1h15
RPE
6 - Hard
Add Exercise
Comments
Save
Done
4 - Moderate
5 - Somewhat hard
6 - Hard
7 - Very hard
8 - Very, very hard
Saved
OK

Supplementary Table 1 OSTRC Questionnaire on health problems 2

Question 1 -Participation
Have you had any difficulties participating in normal training and competition due to injury, illness or other health problems during the past week?

1. Full participation without health problems
2. Full participation, but with injury/illness
3. Reduced participation due to injury/illness
4. Cannot participate due to injury/illness

Question 2 - Training volume
To what extent have you reduced your training volume due to injury, illness or other health problems during the past week?

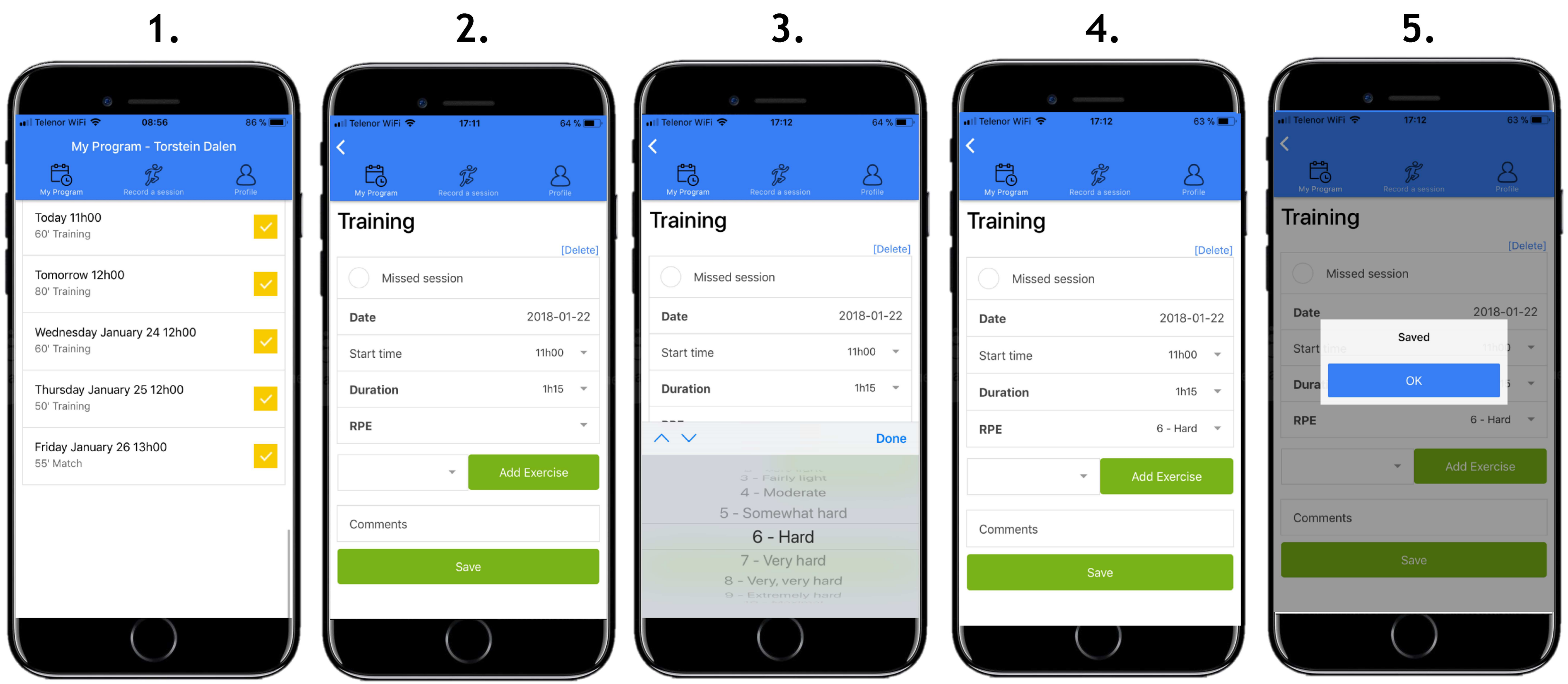
1. No reduction
2. To a minor extent
3. To a moderate extent
4. To a major extent
5. Cannot participate at all

Question 3- Performance
To what extent has injury, illness or other health problems affected your performance during the past week?

1. No reduction
2. To a minor extent
3. To a moderate extent
4. To a major extent
5. Cannot participate at all

Question 4 - Symptoms
To what extent have you experienced symptoms/health complaints during the past week?

1. No symptoms/health complaints
2. To a mild extent
3. To a moderate extent
4. To a severe extent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Paper III

BMJ Open Sport & Exercise Medicine

Facilitators and barriers for implementation of a load management intervention in football

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ABSTRACT

Background In a recent randomised controlled trial, we found that a commonly used training load management approach was not effective in preventing injuries and illnesses in Norwegian elite youth footballers.
Aim To investigate players' and coaches' barriers and facilitators to a load management approach to prevent injuries and illnesses and their attitudes and beliefs of load management and injuries and illnesses in general.
Methods We asked players and coaches about their views on injury risk in football, the benefits and limitations of load management in general and implementation of load management in football. The questionnaires used were based on similar studies using the Reach, Effectiveness, Adoption, Implementation and Maintenance framework.
Results We recorded answers from 250 players and 17 coaches. Most players (88%) reported that scientific evidence showing improved performance from the intervention measures is a key facilitator to completing the intervention. Similarly, coaches reported that the most important facilitator was scientific evidence that the preventive measures were effective (100%). Players reported that the coach's attitude to preventive measures was important (86%), and similarly, 88% of coaches reported that the player's attitude was important.
Conclusions By having a mutual positive attitude towards the intervention, players and coaches can positively contribute to each other's motivation and compliance. Both players and coaches reported scientific evidence for load management having injury-preventive and performance-enhancing effect and being time efficient as important facilitators.
Trial registration number Trial registration number

What is already known?

- A high compliance is needed to test the real effectiveness of an intervention.
- Many preventive measures are not well adopted by coaches, players and other stakeholders, limiting their effectiveness.
- There is a need to create buy-in from club and federation stakeholders, coaches and players when implementing injury preventive measures.

What are the new findings?

- To create interventions that will be implemented, a focus on time-effective easy-to-use measures is key.
- Engage coaches, players and other stakeholders when designing and implementing an intervention.
- To get coach, player and other stakeholder buy-in, focus on both performance and prevention.

INTRODUCTION

Injuries are common among football players, and at both the elite youth and professional level, players can on average expect around two injuries per season.[1–3]

Also, at any given time of the season, the prevalence of health problems (both injuries and illnesses) exceeds 40% among elite youth players.[3] Health problems and the associated loss in participation can negatively affect players' performance,[4] their health later in the career[5 6] and, ultimately, their long-term professional development.[7]

Training load has recently emerged as a potential risk factor for injuries in football.[8–11] Subsequently, many teams, particularly those at an elite level, attempt to manage players' training loads as a preventative measure to mitigate injuries.[12 13] However, the evidence supporting this practice is limited to observational studies of associations between training load and injuries. In a recent randomised controlled trial (RCT),[14] we found that a common model of training load management using the Acute:Chronic Workload Ratio concept[15] did not reduce the prevalence of health problems (both injuries and illnesses) among elite youth footballers of both sexes. Players' reported compliance with our intervention was 63%. This is comparable to previous studies investigating other preventive interventions using a similar research design.[16 17]

Previous studies have shown that the higher the compliance, the better the effectiveness of the intervention.[18–20] Consequently, an understanding of how compliance can be increased is warranted. Regardless of the effect of the intervention, a study examining the implementation can be of value to practitioners and researchers aiming to employ a load management programme in teams and other athlete cohorts.

The Reach, Effectiveness, Adoption, Implementation and Maintenance (RE-AIM)[21] framework was first introduced in sports medicine research by Finch and Donaldson,[22] to help researchers better understand the real-world implementation challenges. Using this framework, an intervention can be seen through the lens of five different dimensions to determine whether the intervention is feasible in a real-world setting. Suppose an intervention that has been deemed effective in controlled settings is not adopted, complied with and sustained. In that case, it is not likely to mitigate injuries and illnesses.[22] The RE-AIM framework has previously been used in similar populations and has guided the implementation of various preventive measures in sports.[23–25]

To guide practitioners towards successful implementation and researchers in future implementation studies, we used questionnaires based on the RE-AIM framework to investigate players' and coaches' experiences from a load management intervention and their attitudes and beliefs to load management and injuries and illnesses in general.

MATERIALS AND METHODS

Study design and participants

The survey was conducted in November 2018 as a part of a cluster-RCT investigating the preventive effect of a load management approach on injuries and illnesses in Norwegian elite youth footballers of both sexes.[14] The RCT was cluster randomised on a team level and consisted of a control group and an intervention group. The intervention entailed coaches adapting to an Acute:Chronic Workload theory-based load management programme. The players in the intervention group recorded their session perceived rating of exertion after every footballing activity on a smartphone application. The training load data were uploaded to an online athlete management system, where the coach could manage their training load. The control group did not record any training load data and performed training as usual. The main outcome of this study was the difference in the reported prevalence of health problems in the two groups. We observed no effect of the intervention on either outcome. The study was registered with the International Standard RCT Number registry, reviewed by the South-Eastern Norway Regional Committee for Medical and Health Research Ethics (2017/2232) and approved by the ethics board of The (39-191217) and the Norwegian Center for Research Data (56935). After the end of the 2018 season, we invited all teams that had completed the RCT to participate (25 teams, 482 players) in the survey. This report is prepared according to the STROBE-SIIS checklist for observational studies.[26]

Patient and public involvement

Coaches were involved in the design of the intervention and recruitment of teams and players to the study. Coaches and players were not involved in the design of the research questions, the outcome measures or the analyses. The results from the study will be disseminated to all teams that were included in the project.

QUESTIONNAIRE

The questionnaires were influenced by the reach, adoption and implementation pillars of the RE-AIM framework[27] and two similar questionnaires used to examine the implementation of the Oslo Sports Trauma Research Centre Shoulder Injury Prevention Programme in handball players[24] and the Adductor Strengthening Programme in football players.[23] The overall theme of the questionnaires was player's and coach's barriers and facilitators for implementation of load management to prevent injuries and illnesses and their attitudes and beliefs of load management and injury and illness in general. The questionnaires differed in two ways (1) coaches were asked specific questions on their role in the intervention and their perception of the players and vice versa and (2) the players and coaches in the intervention group were asked additional questions regarding their experiences of the intervention (for complete questionnaires, see online supplemental file 1). We conducted a pilot test with two players and one coach from a similar youth elite football setting to test their understanding of the questions, the length of the questionnaire and the technical procedures. The questionnaires that were tested were the intervention group player and coach questionnaires, as they include all the questions from the control group questionnaires, in addition to the specific intervention questions. A research staff member interviewed the players and coaches. All agreed that the questions were clear and relevant, the overall length of the questionnaire acceptable and the technical solutions suitable. No changes were made based on the pilot study, as we considered the face validity of the study to be strong. Four versions of the questionnaires were developed; one for the intervention group players, one for the intervention group coaches and one for the control group players and the control group coaches. The questionnaires were in Norwegian, as all players and coaches participating were familiar with the Norwegian language.

DATA COLLECTION

Teams that agreed to participate received a questionnaire distributed using online survey software (Briteback AB, V.2.5.3.1; Norrköping, Sweden). The data collection started as soon as the teams completed their competitive season, and, hence, were finished as participants in the RCT. The questionnaires were distributed at 9 pm on a weekday when all other activities (ie, schoolwork and training) were likely to be completed. Players who did not respond to the initial questionnaire received a reminder 24 hours after the first distribution. Two weeks after the

Table 1 Participant characteristics, n (%)

	Male	Female	Total
Intervention group	74 (69)	33 (31)	107
Control group	91 (64)	52 (36)	143
Total	165 (66)	85 (34)	250
Coaches (%)			
Intervention group	8 (100)	0 (0)	8
Control group	7 (78)	2 (22)	9
Total	15 (88)	2 (12)	17

initial round of distribution, all nonrespondents were sent the questionnaire again as well as the 24 hours post-reminders. If certain teams had many nonrespondents, their coach was asked to encourage their players to fill in the questionnaire. Also, respondents were encouraged to contact the research group to clarify any questions they had concerning the questionnaire's content before filling it in. The questionnaires allowed players to send incomplete responses, and all responses were considered in our analyses.

ANALYSIS

All returned questionnaires were included in the analysis regardless of missing items. All responses were exported into Microsoft Excel (V.16, Microsoft Redmond, Washington) and analysed using descriptive statistics. We have not performed any between-group comparisons, but players and coaches are shown in groups in the Results section.

RESULTS

Participant characteristics

Twenty-three of the 25 teams in the RCT participated in the survey. In total, 250 (51%) of the players enrolled at baseline were included, 107 (46%) of the intervention group and 143 (58%) of the control group, respectively. Seventeen coaches (68%) were included, 8 (73%) from the intervention group and 7 (50%) from the control group, respectively. Participant characteristics are shown in table 1.

Barriers and facilitators to load management implementation

The most important facilitators for players to implement a load management approach were scientific evidence for improved performance (88%) and mitigation of the injuries and illnesses (84%) as well as the coach being positive to it (86%; figures 1 and 2).

For coaches, the player's motivation to record training data (88%), scientific evidence of the preventative effect (100%) and scientific evidence of performance enhancement (71% figures 1 and 2) were considered most important.

Reach and adoption—experiences from the intervention

The questions and the responses from players in the intervention group to the load management programme are shown in table 4. Most players (93%) indicated that they had spent more than 10 min per week on the load management

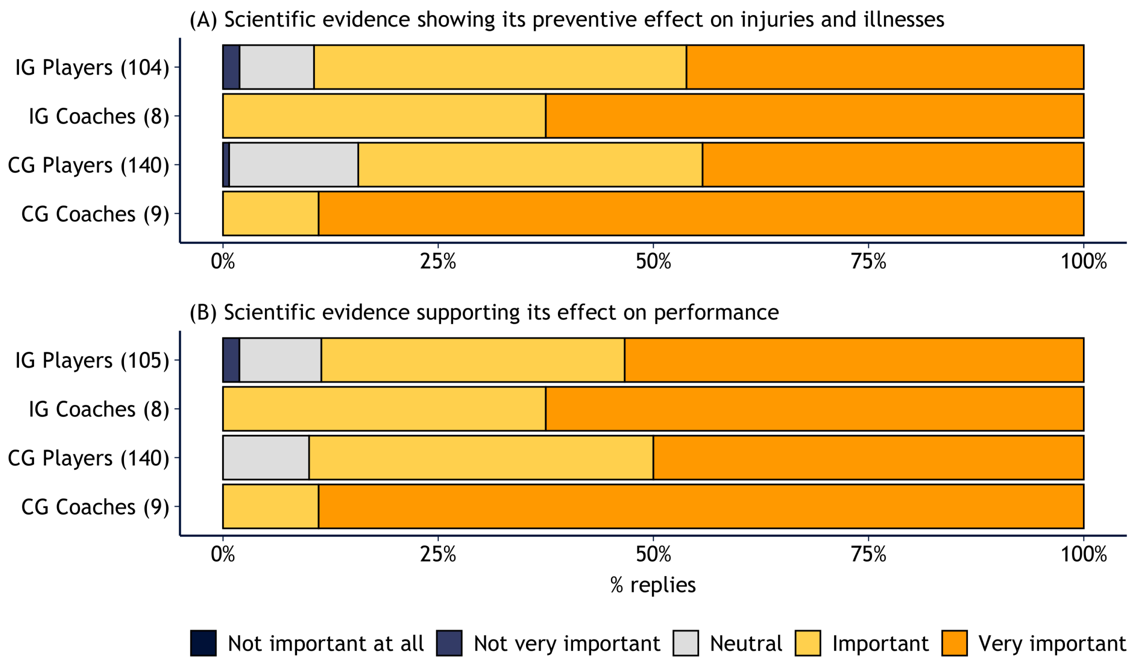

Figure 1 Players' and coaches' response to how important are the following alternatives for your motivation to spend time on overall load management? CG,control group; IG, intervention group.

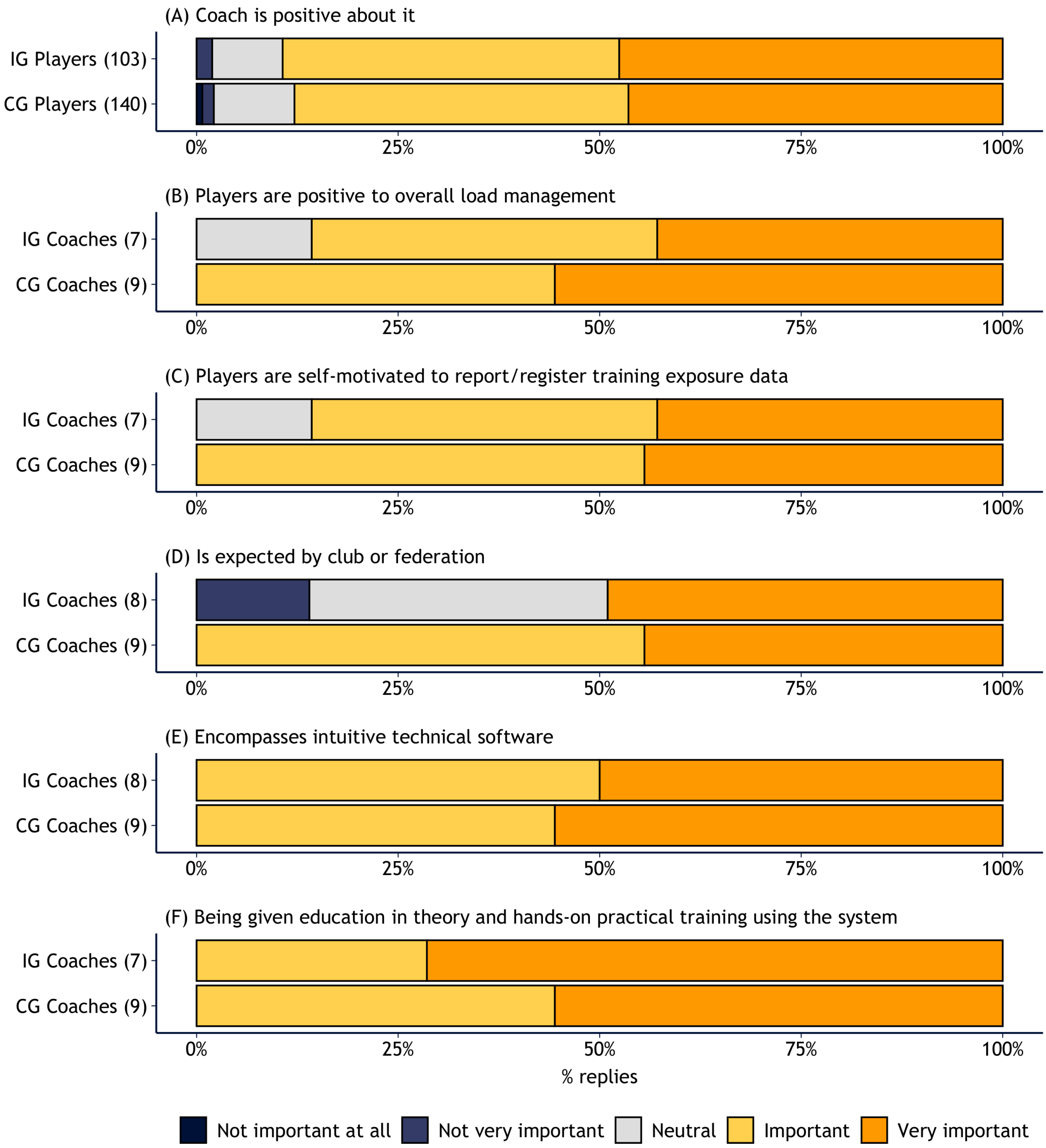

Figure 2 Players' and coaches' response to How important are the following alternatives for your motivation to spend time on overall load management? CG,control group; IG, intervention group.

programme. Coaches reported that they had spent more than 10 min (50%) or more than 30 min per week (50%). Furthermore, coaches indicated that they had used the specific load management programme as intended by the project group (63%) and confirmed that all players (100%) were aware of the ongoing load management programme. When asked whether they wanted to continue using a specific load management programme in the next season, half of the players (45%) and coaches (50%) replied 'yes definitively', and only 9% and 13% of players and coaches, respectively, replied 'no'.

Attitudes to load management and prevention of injuries and illnesses

An overview of the player's responses about their attitude to the prevention of injuries and illnesses is shown in table 2. Of the players included in the study, half (48%) considered footballers to be at high risk of injuries in general, and 55% considered footballers to be at high risk of overuse injuries. More than three quarters of the coaches considered players to be at high risk of injuries in general (76%) and overuse injuries (76%) in particular. Only one in 10 players considered footballers to be at high risk of illnesses. Furthermore, almost all players (90%) and all coaches strongly believed that load management could help reducing injury risk. Regarding overuse injuries, most players (66%) and almost all coaches (94%) strongly believed that a load management approach could have a preventive effect on injuries and illnesses. Despite this, only 28% of players responded that they were willing to spend more than 10 min per week on a load management intervention, even if they thought the intervention could reduce injury. However, if a load management intervention could increase players' performance, more than two-thirds (70%) of the players were willing to spend more than 10 min per week doing it. All coaches responded they were willing to spend more than 10 min per week on a load management measure to ensure both preventative and performance outcomes.

DISCUSSION

This study aimed to investigate players' and coaches' barriers and facilitators to a load management approach for the prevention of injuries and illnesses, and their attitudes and beliefs of load management and injuries and illnesses in general. Our main findings were that players and coaches could contribute to each other's attitude towards an intervention. Both groups need to be motivated for an intervention to be complied with. We also found that players and coaches reported scientific evidence for injury preventive and performance-enhancing effect and time-efficiency as important facilitators. Furthermore, players and coaches believe that footballers are at high risk of sustaining injuries in general and overuse injuries specifically and think that load management could reduce injuries and illnesses.

Facilitators and barriers for implementation

To successfully implement load management measures, coaches and athletes have a symbiotic relationship.[28] Players considered their coach's attitude towards load management measures to be one of the most important facilitators and coaches considered their players' attitudes equally important. Furthermore, the players' self-motivation to register training data is considered 'important' by 81% of the coaches, highlighting the need for both player and coach engagement to implement a load management intervention successfully. This aligns well with the findings of Andersson *et al*, where they demonstrated a link between player motivation and coach motivation.[16] For future studies aiming to implement injury preventive interventions, coaches need to be educated about the importance of their positive attitude to motivate the players and other staff to create a spiral of success.

Finch suggested that an intervention must be easy to adopt, and coaches must be informed on why and how the intervention works.[29] This seems to be supported by our findings, where coaches considered intuitive software solutions and proper training in using them as important facilitators. Moreover, time constraints have been proposed to be one major barrier in implementing preventive interventions.[23 24 28] Despite the players' trust in the preventive effect of load management, only 57% would spend more than 10 min, and less than one in three (28%) would want to spend more than 20 min weekly on injury and illness preventive measures. However, if there was an effect on football performance, more than two-thirds (70%) of the players were willing to spend more than 10 min weekly, but less than half (45%) would want to spend more than 20 min. This reflects a reluctance among players to spend much time on preventive measures regardless of the invention's effectiveness, and specifically more than 20 min. However, the task that the players had to complete in this intervention, the registration of training load in the smartphone application, is likely not to have taken more than 10 min, which means that players might have considered 10 min as enough and were, understandably, not willing to spend more time than advised.

All coaches were willing to spend more than 10 min per week on preventive measures if there were scientific evidence for either injury and illness prevention or performance enhancement. Due to their more time-demanding tasks, spending only 10 min would, contrary to the players, not be enough. Only two-thirds of the coaches were willing to spend more than 1 hour per week if there were evidence for prevention (35%) or performance benefits (41%), which, in our experience, is a reasonable estimate of what would be needed for the coaches to perform the load management intervention. Similar to our previous studies,[16 25] time constraints seem to be a major barrier for the coaches, further highlighting the need for future studies considering the time efficiency of their intervention. However, there is likely a tradeoff between effectiveness, perceived benefit and time spent. Future studies may consider comparing the effect of more time-consuming interventions with interventions being time efficient.

Another aspect to consider when creating an understanding of the importance of implementing preventive measures is to bring on board and engage other stakeholders, such as representatives from federations, associations and clubs. Three quarters (76%) of the coaches replied that the expectations of the club or federation were 'important' for their motivation, suggesting that high-level stakeholders should be targeted when introducing preventive measures.

Reach and adoption—experiences from the intervention

To understand the intervention's reach, we asked the coaches whether the players were aware of the

Table 2 Players' and coaches' attitude towards injury and illness prevention

		High risk	Some risk		Low risk	No risk
How much at risk are footballers to injuries in general?						
Players	IG (n=107)	50 (47)	55 (51)		2 (2)	0 (0)
	CG (n=143)	71 (50)	69 (48)		2 (1)	1 (1)
Coaches	IG (n=8)	6 (75)	2 (25)		0 (0)	0 (0)
	CG (n=9)	7 (78)	2 (22)		0 (0)	0 (0)
How much at risk are footballers to sustain an overuse injury?						
Players	IG (n=107)	54 (51)	50 (47)		3 (3)	0 (0)
	CG (n=143)	84 (59)	55 (39)		3 (2)	1 (1)
Coaches	IG (n=8)	7 (88)	1 (13)		0 (0)	0 (0)
	CG (n=9)	6 (67)	3 (33)		0 (0)	0 (0)
How much at risk are footballers to incur an illness?						
Players	IG (n=107)	9 (8)	63 (59)		32 (30)	3 (3)
	CG (n=143)	16 (11)	74 (52)		47 (33)	6 (4)
Coaches	IG (n=8)	3 (38)	3 (38)		2 (25)	0 (0)
	CG (n=9)	0 (0)	6 (67)		3 (33)	0 (0)
Load management can reduce injuries in general		**Strongly agree**	**Agree**	**Neither agree nor disagree**	**Disagree**	**Strongly disagree**
Players	IG (n=107)	54 (51)	46 (43)	7 (7)	0 (0)	0 (0)
	CG (n=143)	82 (57)	45 (32)	15 (11)	1 (1)	0 (0)
Coaches	IG (n=8)	8 (100)	0 (0)	0 (0)	0 (0)	0 (0)
	CG (n=9)	9 (100.)	0 (0)	0 (0)	0 (0)	0 (0)
Load management can reduce overuse injury						
Players	IG (n=107)	63 (59)	40 (37)	4 (4)	0 (0)	0 (0)
	CG (n=143)	101 (71)	34 (24)	7 (5)	0 (0)	0 (0)
Coaches	IG (n=8)	8 (100)	0 (0)	0 (0)	0 (0)	0 (0)
	CG (n=9)	8 (89)	1 (11)	0 (0)	0 (0)	0 (0)
Load management can reduce illness						
Players	IG (n=107)	28 (26)	49 (46)	29 (7)	1 (1)	0 (0)
	CG (n=143)	41 (29)	53 (37)	45 (32)	3 (2)	1 (1)
Coaches	IG (n=8)	3 (38)	3 (38)	2 (25)	0 (0)	0 (0)
	CG (n=9)	4 (44)	3 (33)	2 (25)	0 (0)	0 (0)
If load management reduced injury and illness - How much time would you spend weekly doing it?						
		0–10 min	**10–20 min**	**20–30 min**	**30–60 min**	**60 minutes**
Players	IG (n=104)	45 (43)	27 (26)	17 (16)	7 (7)	4 (4)
	CG (n=143)	52 (36)	46 (32)	23 (16)	8 (6)	9 (6)
Coaches	IG (n=8)	0 (0)	2 (25)	3 (38)	1 (13)	2 (25)
	CG (n=9)	0 (0)	1 (11)	2 (22)	2 (22)	4 (44)
If load management increased football performance - How much time would you spend weekly doing it?						
Players	IG (n=104)	35 (34)	29 (28)	18 (17)	13 (13)	6 (6)
	CG (n=141)	32 (23)	41 (29)	31 (22)	15 (11)	17 (12)
Coaches	IG (n=8)	0 (0)	2 (25)	2 (25)	2 (25)	2 (25)
	CG (n=9)	0 (0)	1 (11)	2 (22)	1 (11)	5 (56)

Continued

Table 2 Continued

	High risk	Some risk	Low risk	No risk

N (%).
CG, control group; IG, intervention group.

intervention. All the coaches reported that all players were aware of the protocol, suggesting that the population was reached. Most of the players (74%) reported having spent less than 5 min weekly on reporting load (table 3). This could be enough to report all footballing activity as advised, as the recording process itself is very time efficient. The coaches who had a much more time-demanding task as part of the intervention reported having followed the instructions on using the load management protocol 1 hour every week (63%), implying that the plan and intention for the intervention have been followed.

Attitudes towards injuries, illnesses and load management

The attitudes of most players and coaches are consistent with the current scientific literature on football players' overall risk of injury and risk of overuse injury.[1 3] Furthermore, coaches' and players' attitudes are also consistent with the literature that illness is not a major problem in football.[30] Players and coaches were aligned in their belief that injury overall and overuse injury specifically, but not illness, could be mitigated by load management. Whether this belief is consistent with scientific evidence is currently unclear.[14 31–33] Similarly, in an investigation among high-level academy and elite players in Germany, Zech and Wellmann[34] found that players believe that injury prevention is important and that players' considerations of what increases injury risk are not consistent with current scientific literature. When investigating coaches' perceptions on injury risk and prevention, Klein *et al*[35] reported that coaches rated injury prevention as highly relevant and that load management should be given greater priority in the coach education. Furthermore, the coaches' and players' belief on an effect can potentially be a facilitator in itself and may, thus, aid the implementation.[36] Also, players and coaches have a common understanding of the true scale of injuries and illnesses in football, which is a fundamental starting point when implementing preventive measures.

METHODOLOGICAL CONSIDERATIONS

The questionnaires used were tested in a small pilot study, and we cannot be certain all the participants understood the questions and similarly interpreted them. The two questions surrounding the risk of injuries overall and overuse injures specifically is likely to have been somewhat misinterpreted as players considered footballers to

Table 3 Players' and coaches' perceptions of the load management intervention

How much time did you spend weekly on the overall load management programme?								
		No time	<5 min	10 min	20 min	30 min	45 min	1 hour or more
Players	IG (n=111)	7 (6)	0 (0)	83 (75)	16 (15)	5 (5)	0 (0)	0 (0)
Coaches	IG (n=8)	0 (0)	0 (0)	3 (38)	1 (13)	2 (25)	0 (0)	2 (25)
Were the players aware of the programme?								
		Yes, all players	More than half of the players	Less than half of the players	None of the players			
Coaches	IG (n=8)	8 (100)	0 (0)	0 (0)	0 (0)			
Was the load management programme used as intended? (Minimum 1 hour before each training week)								
		Yes, every week	No, every other week	No, once per month	Was not used at all			
Coaches	IG (n=8)	5 (63)	1 (13)	2 (25)	0 (0)			
Are you planning to use an overall load management programme next season?								
		Yes, definitively	Yes, but in a less challenging way than this year	No	Do not know			
Players	IG (n=105)	47 (45)	23 (22)	9 (9)	26 (25)			
Coaches	IG (n=8)	4 (50)	0 (0)	1 (13)	3 (38)			

N (%).
CG, control group; IG, intervention group.

have a higher risk of overuse injuries than injuries overall. Furthermore, the terms 'scientific evidence' and 'performance' could have been more thoroughly refined in a focus group or pilot study as they might mean different things to different participants. The survey-based methodology is limited because it is only giving information in the specific areas assessed, meaning important components might have been missed, as they were not deemed as important when constructing the survey. A qualitative study design would have added value and might have been a more appropriate approach to achieve a deeper and more comprehensive understanding of the player's and coaches' perceptions.

When interpreting this study's results, the study's compliance was also suboptimal, and selection bias should be considered. We suspect that the players and coaches who responded to the questionnaire were more likely to have been positive to the intervention compared with nonrespondents, which may have influenced the results. Specifically, the low compliance of the players in the intervention group is a limitation. The intervention group players had lower compliance in the RCT as well, suggesting questionnaire fatigue from registering training data daily. The low number of coaches involved in this study means that we do not have too robust data on this group, so our findings of the coaches should be interpreted with caution. Also, the questionnaire did not include questions giving detailed information about maintenance, one of the key dimensions of the RE-AIM framework.

A strength of the study is the balanced number of male and female participants, representing the population of elite youth players in Norway, increasing the external validity. An additional strength is the low risk of contamination between players due to the late-night distribution of the questionnaire. This separates this study from a similar study that used paper-based questionnaires distributed in the dressing room with the whole team present.[23] Despite a nonoptimal response rate, this study still includes more than 250 participants supporting the strength of our findings.

PERSPECTIVES

As with previous research on preventive measures in sports, high compliance is necessary to investigate its real effectiveness. Given that coaches and players think that injury in general and overuse injury specifically are prevalent in football, and that load management measures can reduce them. It seems that the potential for successful implementation is present. However, there are two major circular problems. First, to adhere to the intervention, the players and coaches want evidence for effectiveness, but to investigate its effectiveness, we need players and coaches to adhere to the intervention. Second, to convince players to adhere to the intervention, players want coaches who are positive towards the intervention, motivating them to participate. On the contrary, to get the buy-in from the coaches, players adhering to the intervention is key.

When implementing a load management intervention, we can, based on the findings in this paper, give the following advice: (1) focus on the technical solutions for both coaches and players and make all participant involvement of an intervention time-efficient, (2) create buy-in from club and federation stakeholders as well as coaches and players and (3) focus on both performance and prevention when communicating with all relevant stakeholders. To engage end users' and gain population-specific knowledge, future implementations should consider qualitative surveying parts of the RE-AIM framework before planning the intervention. Although more detailed answerers regarding experiences from an intervention must be obtained after participating, initial key facilitators and barriers can be identified and planned for before the study starts.

Further investigations into coaches' and players' attitudes and beliefs of load management measures and the implementation of an intervention to mitigate injuries and illnesses are warranted as well as experimental investigations on the potential preventive and performance effect of a load management approach.

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Translated Questionnaire

Intervention group players								
1	**Were the players well aware of the programme?**							
		Yes, all players	More than half of the players	Less than half of the players	None of the players			
2	**Was the load management programme used as intended? (Minimum one hour prior to each training week)**							
		Yes, every week	No, every other week	No, once per month	Was not used at all			
3	**How much time weekly did you spend on the overall load management programme?**							
		No time	<5 Minutes	10 Minutes	20 Minutes	30 Minutes	45 Minutes	1 Hour or more
4	**Load management can reduce overuse injuries**	Fully agree	Agree	Not sure	Disagree	Totally disagree		
5	**Load management can increase performance**							
		Fully agree	Agree	Not sure	Disagree	Totally disagree		
6	**Which of the following affects your motivation to follow the programme? (You can select multiple alternatives)**							
		Belief that the programme can reduce injury and illness	Belief that the programme can increase performance	Sense of duty	Coach expectation	Medical staff expectation	Automatic reminder notifications	Other
7	**Did you observe an effect using the load management programme on injuries and illnesses?**							
		Yes, we had fewer injuries and or illnesses	No		No, we had more injuries and or illnesses		Don't know	
8	**Did you observe an effect using the overall load management programme on the teams performance?**							
		Yes, we had an improvement in performance	No		No, we had a reduction in performance		Don't know	

9	**How much do you agree with the following statements?**					
a	**Load management can reduce injuries**					
		Fully agree	Agree	Not sure	Disagree	Totally disagree
b	**Load management can reduce overuse injuries**					
		Fully agree	Agree	Not sure	Disagree	Totally disagree
c	**Load management can reduce illnesses**					
		Fully agree	Agree	Not sure	Disagree	Totally disagree
10	**How much at risk are footballers to injuries?**					
		High risk	Somewhat risk	Low risk	No risk	
11	**How much at risk are footballers to overuse injuries?**					
		High risk	Somewhat risk	Low risk	No risk	
12	**How much at risk are footballers to illnesses?**					
		High risk	Somewhat risk	Low risk	No risk	
13	**Of these alternatives, what is most associated with injuries overall among footballers?**					
		Too little training	Too much training	Poor load management	Other	
14	**Of these alternatives, what is most associated with overuse injuries among footballers?**					
		Too little training	Too much training	Poor load management	Other	
15	**Of these alternatives, what is most associated with illnesses among footballers?**					
		Too little training	Too much training	Poor load management	Other	

16	**How large are the injury and illness problems in elite youth football compared to professional football?**						
		Much lower	Lower	Same	Higher	Much higher	
17	**How much do you agree with the following statements?**						
a	**My team should have more footballing training sessions**						
		Fully agree	Agree	Not sure	Disagree	Totally disagree	
b	**My team should have fewer footballing training sessions**						
		Fully agree	Agree	Not sure	Disagree	Totally disagree	
c	**My team should play more matches**						
		Fully agree	Agree	Not sure	Disagree	Totally disagree	
d	**My team should play fewer maches**						
		Fully agree	Agree	Not sure	Disagree	Totally disagree	
18	**If a load management programme could reduce injuries and illnesses - How much time are you willing to spend on it weekly?**						
		Not willing to spend any time	0-10 minutes	10-20 minutes	20-30 minutes	30-60 minutes	Over 60 minutes
19	**If a load management programme could increase football performance - How much time are you willing to spend on it weekly?**						
		Not willing to spend any time	0-10 minutes	10-20 minutes	20-30 minutes	30-60 minutes	Over 60 minutes
20	**How imporant are the followign reasons for your motivation to spend time on load management?**						
a	**Demanded by the coach**						
		Very important	Important	Neutral	Not very important	Not important at all	
b	**Coach is positive towards it**						

		Very important	Important	Neutral	Not very important	Not important at all
c	**Scientific backing for its preventive effect on injury and illness**					
		Very important	Important	Neutral	Not very important	Not important at all
d	**Scientific backing for its preventive effect on performance enhancment**					
		Very important	Important	Neutral	Not very important	Not important at all
e	**Are you planning to use an overall load management programme next season too?**					
		Yes, definitively		Yes, but in a less challenging way than this year	No	Don't know

Control group players

1	**Are you familiar with the Session Rating Of Percieved Exertion (sRPE) concept?**					
		Yes	No	Don't know		
2	**Did your club use any load monitoring measures during the course of this season?**					
		Yes	No	Don't know		
3	**How much do you agree with the following statements?**					
a	**Load management can reduce injuries**					
		Fully agree	Agree	Not sure	Disagree	Totally disagree
b	**Load management can reduce overuse injuries**					
		Fully agree	Agree	Not sure	Disagree	Totally disagree
c	**Load management can reduce illnesses**					
		Fully agree	Agree	Not sure	Disagree	Totally disagree

4	**How much at risk are footballers to injuries?**					
		High risk	Somewhat risk	Low risk	No risk	
5	**How much at risk are footballers to overuse injuries?**					
		High risk	Somewhat risk	Low risk	No risk	
6	**How much at risk are footballers to illnesses?**					
		High risk	Somewhat risk	Low risk	No risk	
7	**Of these alternatives, what is most associated with injuries overall among footballers?**					
		Too little training	Too much training	Poor load management	Other	
8	**Of these alternatives, what is most associated with overuse injuries among footballers?**					
		Too little training	Too much training	Poor load management	Other	
9	**Of these alternatives, what is most associated with illnesses among footballers?**					
		Too little training	Too much training	Poor load management	Other	
10	**How large are the injury and illness problems in elite youth football compared to professional football?**					
		Much lower	Lower	Same	Higher	Much higher
11	**How much do you agree with the following statements?**					
a	**My team should have more footballing training sessions**					
		Fully agree	Agree	Not sure	Disagree	Totally disagree
b	**My team should have fewer footballing training sessions**					
		Fully agree	Agree	Not sure	Disagree	Totally disagree

c	**My team should play more matches**							
		Fully agree	Agree	Not sure	Disagree	Totally disagree		
d	**My team should play fewer maches**							
		Fully agree	Agree	Not sure	Disagree	Totally disagree		
11	**If a load management programme could reduce injuries and illnesses - How much time are you willing to spend on it weekly?**							
		Not willing to spend any time	0-10 minutes	10-20 minutes	20-30 minutes	30-60 minutes	Over 60 minutes	
12	**If a load management programme could increase football performance - How much time are you willing to spend on it weekly?**							
		Not willing to spend any time	0-10 minutes	10-20 minutes	20-30 minutes	30-60 minutes	Over 60 minutes	
13	**How imporant are the followign reasons for your motivation to spend time on load management?**							
a	**Demanded by the coach**							
		Very important	Important	Neutral	Not important	Negligible		
b	**Coach is positive towards it**							
		Very important	Important	Neutral	Not important	Negligible		
c	**Scientific backing for its preventive effect on injury and illness**							
		Very important	Important	Neutral	Not important	Negligible		
d	**Scientific backing for its preventive effect on performance enhancment**							
		Very important	Important	Neutral	Not important	Negligible		
14	**Are you planning to use an overall load management programme next season?**							
		Yes, definitively		Yes, but in a less challenging way than this year		No		Don't know

Intervention group coaches

1	**Are the following personell well aware of the training load management programme?**						
	Head coach						
		Yes	No	Don't know			
	Sports medicine staff						
		Yes	No	Don't know			
	Other coaching staff						
		Yes	No	Don't know			
2	**Are the players well aware of the training load management programme?**						
		Yes, all players	More than half of the players	Less than half of the players	No, none of the players		
3	**Was the programme used as prescribed? (Minimum one time before each training week)**						
		Yes, every week	No, every other week	No, once per month	Was not used at all		
4	**Which of the players have recorded all their training data?**						
		All	Those with previous overuse problems	Those with existing overuse problems	The most abitious ones	None	Don't know
5	**Do you believe that a load managment programme can reduce injuries and/or illnesses?**						
		Fully agree	Agree	Not sure	Disagree	Totally disagree	
6	**Do you believe that a load managment programme can increase team performance?**						
		Fully agree	Agree	Not sure	Disagree	Totally disagree	
7	**How is the general attitute towards injury preventive measures in the following groups in your club?**						
a	**Coaching staff**						

		Very positive	Positive	Neutral	Negative	Very negative		
b	**Sports medicine staff**							
		Very positive	Positive	Neutral	Negative	Very negative		
c	**Players**							
		Very positive	Positive	Neutral	Negative	Very negative		
d	**Other stakeholders**							
		Very positive	Positive	Neutral	Negative	Very negative		
8	**How much time per week did you spend on the load management programme?**							
		No time	<5 Minutes	10 Minutes	20 Minutes	30 Minutes	45 Minutes	1 Hour or more
9	**Did you observe an effect using the load management programme on injuries and illnesses?**							
		Yes, we had fewer injuries and or illnesses	No		No, we had more injuries and or illnesses		Don't know	
10	**Did you observe an effect using the overall load management programme on the teams performance?**							
		Yes, we had an improvement in performance	No		No, we had a reduction in performance		Don't know	
11	**How much do you agree with the following statements?**							
a	**Load management can reduce injuries**							
		Fully agree	Agree	Not sure	Disagree	Totally disagree		
b	**Load management can reduce overuse injuries**							
		Fully agree	Agree	Not sure	Disagree	Totally disagree		
c	**Load management can reduce illnesses**							
		Fully agree	Agree	Not sure	Disagree	Totally disagree		

12	**How much at risk are footballers to injuries?**						
		High risk	Somewhat risk	Low risk	No risk		
13	**How much at risk are footballers to overuse injuries?**						
		High risk	Somewhat risk	Low risk	No risk		
14	**How much at risk are footballers to illnesses?**						
		High risk	Somewhat risk	Low risk	No risk		
15	**Of these alternatives, what is most associated with injuries overall among footballers?**						
		Too little training	Too much training	Poor load management	Other		
15	**Of these alternatives, what is most associated with overuse injuries among footballers?**						
		Too little training	Too much training	Poor load management	Other		
17	**Of these alternatives, what is most associated with illnesses among footballers?**						
		Too little training	Too much training	Poor load management	Other		
18	**How large are the injury and illness problems in elite youth football compared to professional football?**						
		Much lower	Lower	Same	Higher	Much higher	
19	**Did you employ other injury preventive measures during the course of the season**						
		Yes	No	Don't know			
20	**If a load management programme could reduce injuries and illnesses - How much time are you willing to spend on it weekly?**						
		Not willing to spend any time	0-10 minutes	10-20 minutes	20-30 minutes	30-60 minutes	Over 60 minutes

21	**If a load management programme could increase football performance - How much time are you willing to spend on it weekly?**						
		Not willing to spend any time	0-10 minutes	10-20 minutes	20-30 minutes	30-60 minutes	Over 60 minutes
22	**How imporant are the following reasons for your motivation to spend time on load management?**						
a	**Easy and intuitive software**						
		Very important	Important	Neutral	Not very important	Not important at all	
b	**Can be controlled by an app**						
		Very important	Important	Neutral	Not very important	Not important at all	
c	**That you are given proper training in theory and in practical use of the system**						
		Very important	Important	Neutral	Not very important	Not important at all	
d	**That the physio and or fitness coach is given training in theory and use of the system**						
		Very important	Important	Neutral	Not very important	Not important at all	
e	**That the club recieves regular follow up in theory and the use of the system**						
		Very important	Important	Neutral	Not very important	Not important at all	
f	**That it takes a short amount of time**						
		Very important	Important	Neutral	Not very important	Not important at all	
g	**That the players are motivated to answer**						
		Very important	Important	Neutral	Not very important	Not important at all	
h	**Players are positive towards load management**						
		Very important	Important	Neutral	Not very important	Not important at all	
i	**That other clubs are using it**						

		Very important	Important	Neutral	Not very important	Not important at all			
j	**Scientific backing for its preventive effect on injury and illness**								
		Very important	Important	Neutral	Not very important	Not important at all			
k	**Scientific backing for its preventive effect on performance enhancment**								
		Very important	Important	Neutral	Not very important	Not important at all			
l	**Demanded by the footballing authority**								
		Very important	Important	Neutral	Not very important	Not important at all			
23	**Are you planning to use a similar load management programme next season?**								
		Yes, definitively		Yes, but in a less challenging way than this year		No		Don't know	
24	**What is your highest qualification? (Multiple answers are possible)**								
	No education	Sports studies foundation	Bachelor sports science	Masters sports science	UEFA C-license	UEFA B-license	UEFA A-license	Sports medicine relevant foundation studies	Sports medicine relevant bachelor
25	**How many years experience as a coach do you have?**								
	0-2 years	2-4 years	4-6 years	6-8 years	10-12 years	12-14 years	More than 14 years		

Control group coaches

1	**Do you believe that a load managment programme can reduce injuries and/or illnesses?**					
		Fully agree	Agree	Not sure	Disagree	Totally disagree

2	**Do you believe that a load managment programme can increase team performance?**					
		Fully agree	Agree	Not sure	Disagree	Totally disagree
3	**How much do you agree with the following statements?**					
a	**Load management can reduce injuries**					
		Fully agree	Agree	Not sure	Disagree	Totally disagree
b	**Load management can reduce overuse injuries**					
		Fully agree	Agree	Not sure	Disagree	Totally disagree
c	**Load management can reduce illnesses**					
		Fully agree	Agree	Not sure	Disagree	Totally disagree
4	**How much at risk are footballers to injuries?**					
		High risk	Somewhat risk	Low risk	No risk	
5	**How much at risk are footballers to overuse injuries?**					
		High risk	Somewhat risk	Low risk	No risk	
6	**How much at risk are footballers to illnesses?**					
		High risk	Somewhat risk	Low risk	No risk	
7	**Of these alternatives, what is most associated with injuries overall among footballers?**					
		Too little training	Too much training	Poor load management	Other	
8	**Of these alternatives, what is most associated with overuse injuries among footballers?**					
		Too little training	Too much training	Poor load management	Other	
9	**Of these alternatives, what is most associated with illnesses among footballers?**					

		Too little training	Too much training	Poor load management	Other		
10	**How large are the injury and illness problems in elite youth football compared to professional football?**						
		Much lower	Lower	Same	Higher	Much higher	
11	**Did you employ other injury preventive measures during the course of the season**						
		Yes	No	Don't know			
12	**If a load management programme could reduce injuries and illnesses - How much time are you willing to spend on it weekly?**						
		Not willing to spend any time	0-10 minutes	10-20 minutes	20-30 minutes	30-60 minutes	Over 60 minutes
13	**If a load management programme could increase football performance - How much time are you willing to spend on it weekly?**						
		Not willing to spend any time	0-10 minutes	10-20 minutes	20-30 minutes	30-60 minutes	Over 60 minutes
14	**How imporant are the following reasons for your motivation to spend time on load management?**						
a	**Easy and intuitive software**						
		Very important	Important	Neutral	Not very important	Not important at all	
b	**Can be controlled by an app**						
		Very important	Important	Neutral	Not very important	Not important at all	
c	**That you are given proper training in theory and in practical use of the system**						
		Very important	Important	Neutral	Not very important	Not important at all	
d	**That the physio and or fitness coach is given training in theory and use of the system**						
		Very important	Important	Neutral	Not very important	Not important at all	

e	**That the club recieves regular follow up in theory and the use of the system**					
		Very important	Important	Neutral	Not very important	Not important at all
f	**That it takes a short amount of time**					
		Very important	Important	Neutral	Not very important	Not important at all
g	**That the players are motivated to answer**					
		Very important	Important	Neutral	Not very important	Not important at all
h	**Players are positive towards load management**					
		Very important	Important	Neutral	Not very important	Not important at all
i	**That other clubs are using it**					
		Very important	Important	Neutral	Not very important	Not important at all
j	**Scientific backing for its preventive effect on injury and illness**					
		Very important	Important	Neutral	Not very important	Not important at all
k	**Scientific backing for its preventive effect on performance enhancment**					
		Very important	Important	Neutral	Not very important	Not important at all
l	**Demanded by the footballing authority**					
		Very important	Important	Neutral	Not very important	Not important at all

15	**Are you planning to use a similar load management programme next season?**				
		Yes, definitively	Yes, but in a less challenging way than this year	No	Don't know

16 **What is your highest qualification? (Multiple answers are possible)**

	No education	Sports studies foundation	Bachelor sports science	Masters sports science	UEFA C-license	UEFA B-license	UEFA A-license	Sports medicine relevant foundation studies	Sports medicine relevant bachelor
17	**How many years experience as a coach do you have?**								
	0-2 years	2-4 years	4-6 years	6-8 years	10-12 years	12-14 years	More than 14 years		

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Injury characteristics in Norwegian Male professional football: A comparison between a regular season and a season in the pandemic

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ABSTRACT

The Coronavirus Disease-19 (COVID-19) pandemic forced the Norwegian male premier league football season to reschedule, reducing the fixture calendar substantially. Previous research has shown that a congested match schedule can affect injury rates in professional football. Therefore, we aimed to investigate whether the Norwegian premier league teams suffered more injuries in the match congested 2020 season than the regular 2019-season.

We invited all teams having participated in both seasons to export their injury data. Only teams that used the same medical staff to register injuries in both seasons were included, and to maximise data comparability between seasons, we applied a time-loss injury definition only.

Eight of 13 teams agreed to participate and exported their injury data. The 2020 season was 57 days shorter than the 2019 season. The match injury incidence differed insignificantly (incidence rate ratio 0.76 (0.48 to 1.20; p=0.24) in the 2020 season compared to the 2019 season. Furthermore, we found no differences in the number of injuries, days lost to injury, matches missed to injury, or injury severity.

We present the first injury data from a complete post-lockdown professional football season. We could not detect any differences between the two seasons, suggesting the congested match calendar in the 2020 season is a safe alternative in future seasons.

INTRODUCTION

Following the world-wide spreading of the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) and the subsequent Coronavirus Disease-19 (COVID-19), all sports in Norway suddenly stopped in mid-March 2020. Consequently, the 2020 Norwegian male premier league that was scheduled to start on the 4th of April was postponed until the 16th of June, thus shortening the fixture calendar by 49 days.

To fully recover from football matches, players need a recovery period of up to 72 hours.[1,2] Resuming match play before players are fully recovered may lead to them playing with decreased muscular function,[3] muscle tissue damage[4] and mental fatigue.[5] Previous research has shown that injury risk can be affected when matches are congested into shorter periods.[6-10] Research examining match congestion effects on injury rates has used many different thresholds and definitions. Matches played with four or fewer recovery days had higher injury rates than matches with six or more recovery days.[9] Injury rates also increased when matches were played in succession with three days of recovery,[6] when teams had five days or less recovery[8] and when teams had three days or less recovery.[7] Furthermore, Howle et al[10] found an increase in injury rates in weeks with more than one match and in seasons containing periods of match congestion. Contrary to these findings, Carling et al[11] found no difference in injury rates in periods of match congestion (8 matches in 26 days). The first study examining the effect of rescheduling the fixture calendar due to COVID-19 was the German Bundesliga observing an increase in match injury incidence following a lockdown period compared to the pre-lockdown match period.[12]

It is unknown whether this also happened in Norwegian male premier league football following the COVID-19 lockdown period is unknown. To inform federations and league organisations, technical and medical staff in future planning of match and training schedules, an investigation of the effect of match congestion on the 2020 season injury rates is warranted. Therefore, this study aimed to investigate seasonal differences in injury characteristics between the 2019 and the 2020 seasons.

METHOD

This longitudinal descriptive study compared the injury characteristics in two seasons in the Norwegian male premier league (Eliteserien). All teams that participated in both the 2019 and 2020 (N=13) seasons were invited. We included teams that, in their own club setting, had recorded injuries with a reliable method, using the same medical staff to register injuries in both seasons. Towards the end of the 2020-season, we contacted each team's medical coordinator to introduce them to the study and inquire about their injury registration routines. All players with a first-team contract in 2019 and/or 2020 were invited. The study was reviewed by the Norwegian School of Sport Sciences' Ethical committee and approved by the Norwegian Centre for Research Data (896416). All eligible players signed written informed consent before the study start. We prepared this study according to the International Olympic Committee (IOC) consensus statement on methods for recording and reporting on epidemiology data in sport, and the STROBE Extension for Sports Injury and Illness Surveillance.[13]

Data collection

All data were anonymised by the team's responsible medical staff member and exported to the principal investigator (TDL) via email or post. Six teams manually extracted injury data from the medical records and/or their data records, whereas two teams exported data directly from their Athlete Monitoring System (AMS). When organising the data into comparable spreadsheets, the principal investigator had video or telephone consultations with each of the teams' medical coordinators to ensure that all data were comparable across the two seasons and to exclude any data recording errors.

Injury

An injury was defined using a time-loss definition.[13,14] We ensured that all team's had used the same interpretation. All reported that they used the same criteria for return to play, i.e. when a player was cleared for full participation in either team training or match play. The number of days injured starting from the day after the onset of the injury (i.e. the first potential absence from team training activity) until the return to full participation was considered days lost to injury and used to calculate injury incidence and injury burden. When analysing the injury burden, all days lost to injury were assigned to the month the injury was registered (i.e. an ACL injury in January 2019 would be attributed 300 days lost to injury and 30 matches missed in January). Injury severity was calculated based on the number of days lost per injury and categorised as recommended in the IOC consensus statement.[13] Availability was calculated as the average percentage of players available for match selection. If a player was absent due to a reason other than an injury, the player was removed from the available player's calculation. The absence of players was expressed using the average percentage of players that were absent from training or match due to injury or illness.

Exposure

We used data from the Football Association of Norway to record each teams' match exposure. All match exposures were calculated as *11 players X 90 minutes – minutes missed from red cards*, and we included league matches for the match exposure analysis. Since only three teams reported training exposure data, we excluded this data from the analyses.

Data analyses

Continuous data are presented as mean (standard deviation; SD). Incidence was calculated in R[15] using the *epiR*-package[16] (script and data available as supplementary data, #1). Incidence was expressed as the number of injuries per 1000 hours of exposure. Injury burden was expressed as the sum of all days off caused by injury.

When analysing between season-difference in incidence and the number of injuries, a Poisson regression was used. The analysis was performed in R using the *sandwich* [17]and *msm* [18] packages (script and data available as supplementary data, #2) and was reported with robust standard errors.[19] To analyse the difference in the number of days lost and matches missed due to injury, a one-sample t-test was used for the average of the team's seasonal difference in Stata (V.15.3-StataCorp LLC, College Station, Texas, USA) using the t-test-command (script and results available as supplementary data, #3). We did not analyse monthly seasonal differences on either injury parameter

Results

We recorded 3461 and 3462 hours of match exposure from the 2019 and the 2020 seasons, respectively. A total of 506 injuries were recorded (Table 1), of which 183 occurred during match play. In total, we found 13 963 days lost and 1469 matches missed due to injury.

Participants and exposure

The 2019-season started on the 31st of March and ended on the 1st of December, lasting 246 days. Due to Covid-19 restrictions, the 2020-season was postponed from the scheduled start on the 5th of April until the 16th of June and ended on the 22nd of December, reducing the planned match period from 238 to 189 days (Figure 1). The average number of recovery days between matches was 7.5 and 5.5 days in 2019 and 2020, respectively. However, the number of recovery days differed vastly between periods within both seasons, especially in game week 1 to 12 and 25 to 29 in 2020 (Figure 1).

Eight of 13 eligible teams agreed to participate (Figure 2). These teams had on average 26 players in their squad, and we included 213 players in the 2019 season and 208 in the 2020 season, giving a total of 412 player-seasons. Of the five teams that declined participation, two teams reported they had not registered injury data appropriately. One team had changed athlete management system (AMS) and felt they did not have comparable data. One team reported they did not have resources to organise and export the data and one team declined without providing any reason.

Injury incidence

The number of all injuries ranged from one team reporting seven injuries in the 2019 season to another team reporting 88 injuries in the 2020 season. There were in total 14 more injuries recorded in the 2020 season than in the 2019 season (1.05, Confidence Interval; CI 0.54 to 2.04; p=0.88; Table 1).

Match injury incidence

We recorded 104 match injuries in the 2019 season and 79 match injuries in the 2020 season (Table 1). There was a large between-team discrepancy in match injury incidence (Table 2), ranging from 4.04 per 1000h to 48.54 per 1000h. The total match incidence was 7.23 per 1000h lower in 2020 (22.82 per 1000h; CI 18.07 to 28.44; Incidence Rate Ratio; IRR 0.76) than in 2019 (30.05 per 1000h; CI 24.55 to 36.41), however, this was not a significant difference (Table 2).

The match incidence did not appear to follow a distinct pattern in either of the seasons (Figure 3).

Injury burden

We found no difference in the number of injuries (0.94, CI- 0.49 to 1.8; p=0.84), days lost to injury (-15.57 (CI -273.49 to 242.35; p=0.89), or matches missed (4.28 (CI -32.26 to 40.83; p=0.78) between the two seasons (Table 1, Figure 4).

Availability

The average training availability was 84.1% and 85.9% in the 2019 and the 2020 seasons, respectively. The average match availability was 86.6% in the 2019 season and 88.2% in the 2020 seasons. Thus, we found no significant differences between the two seasons for neither training nor match availability.

Injury severity

In the 2020-season, there were slightly fewer days lost to injury (n=6995 – n=6881). The injury severity seems to follow a similar distribution in both seasons, approximately 1/3 of the number of injuries are distributed in each of the categories mild, moderate and severe (Table 3).

Discussion

We present the first published data from a complete post-lockdown professional football season. This study aimed to compare potential differences in the injury patterns in one regular season and one congested season in Norwegian male professional football. The planned congested match schedule raised concerns among players and coaches related to match load and injury risk; however, as there was no increase in injuries in 2020, players' and coaches' were unjustified.

Match injury incidence

The match injury incidence was higher compared to previous studies from the Norwegian male premier league.[20] Bjørneboe et al found an overall increase in match injury incidence from 2002 to 2007, the increase found then is likely to have continued.[20] The match injury incidence in this study is comparable with findings from the comprehensive UEFA Champions League injury audit (23 per 1000h).[21] Our results (30 per 1000h and 23 per 1000h, respectively) are slightly lower than the match injury incidence of 36 per 1000h reported by López-Valenciano et al[22] in a meta-analysis of 40 studies in professional male football.

We did not observe a between-season difference, even though the 2020-season was played with an average of two fewer recovery days between matches. Previous studies examining the effect of a congested match schedule have reported increased[6-11] and unchanged[23,24] injury rates. Most of these studies have investigated whether shorter periods of matches congestion lead to increased injury risk compared with match periods with more recovery days in between.[6-9,11,23,24] We compared two complete seasons where one had 5.5 and the other had 7.5 average recovery days between matches, making a direct comparison with most previous study difficult. One exemption, however, is the study by Howle et al,[10] who compared three full seasons and found that the season with congested match periods had higher injury rates. This was not in line with our results. Despite the 2020 season having 5.5 recovery days on average, many match periods were even more congested (Figure 1). For instance, following a positive COVID-19 test in one team, the team was quarantined for ten days not allowed to any scheduled team training. Immediately following the quarantine period, the team played five matches in 13 days, resulting in three match injuries.

One study has compared injury rates before and after the COVID-19 pandemic lockdown, only. Seshadri et al[12] reported a threefold increase in injury rate when the German Bundesliga resumed playing after two months in lockdown. The study compared the seven rounds played after lockdown with the 26 rounds played pre-lockdown. Whereas, in our study, we compared two complete seasons and the lockdown period happening in the season-break in between the two seasons. Furthermore, the Bundesliga teams had only ten days of team training and no friendly matches before resuming match play.[25]

Due to the pandemic, the Norwegian male premier league preseason was interrupted after two months (mid-March), then players being allowed to train in small cohorts of five from mid-April to mid-May. After mid-May, normal-proximity team training and friendly matches were allowed for four weeks before the season started in mid-June. The four week period of regular preseason preparation in the Norwegian premier league is likely to have mitigated some of the injury risk.[26]

In an attempt to decrease the individual match load on the players', teams were permitted five substitutions in the 2020-season, compared to three in the 2019-season.[27] This affected the number of substitutions, as the average number of substitutions increased by 0.8 per match (2.8 in 2019, 3.6 in 2020) in the teams participating in this study. Moreover, this rule change has enabled teams rotating players to manage the load of players individually based on risk of injury, likely contributing to mitigating some of the injury risk in the 2020-season.

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Availability, injury severity and injury burden

Periods of match congestion can lead to a decrease in weekly training load,[28] and thus expose players to injury during training affecting the overall number of injuries. We recorded an average training (84% and 86%, respectively) and match availability (87% and 88%, respectively), similar to the previously reported training availability (88%) and match availability (88%) by Ekstrand et al.[21] We did not find any differences in days lost to injury between the two seasons. In periods of match congestion, the same number of days lost to injury would mean more matches missed than in a normal period (i.e. a two-week absence in mid-June would result in zero matches missed in 2019 and five matches missed in 2020). This was not the case in our study, neither regarding matches missed due to injury or match availability.

Methodological considerations

What constitutes a ‘recordable event’ is arguably one of the most critical methodological factors in sports injury and illness surveillance studies.[29] In this study, we used data from the teams’ injury surveillance systems, and differences in perception of what constitutes a recordable event could explain the large inter-team variation. Surveillance data from different data recorders are not necessarily comparable,[30] and therefore, we only compared each team’s data with their own data. We chose to use a time-loss definition as it is considered the most reliable definition, because full participation in training or match play is relatively easy to measure, and is considered reliable across recorders.[31] There are, however, a large number of injury problems that do not lead to reduced participation, which are overlooked using the time-loss definition.[29,32,33]

One major limitation in this study is the lack of training exposure data. This was not made accessible by the teams, and therefore, we were prevented from calculating the recommended metrics of the overall incidence and injury burden per 1000 hours in this study.[13,34] Consequently, we cannot be sure that our results of the overall number of injuries arise due to differences in exposure. Furthermore, only using one season as a baseline for what is “normal” is a limitation injury rates will vary from season to season.[23,35] Hence, we cannot be sure that the 2019-season is a correct measure of a regular Norwegian premier league season.

Our findings are not necessarily comparable to the top-elite leagues in Europe. A regular competitive season in the Norwegian premier league involves an average of ~4.6 matches per month from April to November. This is lower than top-level teams in international leagues who play approximately six matches per month for ten months.[7] However, these findings may inform practice for leagues having similar schedules.

Perspectives

Despite the limitations of this study, our results can inform federations and league organisations in scheduling competitive season setup. The rule change implemented due to the pandemic which allowed five substitutions per match enabled teams to incorporate and improve rotation strategies. This may have mitigated an increased injury risk due to match congestion. We think this should be considered when planning seasons with unexpected or unusual high match congestion in the future. Our findings are especially applicable for leagues playing a similar amount and frequency of matches.

Based on the data from this study, playing a more match congested calendar congestion is safe, using safety measures such as an increased allowance of substitutions.

Contributions

Contributed to conception and design: TDL, JB, BC, TEA

Contributed to acquisition of data: TDL, JB, CT, MB, DT, AB, TGL, CW, EM

Contributed to analysis and interpretation of data: TDL, JB, CT, MB, DT, AB, TGL, CW, EM, BC, TEA

Drafted and/or revised the article: TDL, JB, CT, MB, DT, AB, TGL, CW, EM, BC, TEA

Approved the submitted version for publication: TDL, JB, CT, MB, DT, AB, TGL, CW, EM, BC, TEA

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Data and Supplementary Material Accessibility

All data are available at https://osf.io/f8dc9/

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TABLES

Table 1 Number of match injuries, all injuries, total days lost due to injury and matches missed for the 2019 and the 2020 seasons

Team	Match injuries			All injuries			Total days lost			Matches missed		
	2019	2020	Change	2019	2020	Change	2019	2020	Change	2019	2020	Change
1	4	2	-2	7	9	2	387	362	-25	40	47	7
2	18	10	-8	63	87	24	752	995	243	70	100	30
3	24	17	-7	71	44	-27	2300	1745	-555	204	126	-78

4	21	17	-4	38	44	6	771	1037	266	95	116	21
5	11	15	4	18	30	12	516	540	24	46	72	26
6	15	8	-7	30	24	-6	1205	1057	-148	116	105	-11
7	11	10	-1	19	21	2	1105	1191	86	99	134	35
8	N/A	N/A		N/A	N/A		N/A	N/A		67	32	-35
X / Sum	104	79	-25	246	260	14	7036	6927	-109	737	732	-5

Table 2 Match injury incidence in the 2019 and the 2020 seasons.

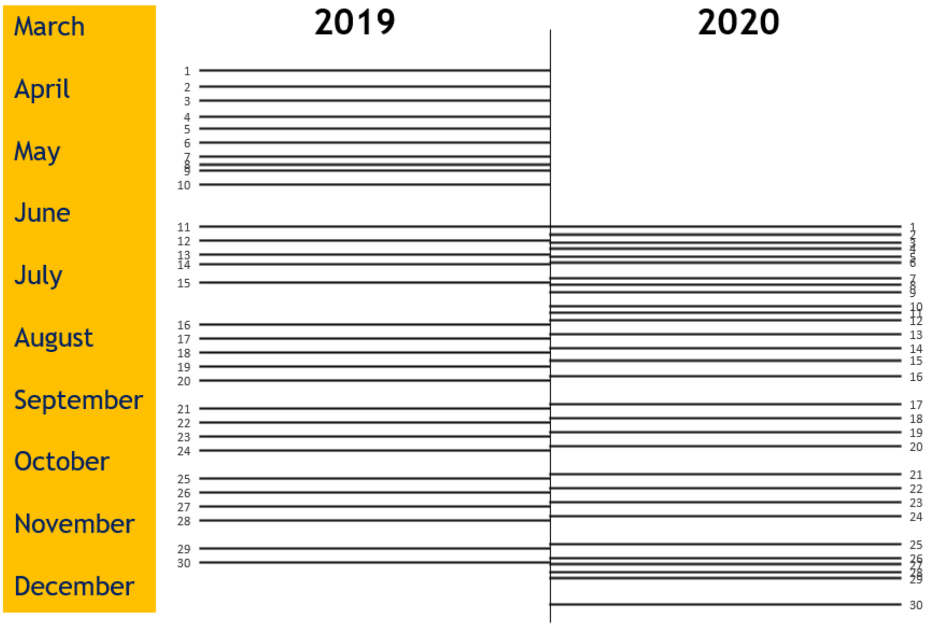
Team	Match injury incidence				
	2019	2020	Change	Incidence rate ratio	p-value
1	8.09 (2.2 - 20.72)	4.04 (0.49 - 14.61)	-4.05		
2	36.36 (21.55 - 57.47)	20.21 (9.69 - 37.16)	-16.16		
3	48.54 (31.01 - 72.22)	34.34 (20.01 -54.99)	-14.20		
4	42.42 (26.26 - 64.85)	34.43 (20.06 - 55.13)	-7.99		
5	22.29 (11.13 - 39.89)	30.39 (17 - 50.12)	8.10		
6	30.39 (17 - 50.12)	16.16 (6.97 - 31.84)	-14.23		
7	22.22 (11.09 - 39.76)	20.22 (9.69 - 37.18)	-2.00		
8	N/A	N/A			
Average	30.05 (24.55 - 36.41)	22.82 (18.07 - 28.44)	-7.23	0.76 (0.48-1.20)	0.24

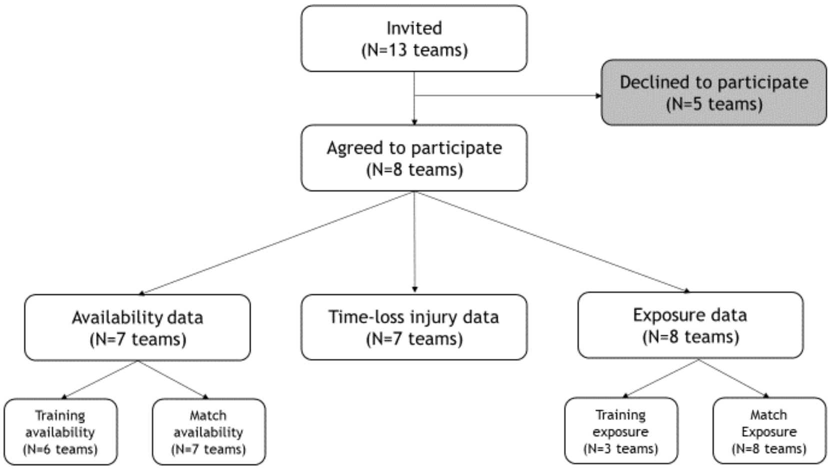
Table 3 Number of injuries and total days lost due to injury categorised by their severity

	Number of injuries			Total days lost to injury		
Category (days)	2019	2020	Diff	2019	2020	Diff
Slight (0)	0	1	1	0	0	0
Mild (1-7)	90	96	6	313	295	-18
Moderate (8-27)	87	93	6	1294	1449	155
Severe (>28)	69	70	1	5388	5137	-251
All	246	260	14	6995	6881	-114

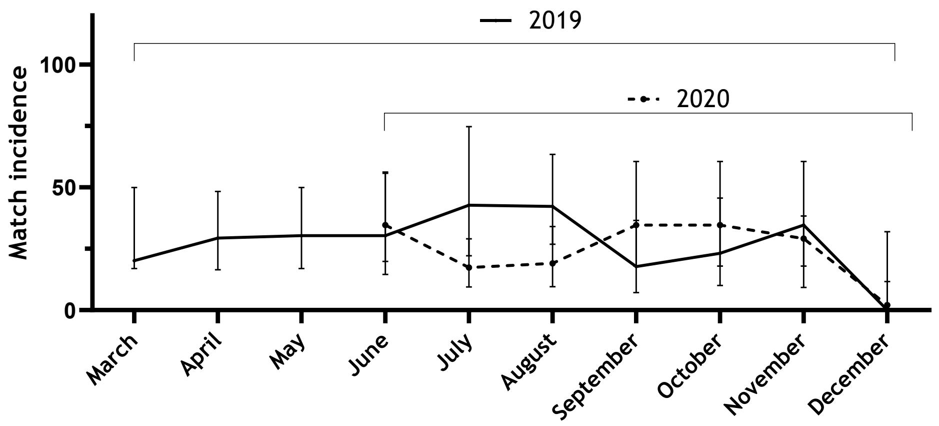
DOI: 10.31236/osf.io/7tqnf

FIGURES

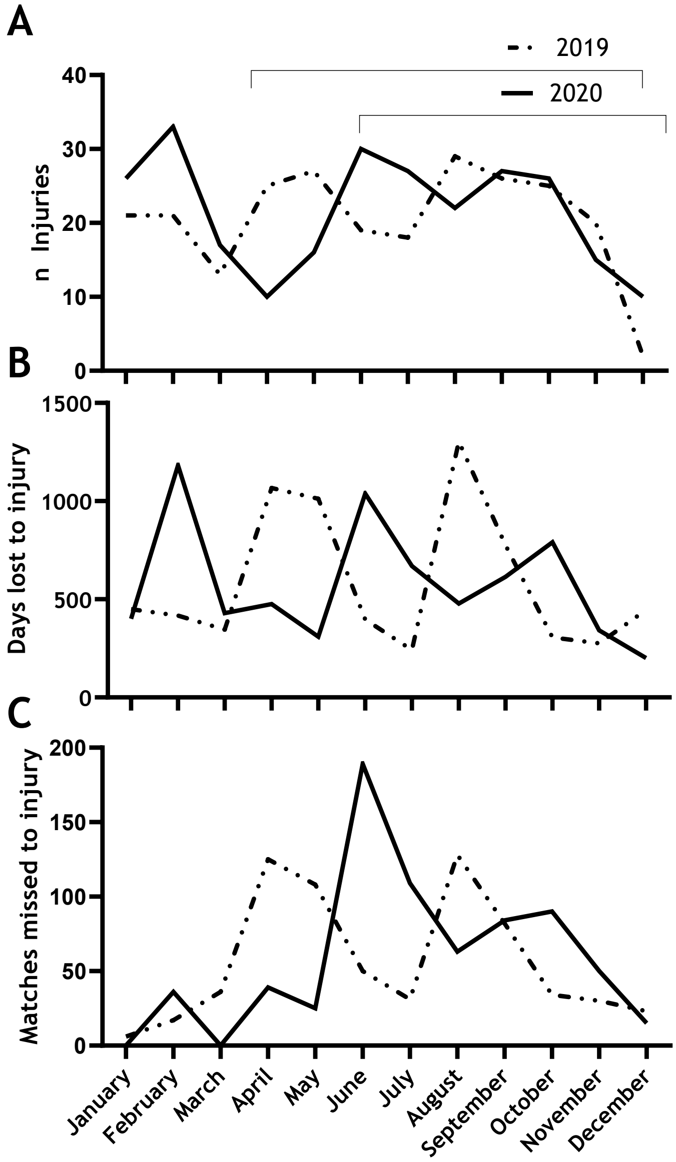

March
April
May
June
July
August
September
October
November
December
2019
2020



DOI: 10.31236/osf.io/7tqnf



DOI: 10.31236/osf.io/7tqnf


A
2019
2020
n Injuries
40
30
20
10
0
B
Days lost to injury
1500
1000
500
0
C
Matches missed to injury
200
150
100
50
0
January
February
March
April
May
June
July
August
September
October
November
December

4

5

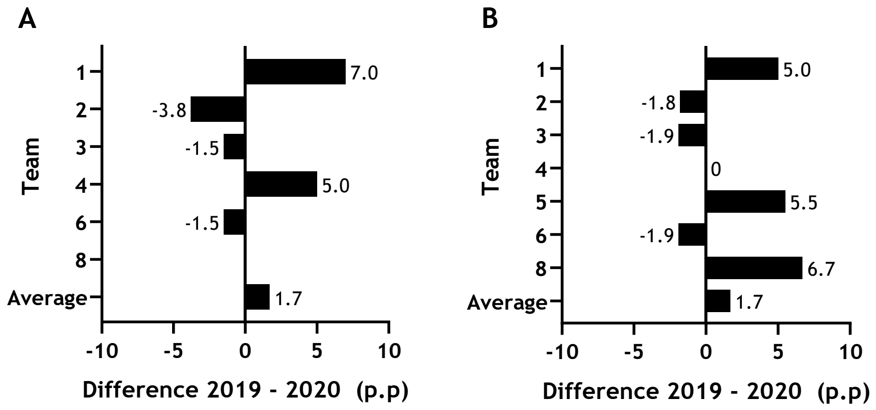


FIGURE CAPTIONS

Figure 1 Distribution of matches in the Norwegian male premier league in the 2019 and 2020 seasons. One line represents the main match day for each round. The number represents the game week number.

Figure 2 Flowchart of teams invited to participate in the study and the information obtained from the teams that were included. Thirteen teams were eligible as they were part of both the 2019 and 2020 campaigns.

Figure 3 Timeline of monthly match injury incidence across the 2019 and the 2020 seasons

Figure 4 Timeline of the monthly number of injuries (A), days lost due to injury (B) and matches lost due to injury (C) across the two seasons, 2019 and 2020.

Figure 5 Training (A) and match (B

Appendix I

Decision letters from the Regional Committee for Medical and Health Research Ethics, the Norwegian School of Sport Sciences' Ethical committee and the Norwegian Centre for Research Data and informed consent forms.

Papers I

Torstein Dalen
Seksjon for idrettsmedisin

OSLO 28. august 2017

Søknad 17-220817 – Treningsbelastning sin påvirkning på skader og sykdom i elite-JR fotball

Vi viser til søknad, prosjektbeskrivelse, informasjonsskriv og innsendt og godkjent søknad til NSD.

I henhold til retningslinjer for behandling av søknad til etisk komite for idrettsvitenskapelig forskning på mennesker, ble det i komiteens møte av 22. august 2017 konkludert med følgende:

Vedtak

På bakgrunn av forelagte dokumentasjon finner komiteen at prosjektet er forsvarlig og at det kan gjennomføres innenfor rammene av anerkjente etiske forskningsetiske normer nedfelt i NIHs retningslinjer. Til vedtaket har komiteen lagt følgende forutsetning til grunn:

- *At vilkår fra NSD følges*

Komiteen vil bemerke at det er seksjonsleder som er forskningsansvarlig og ikke stipendiaten som oppgitt i søknaden og at sluttdato i søknaden ikke er i overenstemmelse med sluttdatoen i NSD sin godkjenning. Sluttdato i vedtak fra NSD vil være gjeldende dato for prosjektavslutning. Komiteen gjør videre oppmerksom på at vedtaket er avgrenset i tråd med fremlagte dokumentasjon. Dersom det gjøres vesentlige endringer i prosjektet som kan ha betydning for deltakernes helse og sikkerhet, skal dette legges fram for komiteen før eventuelle endringer kan iverksettes.

Med vennlig hilsen
Professor Sigmund Loland
Leder, Etisk komite, Norges idrettshøgskole

REK
REGIONALE KOMITEER FOR MEDISINSK OG HELSEFAGLIG FORSKNINGSETIKK

Region:	Saksbehandler:	Telefon:	Vår dato:	Vår referanse:
REK sør-øst	Tove Irene Klokk	22845522	22.06.2017	2017/1015/REK sør-øst A
			Deres dato:	Deres referanse:
			09.05.2017	

Vår referanse må oppgis ved alle henvendelser

Torstein Dalen
Seksjon for idrettsmedisin / Senter for idrettsskadeforskning

2017/1015 Treningsbelastning sin påvirkning på skader og sykdom i elite-JR fotball

Forskningsansvarlig: Norges idrettshøgskole
Prosjektleder: Torstein Dalen

Vi viser til søknad om forhåndsgodkjenning av ovennevnte forskningsprosjekt. Søknaden ble behandlet av Regional komité for medisinsk og helsefaglig forskningsetikk (REK sør-øst) i møtet 08.06.2017. Vurderingen er gjort med hjemmel i helseforskningsloven § 10.

Prosjektbeskrivelse (revidert av REK)

Formålet med prosjektet er todelt: det første formålet er å undersøke omfanget av skader og sykdom hos fotballspillere i alderen 16-19 år, og det andre formålet er å undersøke hvilke parametre for treningsbelastning som eventuelt har sammenheng med risiko for sykdom eller skade.

Det skal rekrutteres 100 forsøkspersoner, fordelt på 3 fotballag av hvert kjønn i alderen 16-19 år. Deltakerne skal rekrutteres via støtteapparatet i klubbene, og det skal innhentes skriftlig samtykke. Deltakerne skal en gang per dag rapportere varighet og hvordan de selv opplever intensiteten av hver fotballøkt og fotballkamp, via en applikasjon for smarttelefon. I tillegg skal de en gang i uken besvare OSTRC (Oslo Sports Trauma Research Center) sitt spørreskjema Questionnaire on health problems. Informasjonen vil samles over en periode på 15 uker. Hovedutfallsmålet er prevalens av helseproblemer og hvordan treningsbelastning påvirker forekomsten av helseproblemer.

Vurdering

Formålet med prosjektet, slik det fremkommer av søknad og protokoll, er å undersøke sammenhengen mellom treningsbelastning og skader og sykdom hos elite-juniorspillere i fotball.

Prosjektet har etter komiteens vurdering ikke som formål å skaffe til veie ny kunnskap om helse og sykdom, og faller dermed utenfor helseforskningslovens virkeområde. Helseforskningsloven gjelder for medisinsk og helsefaglig forskning, definert som forskning på mennesker, humant biologisk materiale og helseopplysninger, som har som formål å frambringe ny kunnskap om helse og sykdom, jf. helseforskningsloven §§ 2 og 4a. Formålet er avgjørende, ikke om forskningen utføres av helsepersonell eller på pasienter eller benytter helseopplysninger.

Prosjekter som faller utenfor helseforskningslovens virkeområde kan gjennomføres uten godkjenning av REK. Det er institusjonens ansvar på å sørge for at prosjektet gjennomføres på en forsvarlig måte med hensyn til for eksempel regler for taushetsplikt og personvern.

Vedtak

Prosjektet faller utenfor helseforskningslovens virkeområde, jf. § 2, og kan derfor gjennomføres uten godkjenning av REK.

Klageadgang

Komiteens vedtak kan påklages til Den nasjonale forskningsetiske komité for medisin og helsefag, jf. helseforskningsloven § 10, 3 ledd og forvaltningsloven § 28. En eventuell klage sendes til REK Sørøst A. Klagefristen er tre uker fra mottak av dette brevet, jf. forvaltningsloven § 29.

Med vennlig hilsen

Knut Engedal
Professor dr. med.
Leder

Tove Irene Klokk
Rådgiver

Kopi til: torstein.dalen@nih.no, Norges idrettshøgskole ved øverste administrative ledelse: postmottak@nih.no

Torstein Dalen
Seksjon for idrettsmedisinske fag Norges idrettshøgskole
Postboks 4014 Ullevål Stadion
0806 OSLO

Vår dato: 30.06.2017 Vår ref: 54857 / 3 / AMS Deres dato: Deres ref:

TILBAKEMELDING PÅ MELDING OM BEHANDLING AV PERSONOPPLYSNINGER

Vi viser til melding om behandling av personopplysninger, mottatt 26.06.2017. Meldingen gjelder prosjektet:

54857	*Treningsbelastning sin påvirkning på skader og sykdom i elite juniorfotball.*
Behandlingsansvarlig	*Norges idrettshøgskole, ved institusjonens øverste leder*
Daglig ansvarlig	*Torstein Dalen*

Personvernombudet har vurdert prosjektet, og finner at behandlingen av personopplysninger vil være regulert av § 7-27 i personopplysningsforskriften. Personvernombudet tilrår at prosjektet gjennomføres.

Personvernombudets tilråding forutsetter at prosjektet gjennomføres i tråd med opplysningene gitt i meldeskjemaet, korrespondanse med ombudet, ombudets kommentarer samt personopplysningsloven og helseregisterloven med forskrifter. Behandlingen av personopplysninger kan settes i gang.

Det gjøres oppmerksom på at det skal gis ny melding dersom behandlingen endres i forhold til de opplysninger som ligger til grunn for personvernombudets vurdering. Endringsmeldinger gis via et eget skjema, http://www.nsd.uib.no/personvernombud/meld_prosjekt/meld_endringer.html. Det skal også gis melding etter tre år dersom prosjektet fortsatt pågår. Meldinger skal skje skriftlig til ombudet.

Personvernombudet har lagt ut opplysninger om prosjektet i en offentlig database, http://pvo.nsd.no/prosjekt.

Personvernombudet vil ved prosjektets avslutning, 15.10.2017, rette en henvendelse angående status for behandlingen av personopplysninger.

Vennlig hilsen

Kjersti Haugstvedt

Anne-Mette Somby

Kontaktperson: Anne-Mette Somby tlf: 55 58 24 10
Vedlegg: Prosjektvurdering

Dokumentet er elektronisk produsert og godkjent ved NSDs rutiner for elektronisk godkjenning.

NSD – Norsk senter for forskningsdata AS Harald Hårfagres gate 29 Tel: +47-55 58 21 17 nsd@nsd.no Org.nr. 985 321 884
NSD – Norwegian Centre for Research Data NO-5007 Bergen, NORWAY Faks: +47-55 58 96 50 www.nsd.no

Personvernombudet for forskning

Prosjektvurdering - Kommentar

Prosjektnr: 54857

FORMÅL

Formål med prosjektet er todelt. Det første er å undersøke omfanget av skader og sykdom hos fotballspillere i aldersgruppen 16-19 år. Det andre formålet er å undersøke hvilke parameter for treningsbelastning som eventuelt har sammenheng med risiko for sykdom eller skade. Dette skal igjen brukes til å lage et verktøy for å kontrollere endring i treningsbelastning som vi senere skal undersøke i en intervensjonsstudie.

REK har vurdert at prosjektet ikke omfattes av Helseforskningslovens bestemmelser.

INFORMASJON OG SAMTYKKE

Ungdommene skal informeres skriftlig og muntlig om prosjektet og samtykker til deltakelse.
Informasjonsskrivet er godt utformet.
I utgangspunktet skal det innhentes samtykke fra foresatte når det registreres opplysninger om helse, eller andre sensitive opplysninger, fra umyndige. Vi anbefaler derfor at ungdommen også får samtykke fra foresatte dersom han/hun er under 18 år. I den grad det er praktisk vanskelig å få skriftlige samtykker kan samtykke gis muntlig. Hvis dette ikke kan la seg gjøre innenfor tidsrammene anbefaler vi at ungdommen samtykker selv. Vi legger da vekt på at omfanget av sensitive opplysninger er lite og prosjektet er svært kortvarig.

SENSITIVE DATA

I meldeskjemaet er det ikke oppgitt at det skal innhentes opplysninger om helse, og vi har derfor korrigert skjemaet på dette punktet og tilrår at det kan behandles slike opplysninger.

DATASIKKERHET

Personvernombudet legger til grunn at forsker etterfølger Norges idrettshøgskole sine interne rutiner for datasikkerhet.

PROSJEKTSLUTT OG ANONYMISERING

Forventet prosjektslutt er 15.10.2017. Ifølge prosjektmeldingen skal innsamlede opplysninger da anonymiseres. Anonymisering innebærer å bearbeide datamaterialet slik at ingen enkeltpersoner kan gjenkjennes. Det gjøres ved å:

- slette direkte personopplysninger (som navn/koblingsnøkkel)
- slette/omskrive indirekte personopplysninger (identifiserende sammenstilling av bakgrunnsopplysninger som f.eks. bosted/arbeidssted, alder og kjønn)

Senter for idrettsskadeforskning
NORGES IDRETTSHØGSKOLE

Forespørsel om deltagelse i forskningsprosjekt.

Påvirker treningsbelastning skader og sykdom i elite juniorfotball?

Bakgrunn for prosjektet
Fotballspillere av begge kjønn trener mye på juniornivå, 16-19 år. I tillegg til å trene med sitt eget lag, deltar de ofte på mange andre arenaer som skoletrening, landslag og eldre lag. Samtidig har tidligere undersøkelser vist at dårlig styring av individuell treningsbelastning gir økt risiko for sykdom og skade. De fleste spillere opplever fravær fra trening og kamp grunnet skade i junioralder. Dette medfører ofte dårligere prestasjoner både rett i etterkant av skadeperioden, men kan også påvirke den langsiktige utviklingen som fotballspiller. Skade- og sykdomsomfanget i norsk juniorfotball er tidligere ikke undersøkt, og vi ønsker derfor å kartlegge dette ved en studie over 15 uker. I tillegg til skade- og sykdomsinformasjon ønsker vi å vite hvor mye og hvor intensivt juniorspillere trener. Resultatene i denne studien vil danne grunnlag for vår skadeforebyggende modell som vi skal undersøke effekten av gjennom 2018-sesongen.

Senter for idrettsskadeforskning har som formål å forebygge skader og andre helseproblemer i idrett gjennom et langsiktig forskningsprogram med fokus på risikofaktorer, skademekanismer og skadeforebyggende tiltak. Hovedfokuset er skader i håndball, fotball, ski og snowboard. Denne studien er en viktig brikke i arbeidet med å redusere omfanget av skader og sykdom i fotball.

Gjennomføring av prosjektet
Vi ønsker at du som spiller i G-19 nasjonal serie, G-19 interkrets eller J-19 1.divisjon deltar i denne undersøkelsen, og deltakelsen er frivillig. Det vil kreves av deg at du en gang per dag rapporterer varighet og hvordan du selv opplever intensiteten fra hver fotballøkt og fotballkamp, i tillegg til din helsestatus. Metoden for innsamlingen vil være en SMS-basert spørreundersøkelse. Undersøkelsen vil gå over 15 uker i fotballsesongen 2017.

Hva skjer med informasjonen om deg?
I etterkant av undersøkelsen vil vi analysere dataene for å se hvor ofte juniorspillere er plaget av skade eller sykdom, samt om det har en sammenheng med treningsbelastning. Informasjonen som registreres om deg vil kun brukes slik som beskrevet i hensikten med studien. Alle opplysningene vil bli behandlet uten navn og fødselsnummer eller annen direkte gjenkjennende informasjon. Dataene vil bli behandlet konfidensielt, kun brukes til forskning og vil bli anonymisert ved prosjektets slutt, 01.11.2017. Alle som deltar i gjennomføring av prosjektet og forskere som benytter dataene har taushetsplikt.

Senter for idrettsskadeforskning
NORGES IDRETTSHØGSKOLE

Angrer du?
Det er frivillig å delta i undersøkelsen. Du kan når som helst og uten å oppgi noen grunn trekke deg fra undersøkelsen. Dersom du ønsker å delta, undertegner du samtykkeerklæringen. Om du nå sier ja til å delta, kan du senere trekke tilbake ditt samtykke.

Spørsmål?
Ring gjerne til stipendiat Torstein Dalen, tlf.: 938 41 844 dersom du har spørsmål om prosjektet, eller send e-post til torstein.dalen@nih.no.

SAMTYKKEERKLÆRING

Jeg har mottatt skriftlig og muntlig informasjon om studien "***Utvikling av en modell for treningsplanlegging for å redusere skader og sykdom i elite juniorfotball***".

Jeg er klar over at jeg kan trekke meg på et hvilket som helst tidspunkt.

....
Sted   Dato

....
Underskrift spiller

....
Navn (blokkbokstaver)

....
Adresse

....
Mobiltelefon

....
E-post adresse

Appendix II

Decision letters from the Regional Committee for Medical and Health Research Ethics, the Norwegian School of Sport Sciences' Ethical committee and the Norwegian Centre for Research Data and informed consent forms.

Papers II and III

Emne: Sv: Kan styring av treningsbelastning redusere skader og sykdom i elite-junior fotball?
Fra: post@helseforskning.etikkom.no
Dato: 01.12.2017 10:20
Til: torstein.dalen@gmail.com
Kopi:

Vår ref.nr.: 2017/2311 A
Kan styring av treningsbelastning redusere skader og sykdom i elite-junior fotball?

Viser til skjema om framleggingsvurdering av dette prosjektet, mottatt 21.112017.

Helseforskningsloven gjelder for medisinsk og helsefaglig forskning på mennesker, humant biologisk materiale eller helseopplysninger, jf § 2. Medisinsk og helsefaglig forskning defineres som virksomhet som utføres med vitenskapelig metodikk for å skaffe til veie ny kunnskap om helse og sykdom, jf §4 bokstav a.

Studiens hovedfokus er å undersøke om individuellstyring av treningsbelastning kan være en løsning for at hver enkelt utøver skal ha en kontrollert progresjon i sin treningsbelastning gjennom en hel sesong, og kan potensielt redusere risiko for skade og sykdom.

Basert på opplysningene som gis, er ikke formålet med prosjektet å fremskaffe ny kunnskap om helse og sykdom i seg selv. Prosjektet faller utenfor helseforskningslovens virkeområde, og kan derfor gjennomføres uten godkjenning av REK.

Det er institusjonens ansvar på å sørge for at prosjektet gjennomføres på en forsvarlig måte med hensyn til for eksempel regler for taushetsplikt og personvern samt innhenting av stedlige godkjenninger.

Jeg gjør oppmerksom på at konklusjonen er å anse som veiledende jfr. forvaltningsloven § 11.

Dersom dere likevel ønsker å søke REK vil søknaden bli behandlet i komitémøte, og det vil bli fattet et enkeltvedtak etter forvaltningsloven.

Med vennlig hilsen
Leena Heinonen
rådgiver
post@helseforskning.etikkom.no
T: 22845522

Regional komité for medisinsk og helsefaglig forskningsetikk REK sør-øst-Norge (REK sør-øst)
http://helseforskning.etikkom.no

REK
REGIONALE KOMITEER FOR MEDISINSK OG HELSEFAGLIG FORSKNINGSETIKK

Torstein Dalen
Postboks 4014 Ullevål Stadion
0806 OSLO

Vår dato: 05.12.2017	Vår ref: 56935 / 3 / STM	Deres dato:	Deres ref:

Tilrådning fra NSD Personvernombudet for forskning § 7-27

Personvernombudet for forskning viser til meldeskjema mottatt 31.10.2017 for prosjektet:

56935	*Kan individuell styring av treningsbelastning redusere skader og sykdom i fotball?*
Behandlingsansvarlig	*Norges idrettshøgskole, ved institusjonens øverste leder*
Daglig ansvarlig	*Torstein Dalen*

Vurdering

Etter gjennomgang av opplysningene i meldeskjemaet og øvrig dokumentasjon finner vi at prosjektet er unntatt konsesjonsplikt og at personopplysningene som blir samlet inn i dette prosjektet er regulert av § 7-27 i personopplysningsforskriften. På den neste siden er vår vurdering av prosjektopplegget slik det er meldt til oss. Du kan nå gå i gang med å behandle personopplysninger.

Vilkår for vår anbefaling

Vår anbefaling forutsetter at du gjennomfører prosjektet i tråd med:

- opplysningene gitt i meldeskjemaet og øvrig dokumentasjon
- vår prosjektvurdering, se side 2
- eventuell korrespondanse med oss

Meld fra hvis du gjør vesentlige endringer i prosjektet

Dersom prosjektet endrer seg, kan det være nødvendig å sende inn endringsmelding. På våre nettsider finner du svar på hvilke endringer du må melde, samt endringsskjema.

Opplysninger om prosjektet blir lagt ut på våre nettsider og i Meldingsarkivet

Vi har lagt ut opplysninger om prosjektet på nettsidene våre. Alle våre institusjoner har også tilgang til egne prosjekter i Meldingsarkivet.

Vi tar kontakt om status for behandling av personopplysninger ved prosjektslutt

Ved prosjektslutt 31.12.2018 vil vi ta kontakt for å avklare status for behandlingen av personopplysninger.

Dokumentet er elektronisk produsert og godkjent ved NSDs rutiner for elektronisk godkjenning.

Se våre nettsider eller ta kontakt dersom du har spørsmål. Vi ønsker lykke til med prosjektet!

Vennlig hilsen

Marianne Høgetveit Myhren

Siri Tenden Myklebust

Kontaktperson: Siri Tenden Myklebust tlf: 55 58 22 68 / Siri.Myklebust@nsd.no
Vedlegg: Prosjektvurdering

Personvernombudet for forskning

Prosjektvurdering - Kommentar

Prosjektnr: 56935

FORMÅL
«Tidligere studier har vist lik skade- og sykdomsforekomst i elite ungdomsfotball som i profesjonell fotball. Brå endring i treningsbelastning har vist seg å øke risikoen for både skader og sykdom i en rekke idretter. Ungdom i junioralder har ofte mange treningsarenaer som skole, klubblag, eldre klubblag, regionale- og nasjonale lag. Dette kan gjøre det vanskelig å kontrollere belastingen til hver enkelt utøver. Individuell styring av treningsbelastning kan være en løsning for at hver enkelt utøver skal ha en kontrollert progresjon i sin treningsbelastning gjennom en hel sesong, og kan potensielt redusere risiko for skade og sykdom. Formålet med denne studien er å undersøke om styring av treningsbelastning kan senke risiko for skade og sykdom.»

REK har uttalt at prosjektet ikke er fremleggelsespliktig.

UTVALG OG REKRUTTERING
Utvalget består av fotballspillere i alderen 15 til 19 år. Deltakerne rekrutteres via trener/lagleder. Vi legger til grunn at forespørsel rettes på en slik måte at frivilligheten ved deltakelse ivaretas.

SENSITIVE OPPLYSNINGER
Det behandles sensitive personopplysninger om helseforhold.

INFORMASJON OG SAMTYKKE
Utvalget informeres skriftlig og muntlig om prosjektet og samtykker til deltakelse. Informasjonsskrivet er godt utformet.

Basert på en helhetsvurdering av prosjekts art og omfang, vurderer personvernombudet at det er tilstrekkelig at det innhentes samtykke til deltakelse fra ungdommene selv, så sant de er over 16 år. Dersom dere skal inkludere barn/unge som enda ikke har fylt 16 år må dere innhente samtykke fra foresatte/foreldre.

DATASIKKERHET
Personvernombudet legger til grunn at forskerne etterfølger Norges idrettshøgskole sine interne rutiner for datasikkerhet.

PROSJEKTSLUTT OG ANONYMISERING
Forventet prosjektslutt er 31.12.2018. Ifølge prosjektmeldingen skal innsamlede opplysninger da anonymiseres. Anonymisering innebærer å bearbeide datamaterialet slik at ingen enkeltpersoner kan gjenkjennes. Det gjøres ved å:
- slette direkte personopplysninger (som navn/koblingsnøkkel)
- slette/omskrive indirekte personopplysninger (identifiserende sammenstilling av bakgrunnsopplysninger som

f.eks. bosted/arbeidssted, alder og kjønn)

Thor Einar Andersen,
Seksjon for idrettsmedisinske fag

OSLO 21. desember 2017

Søknad 39-191217 – Kan styring av treningsbelastning redusere skader og sykdom i elite-junior fotball?

Vi viser til søknad, prosjektbeskrivelse, informasjonsskriv og innsendt søknad til NSD.

I henhold til retningslinjer for behandling av søknad til etisk komite for idrettsvitenskapelig forskning på mennesker, ble det i komiteens møte av 19. desember 2017 konkludert med følgende:

Vedtak

På bakgrunn av forelagte dokumentasjon finner komiteen at prosjektet er forsvarlig, og at det kan gjennomføres innenfor rammene av anerkjente etiske forskningsetiske normer nedfelt i NIHs retningslinjer.

Til vedtaket har komiteen lagt følgende forutsetning til grunn:

- *At det utarbeides tilpasset informasjonsskriv til deltakere under 16 år og til foresatte som skal samtykke på vegne av deltaker.*
- *Forskningsprotokollen oppdateres med hensyn til godkjenning («Ethical aspects»).*

Komiteen gjør oppmerksom på at vedtaket er avgrenset i tråd med fremlagte dokumentasjon. Dersom det gjøres vesentlige endringer i prosjektet som kan ha betydning for deltakernes helse og sikkerhet, skal dette legges fram for komiteen før eventuelle endringer kan iverksettes.

Med vennlig hilsen
Professor Sigmund Loland
Leder, Etisk komite, Norges idrettshøgskole

Senter for idrettsskadeforskning
NORGES IDRETTSHØGSKOLE

Forespørsel om deltagelse i forskningsprosjekt.

Kan individuell styring av treningsbelastning redusere skader og sykdom i fotball?

Bakgrunn for prosjektet
Fotballspillere av begge kjønn trener mye på juniornivå. I tillegg til å trene med sitt eget lag, deltar de ofte på andre arenaer som skoletrening, landslag og eldre lag. Tidligere studier har vist at skade- og sykdomsrisiko i norsk juniorfotball er like stor som omfanget i profesjonell fotball. Siden skader og sykdom vil føre til fravær fra fotball, vil skade og sykdom ha en negativ konsekvens både for lag og spiller, både på kort sikt, men og den langsiktige utviklingen. Andre studier har vist at dårlig belastningsstyring gir økt risiko for sykdom og skade.
Vi ønsker derfor å undersøke om individuell styring av treningsbelastning kan senke risikoen for skader og sykdom.

Gjennomføring av prosjektet
Vi ønsker at du som spiller i aldergruppen G19 eller J19 deltar i denne undersøkelsen. Studien vil omfatte to grupper; en kontrollgruppe og en intervensjonsgruppe. Kontrollgruppen vil trene som normalt, men vil bli fulgt opp av en prosjektmedarbeider for å samle inn informasjon om skader og sykdom. Intervensjonsgruppen vil rapportere treningsbelastning daglig slik at trener kan planlegge og gjennomføring av trening. Trenerne vil få tilgang til, og opplæring i et digitalt verktøy som gjør denne planleggingen praktisk og smidig. Spillerne vil også bli fulgt opp av prosjektmedarbeider for å rapportere skader.

Hvis det i etterkant viser seg at individuell styring skulle reduserer forekomsten av skader, vil alle lagene i kontrollgruppen få tilgang til, og opplæring i det digitale verktøyet. Hvilke lag som havner i hvilken gruppe vil bli tilfeldig trukket. Studien vil starte i begynnelsen av fotballsesongen og vare gjennom hele sesongen.

Hva skjer med informasjonen om deg?
I etterkant av undersøkelsen vil vi analysere dataene for å se om denne metoden kan redusere skader og sykdom i juniorfotball. Informasjonen som registreres om deg vil kun brukes slik som beskrevet i hensikten med studien. Alle opplysningene vil bli behandlet uten navn og fødselsnummer eller annen direkte gjenkjennende informasjon. Dataene vil bli behandlet konfidensielt, kun brukes til forskning og vil bli anonymisert ved prosjektets slutt, 31.12.2018. Alle som deltar i gjennomføring av prosjektet og forskere som benytter dataene har taushetsplikt.

Senter for idrettsskadeforskning
NORGES IDRETTSHØGSKOLE

Hvordan deltar du?
Det er frivillig å delta i undersøkelsen, og for å delta signerer du samtykkeerklæringen under.

Angrer du?
Om du nå samtykker til deltagelse, kan du når som helst, og uten å oppgi noen grunn, trekke deg fra undersøkelsen.

Spørsmål?
Ring gjerne til stipendiat Torstein Dalen (938 41 844, torstein.dalen@nih.no) eller ta kontakt med professor dr.med Thor Einar Andersen t.e.andersen@nih.no

SAMTYKKEERKLÆRING

Jeg har mottatt skriftlig og muntlig informasjon om studien *"**Utvikling av en modell for treningsplanlegging for å redusere skader og sykdom i elite juniorfotball**"*. Jeg er klar over at jeg kan trekke meg på et hvilket som helst tidspunkt.

……………………… ……………………
Sted Dato

…………………………………………………………………………………………
Underskrift spiller

…………………………………………………………………………………………
Navn (blokkbokstaver)

…………………………………………………………………………………………
Fødselsdato (DDMMÅÅ)

…………………………………………………………………………………………
Mobiltelefon

…………………………………………………………………………………………

NIH Senter for idrettsskadeforskning
NORGES IDRETTSHØGSKOLE

E-post adresse

Appendix III

Decision letters from the Norwegian Centre for Research Data and informed consent forms

Paper IV

NSD sin vurdering

Skriv ut

Prosjekttittel
Helse- og belastningsregistrering i eliteserien

Referansenummer
896416

Registrert
28.05.2020 av Torstein Dalen-Lorentsen - torsteind@nih.no

Behandlingsansvarlig institusjon
Norges idrettshøgskole / Senter for idrettsskadeforskning

Prosjektansvarlig (vitenskapelig ansatt/veileder eller stipendiat)
Torstein Dalen-Lorentsen, torstein.dalen@nih.no, tlf: 93841844

Type prosjekt
Forskerprosjekt

Prosjektperiode
01.08.2020 - 31.08.2024

Status
25.08.2020 - Vurdert

Vurdering (1)

25.08.2020 - Vurdert
Det er vår vurdering at behandlingen av personopplysninger i prosjektet vil være i samsvar med personvernlovgivningen så fremt den gjennomføres i tråd med det som er dokumentert i meldeskjemaet den 25.8.2020 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 helse og alminnelige kategorier av personopplysninger frem til 31.8.2024.

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.

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).

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: Lisa Lie Bjordal
Tlf. Personverntjenester: 55 58 21 17 (tast 1)

Do you want to participate in the research project

” Health problem and training load registration in the Norwegian premier league”?

This is a query for you to take part in a research project where the aim is to identify the burden of health problems and determine the role of training load as a risk factor. In this information letter, you will get information on the targets of the project, and what this will mean for you as a potential research participant.

Aim
Health problems among footballers are prevalent and each player must expect somewhere around two injuries per season. Health problems are detrimental for long term player development and elicit a negative effect on team performance. In order to implement preventive measures, we must first gain detailed knowledge of health problems in the population. To assess the 2020-season differences compared to previous years, we are seeking to obtain data from the previous five seasons. The 2020-season is an abnormal season both when it comes to direct effects of the Covid-19 epidemic (eg. player illness) and indirect effects (eg. match schedule). To investigate both direct and indirect effect could inform future preventive interventions, as well as the structure of the footballing season. The data will be analysed to investigate the relationship between training and match demands and health problems. To see these relationships and general health problem patterns, we will collect all injury and illness that leads to a player being absent from training or match.
This will include detailed information surrounding the health problem such as diagnosis, location, structure, mechanism, days lost to the problem, if the problem was classified as overuse or acute, if the problem was related to contact from opponent, etc. Depending on where the club has stored the health problem data, some of the information may be gathered from the medical journal of the club (unidentified). Also, we will collect data already obtained by the club via GPS- and accelerometer-based devices. This will include physical data as distance covered in various speeds, movement data on accelerations and decelerations and high intensity actions. All data is unidentified before being sent to us.

Who is responsible for the project?
Oslo Sports Trauma Research Center is responsible for the project.

Why are you invited to participate?
Every player in with a professional contract in a Norwegian premier league club is invited.

What does it mean for you as a participant?
All data will be collected through the clubs own coaching and medical staff with no change in routine or practice. The data used in the project will purely be observational and you as a participant will not be affected in the daily practice.

Participation is optional
Participation in this project is optional. If you choose to participate, you could withdraw at any time, without providing a reason. Withdrawal to the project will not elicit any negative consequence for you at the club or at any other circumstance.

Your privacy – How we store and use your information

We will only use your information in the settings and purposes that is included in this information letter. We will treat the information strictly confidential and in alignment with the General Data Protection Regulation (GDPR).

- *Only the club staff will have access to identifiable. Identifiable data will be unidentified upon transfer from the club. The club will de-code the health and training load data, meaning that all personal information is removed and replaced by a code linking the health and training data together.*
- *The results from the study will be in a manner where the participants will not be recognizable.*

What happens to your information when the project is finished?

Project will end on August 31, 2024. Unidentifiable data will be stored on the OSTRC server.

Your rights
As long as you are identifiable in the data, your rights are:
- Obtain all information about your self
- To correct all information about your self
- To delete all information about your self
- To receive a copy of all information about your self
- To send a complaint to the Data protection officer at the Norwegian School of Sports Sciences or to The Norwegian Data Protection Authority regarding the usage of your personal information.

What gives us the right to use your personal information?
We use your personal information based on your written consent.

On assignment from the Oslo Sports Trauma Research Center has NSD - Norwegian Centre for Research Data assessed that the usage of personal information is aligned with the GDPR

Where can I obtain more information?
If you have questions regarding the project or wish to use your rights, please contact
- *Torstein Dalen-Lorentsen, PhD-Candidate, Oslo Sports Trauma Reserach Center, torstein.dalen@nih.no, +4793841844. Or Thor Einar Andersen, Professor, Oslo Sports Trauma Research Center,* t.e.andersen@nih.no.
- Our GDPR responsible Karine Justad, Norwegian School of Sport Sciences, +4797536704. Karine.justad@nih.no
- NSD - Norwegian Centre for Research Data, personverntjenester@nsd.no, +4755582117

Best regards
Project Leader
Torstein Dalen-Lorentsen

Decleration of consent

I have received and understood information about the project Machine learning in professional football, and I have had access to ask questions regarding the project information.

I hereby give my consent to:

- ☐ Participate in the project (Information is collected through the clubs own routines and practices).

I give consent that my personal information can be used until the project is finished (ca. dec 2023)

(Signed by participant, Date)

Torstein Dalen-Lorentsen // Training load and health problems in football – More complex than we first thought?