NORWEGIAN SCHOOL
OF SPORT SCIENCES

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Physical Characteristics and Physical Fitness in Norwegian Junior Elite Team Handball Players

A cross-sectional study

Master thesis in Sports Science
Department of Sports Medicine
Norwegian School of Sport Sciences, 2018

Abstract

Purpose: Modern elite team handball is an intermittent sport characterized by technical and tactical skills, psychosocial behavior, physical characteristics and physical demands. The aim of the study was to examine physical characteristics and physical fitness in Norwegian junior elite team handball players, and compare players attending private elite sport high schools (NTG) with players attending regular public high schools (non-NTG). Further, we aimed to follow and monitor physical characteristics, fitness and patterns of injuries in a smaller study sample throughout season 2017/18.

Methods: Body composition was measured in 49 NTG players (14 males and 35 females), and 44 non-NTG players (12 males and 32 females) using bioelectrical impedance analysis (InBody 720, Biospace, Seoul, Korea). In addition, physical fitness was measured in 10- and 20-meter sprint, countermovement jump, T-test agility, Yo-Yo intermittent recovery test level 1 and one repetition maximum in squat and bench press. Training hours/week, sleeping hours/night in weekdays and weekends, and injury patterns were recorded through self-conducted questionnaires.

Results: Significant differences in physical characteristics and fitness were observed between sexes, in favor of the male players. There were no significant differences in physical characteristics between NTG and non-NTG players. Further, two out of seven variables of physical fitness showed significant difference between NTG and non-NTG players, in favor of NTG players.

NTG players had significantly more training hours/week than non-NTG players. Male NTG players slept significantly more per night in weekdays compared to non-NTG players, and female NTG players slept significantly more per night during weekends than non-NTG players.

Increased stature was observed in all follow-up groups. Reduced body mass and body fat (kg and %) were observed in female players from baseline (T1) to midterm testing (T2), but increased body mass and muscle mass and reduced body fat (kg and %) were observed from T1 to posttest (T3). Male players increased body mass and muscle mass, and reduced body fat (kg and %) throughout the entire season. Most variables in physical fitness had minor changes throughout the season in all groups, only a few variables had greater changes. NTG players had higher total injury incidence during the entire season than non-NTG players.

Conclusion: The results from the present study showed a significant difference in physical characteristics and physical fitness between junior elite male and female team handball players, in favor of the male players. No differences in physical characteristics were found between NTG and non-NTG players in neither male nor female players. Only two out of seven physical fitness tests revealed significant differences between NTG and non-NTG players in both sexes at baseline, in favor of NTG players. Total injury incidence throughout the competitive season was higher in NTG players than in non-NTG players.

Acknowledgements

The master thesis was carried out at the Norwegian School of Sport Sciences, Department of Sport Medicine from August 2017 to May 2018. This study represents me as a person, and I am truly grateful that I got the opportunity to turn my interest of team handball into a scientific research.

First and foremost my thanks go to my two supervisors Trine Stensrud, Department of Sport Medicine, and Live S. Luteberget, Department of Physical Performance. Trine, thank you for always being supportive and showing an interest in my work, as well as me personal. You are an extremely positive and encouraging person, which has inspired me. Live, you have so much academic insight and experiences within this field. Thank you for sharing. To the both of you, I am deeply grateful for your help planning the study and your constructive feedback on this thesis.

Furthermore my gratitude goes to my outstanding assistants Line, Ingebjørg and Crystal for your exceptional help collecting data. Thank you for always being available, early mornings or late evenings. I would not have finished this thesis without your help!

I would like to give a special thanks to NTG in Bærum and Lillehammer and the different teams, who helped recruiting players to my study. And to all the subjects: thank you for maxing out on every test – you guys rock!

My family back home in Denmark has been tremendous supportive about my Norwegian dream and believing in me every second of the way. No words can describe how much it means to me. To my big brother: you are an inspiration! I thank you for your long-lasting academic discussions and your invaluable feedback on my master thesis. My friends in both Norway and Denmark; I could not have been without you. Thank you for making this journey unforgettable.

Ronan Keating sang *"Life is a rollercoaster – just gotta ride it"*, but I say: *"Life as a master student is a rollercoaster – sometimes we wanted to quit, but we didn't"*.

Oslo, 20th May 2018

Camilla Aalkjær

Contents

1. Introduction

Over the years, team handball has become a popular sport worldwide. In 2016 The Norwegian Handball Federation (NHF) listed 127.000 members, including players, referees, coaches and managers (NHF, 2017). A total of 715 team handball clubs registered 7.900 active playing teams in the season 2016/17 (NHF, 2017). Team handball consists of two teams playing against each other with seven players on court, over a 60-minute period divided in 2 x 30 minutes (Giske, 2006). Modern elite team handball is an intermittent team sport characterized by technical and tactical skills, psychosocial behavior, physical characteristics and physical demands (Michalsik, Aagaard & Madsen, 2013). Especially physical demands seem to be important for performance in team handball (Michalsik et al., 2013; Póvoas, Ascensão, Magalhães, Seabra, Krustrup, Soares, António & Rebelo, 2014). These demands are characterized by combined moderate intensity, such as walking and jogging, and high intensity with explosive movements, such as sprints, jumps, throws and physical confrontations (Michalsik et al., 2013; Póvoas et al., 2014). The importance of these factors is also applicable for young team handball players (Mohamed, Vaeyens, Matthys, Multael, Lefevre, Lenoir & Phillippaerts, 2009). Unfortunately, previous literature presenting physical performance characteristics pertain to junior elite team handball players is limited.

Physical qualities are required in elite team handball in order to exploit the tactical and technical qualities during a match and season (Michalsik & Aagaard, 2015a). Michalsik et al. observed differences in physical demands between male and female elite team handball players. Research indicates that male players perform more high-intensive, strength-related playing actions as well as high-intensive running compared to female players. Conversely, female players seem to cover a larger total distance and thus getting a higher relative workload than male players (Michalsik et al., 2015a).

Existing research connects anthropometrical characteristics to performance at elite level in junior players, especially stature, body mass and lean mass (Moss, McWhannell, Michalsik & Twist, 2015). Junior top-elite team handball players were taller and had greater body mass and lean mass compared to elite and non-elite players (Moss et al., 2015; Zapartidis, Vareltzis, Gouvali & Kororos, 2009). Since team handball is a tough physical contact sport, research suggests that a stronger player has an advantage, and thus maturity must be taken into consideration when evaluating junior performances (Matthys, Vaeyens, Coelho-e-Silva, Lenoir, Philippaerts, 2012).

In Norway, junior team handball players have the opportunity to apply into private elite academies. The Norwegian High School of Elite Sport (NTG) aims to develop sport talents while getting a high school degree. The applicants get evaluated based on physical characteristics and athletic skills, documented sports results, performance level and grades from junior high (NTG[a], n.d.). Each high school accept between 8-15 team handball players of each sex the first year, which means that several junior elite players attend regular public high schools (NTG[b], n.d.). To our knowledge, no earlier studies have examined and compared physical characteristics and physical fitness in junior elite team handball players attending private elite sport high schools with junior elite team handball players attending regular public high school. The hypothesis of the present study is thus based on subjective expectations. Since NTG players have been evaluated to be the best of the applicants based on their physical characteristics and athletic skills, documented sports results and performance level, the hypothesis of the present study is that NTG players have better physical fitness and physical characteristics compared to elite players attending regular public high schools.

1.1 Aim of the study

The primary aim of the present study was to examine physical characteristics (anthropometric factors and body composition) and physical fitness in Norwegian junior elite team handball players (aged 16-18 years), and to compare players attending private elite sport high schools (NTG) with players attending regular public high schools (non-NTG), at their first (Vg1), second (Vg2) and third year (Vg3). Secondarily we aimed to follow and monitor physical characteristics, fitness and injury patterns in a smaller study sample within both groups and sexes throughout season 2017/18.

2. Theoretical background

2.1 Team handball

2.1.1 Origin and development

Team handball, as we know it today, has it origin from a Danish boarding school in 1890's. The first International Handball Federation (IAHF) was founded in 1928, and in 1936 outdoor team handball was presented for the first time at the Olympic Games. Later, team handball went from being an outdoor sport to be carried out in an indoor sport facility (Giske, 2006). During Second World War, IAHF dissolved, but in 1946 the International Handball Federation (IHF) was founded, including eight national federations, containing Norway (Giske, 2006). NHF was founded in May 1937 and the first Norwegian team handball match was carried out at same day. Ever since, the interest for team handball has increased rapidly. It is a professional sport, especially in many European countries, and has become a regular part of the Olympic Games (Giske, 2006).

2.1.2 Brief description of team handball

Team handball consists of two teams playing against each other. Each team is allowed to have 14 players registered in a match but only 7 players simultaneously on court. Remaining players are substitutes and can be substituted unlimited during the match (NHF, 2016). Figure 1 shows the different playing positions in team handball: goalkeeper, wing players, backcourt players (left, right and middle) and pivot (NHF, 2016). Ball possession changes often during the match due to alternate defense and attack. Players in defense try to prevent players in attack from achieving a goal. Ball possession changes when the attacking team attempts a field shot, or in case of a technical error. Team handball is a high-scoring sport, and the team with the highest score at the end of the match wins (Giske, 2006). Indoor team handball is carried out on an indoor court measuring 40x20 meters. The court is divided into two half and consists of a playing area and goal area (6 meter in radius). Outside the goal area is a seven- and a nine-meter line (figure 1). Duration of a match differs by age, but players over 16 years of age play 2 x 30 minutes with approximately a ten-minute break. Both teams have the opportunity to get three short breaks of one minute during the match (NHF, 2016). These breaks can for example be used to do technical and tactical changes in defense and attacking actions.

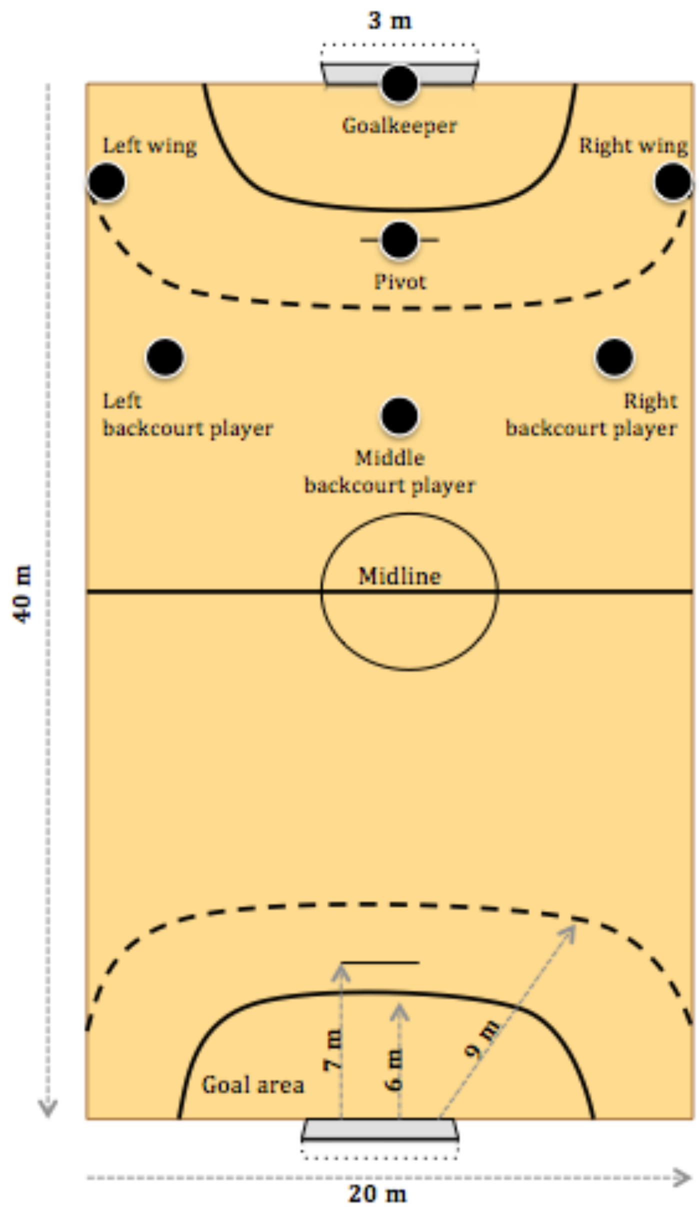


Figure 1: The team handball court with measures and areas (adapted from Giske, 2006).

2.2 Development of junior elite academies

Several public high schools in Norway offer sport specific education. However, some private high schools have developed an educational offer particularly intended for junior elite athletes. "Wang Elite Sports" and "The Norwegian High School of Elite Sports (NTG)" are two of the elite academies in Norway, which offer specialized high school education while developing as elite athletes. Since the present study include players from NTG, the theory will focus on the history of NTG and their ideology. NTG was founded in 1981 and placed in Bærum, and was originally named "The Norwegian High School of Alpine Skiing" (NTG[c], n.d.). The ideology was to offer young athletes an opportunity to combine school and sports. In 1985 the school changed its name to "The Foundation of Norwegian Skiing High School", where most skiing disciplines were represented. It was not until autumn 1990 the school opened to other sport disciplines, and was renamed "The Norwegian High School of Elite Sports (NTG)" (NTG[c], n.d.). Today, in 2018, NTG have six high school departments placed in Bærum, Kongsvinger, Geilo, Lillehammer, Tromsø and Bodø, and five junior high school departments placed in Bærum, Kongsvinger, Lillehammer, Tromsø and Bodø. The different departments offer multiple sport disciplines. Four departments (Bærum, Kongsvinger, Lillehammer and Bodø) offer team handball. The ideology of private elite high schools is to provide optimal learning environment combined with developing as elite players (NTG[b], n.d.). What differentiates NTG from a regular public high school is the amount of training time included in school lessons, as well as their weekly and annual planning of training amount and type (NTG[d], n. d.). Team handball players from NTG have 12 to 18 training hours during school per week, but it differs between grades. In addition, the person's athletic background is taken into consideration, since NTG emphasize individual development within physical, technical and tactical skills (NTG[d], n. d.). Further, NTG aim to progressively develop the tolerance of high intensity and training amount, and prepare the players to perform at senior level (NTG[d], n. d.).

2.3 Physical fitness in general

As presented in the introduction, physical fitness has a great importance in team handball due to the physical demands. To understand why, I will first clarify what physical fitness is.

The term physical fitness refers to a set of attributes that a person achieves or already possesses through physical activity (Caspersen, Powell & Christenson, 1985), and is defined as: *"The ability to carry out daily tasks with vigor and alertness, without undue fatigue and with ample energy to enjoy leisure-time pursuits and to meet unforeseen emergencies"* (Pate, 1983).

This definition gives an overall picture of how physical fitness is considered in the general population. However, terms like vigor, alertness, fatigue and enjoyment can be difficult to measure. Therefore, a number of measurable components contribute to determine physical fitness. According to Caspersen et al. 1985, these components are divided in two categories: (1) Health-related fitness and (2) Skill-related fitness **(figure 2).** Health-related fitness contains of cardiorespiratory endurance, muscular endurance, muscular strength, body composition and flexibility, whereas skill-related fitness contains of agility, balance, coordination, speed, power and reaction time (figure 2).

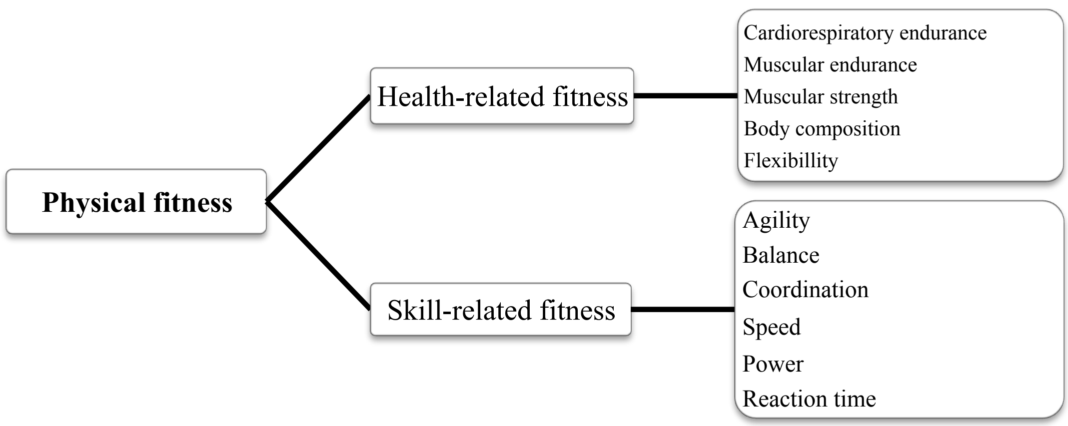


Figure 2: Components of physical fitness divided into health- and skill-related fitness (adapted from Caspersen et al., 1985).

2.4 Physical demands in team handball

Modern elite team handball is a complex intermittent team sport. Determinants of team handball performance have been specified to multiple elements. Based on scientific research performance have been divided into individual performance and team performance (Wagner, Finkenzeller, Würth & Duvillard, 2014). Team performance is influenced by several cognitive factors, hereunder attention, anticipation, reaction, decision making, executive functioning, mental skills and personality. In addition, psychosocial behavior and tactical skills seem to have an impact on performance in team handball (Wagner et al., 2014). Individual performance is influenced by several physical demands such as coordination (sprinting, jumping, agility and flexibility), strength (power and endurance) and endurance (constant, interval and high-intensity-interval-training). In addition to physical demands, anthropometry, genetics, injuries and illness, and nutrition appear to have an impact on performance in team handball (Wagner et al., 2014).

Physical qualities are required in elite team handball in order to exploit the tactical and technical qualities during a match and season (Michalsik et al., 2015a). As mentioned, several physical components have an impact on performance in team handball, since it is combined by standing still, walking, jogging with moderate intensity, and high intensity actions with explosive and rapid movements such as running, sprints, jumps, throws, changes of directions and physical confrontations (Michalsik et al., 2013; Michalsik et al., 2015). Several studies have investigated physical demands in team handball (Michalsik et al., 2013; Michalsik, Madsen & Aagaard, 2014; Michalsik et al., 2015a; Póvoas et al.,2014; Póvoas, Seabra, Ascensão, Magalhães, Soares & Rebelo, 2012). To investigate these demands, team handball players have been observed during several matches. Michalsik et al. and Póvoas investigated match performance, and recorded total running distance per match and time spent in eight difference locomotive categories: standing still, walking, jogging, running, fast running, sprinting, sideways movements and backwards running (Michalsik et al., 2013; Michalsik et al., 2014; Michalsik et al., 2015a; Póvoas et al., 2014; Póvoas et al., 2012). The same researchers registered physical confrontations and observed differences in defense and attack during an entire match.

According to Michalsik et al. (2013), male players covered a total distance of 3627 ± 568 meters with mean speed at 6.40 ± 1.01 km/h. Female players covered a greater total distance (4002 ± 551 meters) than males, but had slower mean speed during the match (5.31 ± 0.33 km/h) (Michalsik et al., 2014). Female wing players and pivots covered a greater total running distance compared to backcourt players per match (Michalsik et al., 2014). In contrast, male backcourt players covered a greater total distance than wing players and pivots per match (Michalsik et al., 2013; Póvoas et al., 2014).

Combined standing still and walking was nearly similar in male and female players per match (Michalsik et al., 2015a). However, female players had significant lower time standing still and higher amount of walking than male players per match, but male players had more high-intensity running than female players (Michalsik et al., 2015a). Female backcourt players performed less high-intensive running than wing players and pivots per match (Michalsik et al., 2014). In contrast, male wing players had more high-intensity running compared to both pivots and backcourt players during a match (Michalsik et al., 2013; Póvoas et al., 2014).

In both defense and attack, most time was reported standing still and walking in both sexes (Póvoas et al., 2012; Michalsik et al., 2013; Michalsik et al., 2014). Further, Póvoas et al. observed that sideways movement among male players was used more frequently in defense, whereas backwards running was equally used in defense and attack (Póvoas et al., 2012). Male players had significantly more sideways movements and backwards running than female players (Michalsik et al., 2015a). Jumping action in team handball is often associated with goal attempts in attack. In average, each male player performed 13.8 jumps during an entire match (Póvoas et al., 2012), and most jumps were registered in backcourt players followed by pivots and wing players (Póvoas et al., 2014). Further, team handball is a physical sport, which contain several confrontations and tackles throughout a match (Michalsik et al., 2015a). In average, male players receive over twice as many tackles and perform 45 % more tackles than female players during a match (Michalsik et al., 2015a).

Since team handball is a tough physical contact sport, with a high amount of physical confrontations, research suggests that higher and heavier players have an advantage in elite team handball (Michalsik et al., 2015a). Male players had higher stature (189.6 ± 5.8 cm) and larger body mass (91.7 ± 7.5 kg) compared to female players (175.4 ± 6.1 cm, 69.5 ± 6.5 kg) in the Danish Premier Team Handball League (Michalsik et al., 2015a). In addition, wing players had lower body mass than the rest of the playing positions within both sexes, and wing players had less physical confrontations in offense and defense than both backcourt players and pivots within senior players (Michalsik et al., 2015a; Póvoas et al., 2014). Anthropometrical characteristics also have an influence on performance at elite level among youth players, especially stature, body mass and lean mass (Moss et al., 2015). Junior top-elite team handball players were taller, had higher body mass and lean mass than elite and non-elite players (Moss et al., 2015; Zapartidis et al., 2009). In addition, physical characteristics differ between playing positions. Among male youth players (U14, U15 and U16), backcourt players were taller and performed better in strength, agility and sprinting compared to wing players and pivots (Matthys, Fransen, Vaeyens, Lenoir & Philippaerts, 2013). There were no significant differences in physical characteristics and physical fitness between U16 and U18 players within neither male nor female players. On average, U16 male players tended to perform better in all physical fitness tests than U18 players. Conversely, there was a tendency that U18 female players performed better in 10- and 30-m sprint, CMJ and squat jumping compared to U16 players (Ingebrigtsen, Jeffreys & Rodahl, 2013). Similarly, differences were observed when examining the physical fitness demands in relation to playing positions among senior players. Male wing players covered a larger distance of endurance running (Yo-Yo test), jumps higher (CMJ) and had higher repeated sprint capacity compared to backcourt players and pivots (Michalsik, Madsen & Aagaard, 2015c).

Several studies show that both male and female players at a high playing level perform better in physical fitness tests such as sprint, agility, jumping, strength and endurance running than their peers at a lower playing level (Moss et al., 2015; Zapartidis et al., 2009; Gorostiaga, Granados, Ibánez & Izquierdo, 2005; Granados, Izquierdo, Bonnabau & Gorostiaga, 2007; Granados, Izquierdo, Ibánez, Ruesta & Gorostiaga, 2013; Massuca, Fragoso & Teles, 2013). Zapartidis et al. investigated physical fitness among young team handball players, aged 14 years. They compared selected and non-selected players for the preliminary national team in Greece within both male and female players. The results showed that selected male players performed significantly better in throwing velocity, standing long jump, 30-m sprint and estimated VO_{2max} compared to non-selected players. Female selected players had significant higher values in throwing velocity and standing long jump compared to non-selected players (Zapartidis et al., 2009). Moss et al. investigated physical fitness in 16 years old team handball players (Moss et al., 2015). They included 120 female players classified as top-elite, elite and non-elite. They reported that top-elite players performed significantly better in most tests (CMJ, 10- and 20-m sprint, throwing velocity, repeated shuttle sprint and jump ability and Yo-Yo IR1) compared to both elite and non-elite players (Moss et al., 2015). No differences appeared between elite and non-elite players, except elite players had greater throwing velocity than non-elite players (Moss et al., 2015). Both Zapartidis et al. and Moss et al. revealed that players at the highest level outperformed players at lower playing level in physical fitness.

2.5 Growth, maturation and development

All young individuals undergo puberty, where growth, maturation and development are essential factors when the body prepares to adulthood (Malina, Bouchard & Bar-Or, 2004). Through puberty, the body is constantly changing and especially stature and body mass indicate the development from child to adult (Malina et al., 2004). Males and females experiences "the adolescent spurt" in the puberty, which refers to a point where the body rapidly increases in height and weight, until it reaches Peak Height Velocity (PHV) and Peak Weight Velocity (PWV) (Malina et al., 2004). PHV and PWV refer to the maximum point in stature and weight during the adolescent spurt. The timing of when the adolescent spurt occurs is individual and depends on the biological age (Malina et al., 2004). However, the adolescent spurt occur two years earlier in females at 12-12.5 years of age, compared to males, 14-14.5 years of age (Armstrong & Welsman, 1997; Malina et al., 2004; Hauspie, Das, Preece & Tanner, 1980). Therefore, males have two more years to grow until they reach their PHV and PWV. In addition, male's adolescent spurt increases more rapidly than females (Malina et al., 2004, Hauspie et al., 1980). Male hormones (testosterone) and female hormones (estrogen and progesterone) cause the majority of the bodily changes during puberty (Sand, Sjaastad, Haug & Toverud, 2014). The body composition changes throughout childhood and puberty, whereas fat-free mass increase and fat mass reduces in males, in contrast to an increase in fat mass among females (Stratton & Oliver, 2014). At the end of the adolescents spurt, Stratton et al. observed that females had twice as high fat percentage than males, and males had 25-30 % greater fat-free mass compared to females (Stratton et al., 2014).

Growth, maturation and social interactions are important to development performance capabilities in sports that require strength, power and speed (Malina et al., 2004; Armstrong, Barker & McManus, 2015). Physical activity is in general necessary for optimal growth and maturation. Among young elite athletes, especially physical characteristics affect performance (Malina et al., 2004). Muscle strength is related to body size, and males who are "early maturing" tend to have higher stature, body mass and are stronger than "late maturity" males (Malina et al., 2004). Between childhood and puberty, both males and females experience a curvilinear increase in maximal strength (Stratton et al., 2014). However, strength in females stagnates before puberty, and males tend to become stronger compared to females (Stratton et al., 2014). Catley and Tomkinson examined physical fitness of Australian children aged 7-19 years (Catley & Tomkinson, 2013). The results showed that males outperformed females in strength power, strength endurance, explosive upper- and lower body exercises, sprint performance and endurance running (Catley et al., 2013). In addition, differences between sexes increased by age, and the magnitude of age-related changes was higher among males compared to females during puberty (Catley et al., 2013).

Time of maturation seem to have an effect on performance in youth team handball players aged 14-15 years (Matthys et al., 2012). "Early maturing" players performed significantly better in strength testing (handgrip) and 20-m sprint than "on-time" and "late maturity" players (Matthys et al., 2012). Further, early maturing players had significantly higher stature, body mass and body fat (%) than on-time players and late-maturity players (Matthys et al., 2012). When examine differences of maturity between playing positions, backcourt players were significantly more mature than wing players at all ages (U14-U16), as well as pivots in U16 (Matthys et al., 2013). However, maturation does not seem to have an effect between U16 and U18 players (Ingebrigtsen et al., 2013).

2.6 Workload, training effect and injury development

Team handball players often experience a high total workload due to the amount of different types of training. Researchers have shown that the total workload has an impact on training effect as well as developing injuries (Paulsen & Raastad, 2010; Windt & Gabbett, 2017a; Windt, Zumbo, Sporer, MacDonald & Gabbett, 2017b). The training effect increases with higher amount of total workload in a session. However, there is a point when the amount of total workload causes the training effect to stagnate and decrease (Paulsen et al., 2010). The optimal workload is defined at level 5 (figure 3), but it is individual when one achieves this level due to several factors. The combination of the total training volume, intensity, degree of effort and frequency is defined as workload that affects the training effect (Paulsen et al., 2010).

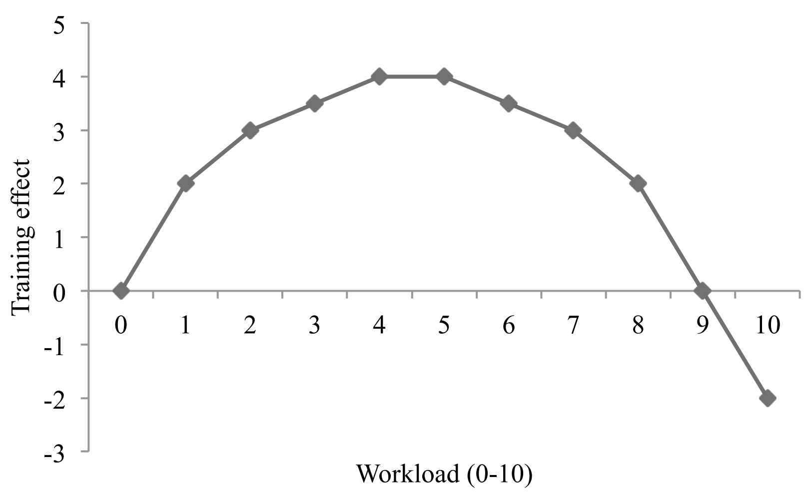


Figure 3: Influence of total workload on training effect in a session (adapted from Paulsen et al., 2010). X-axis: 0 is no training load and 10 are very high training load. Y-axis: -2 is negative effect, 0 is none effect, 2 are good effect and 4 are optimal training effect.

In addition to the association between workload and training effect, studies have shown that a spike in workload causes an increase in injury incidence among athletes (Windt et al., 2017a; Windt et al., 2017b; Møller, Nielsen, Attermann, Wedderkopp, Lind, Sørensen & Myklebust, 2017). Windt and Gabbett developed a new workload-injury aetiology model based on previous studies (Windt et al., 2017a). This aetiology model incorporate workload as an indirectly factor. Instead, training and competition loads (external risk factors), contribute directly to increase injury risk, because the athletes have higher exposure to injurious situations (Windt et al., 2017a). The relationship between workload and injuries, and the aetiology of injuries, is complex and multifactorial, and in addition affected by internal risk factors and neuromuscular fatigue (Windt et al. 2017a). An increase in workload causes higher level of neuromuscular fatigue, which results in higher risk of injuries (Windt et al., 2017a). However, a person's physical fitness has shown to have an impact on neuromuscular fatigue and injury risk (Windt et al., 2017a). Research indicates that individuals with greater physical fitness have less occurrence of neuromuscular fatigue if the total workload suddenly increases (Windt et al., 2017b). Therefore, the risk of injuries is in theory lower among individuals with higher physical fitness compared to individuals with lower physical fitness (Windt et al., 2017b). This relationship between training and competition loads, and development of injuries was observed in a team handball study (Møller et al., 2017). The aim of the study was to investigate if different level of total team handball load was associated with increased risk of shoulder injury. This was a 31-week cohort study, including 679 elite youth players, 14-18 years of age. Team handball load was divided into: (1) <20 % increase or decrease (, (2) between 20 % and 60 % increase and (3) >60 % increase, relative to weekly average amount the preceding four weeks. Results revealed that players who increased total team handball load with >60 % had a greater rate of shoulder injury than players increasing or decreasing <20 % (Møller et al., 2017). This study supports the theory that the total amount of team handball, training and competition loads have to be weekly planned to avoid injuries, and an increase have to happen progressively and not rapidly in young athletes.

3. Method

To identify and examine physical characteristics and physical fitness in junior elite team handball players in Norway, a cross-sectional research design was conducted. To investigate and monitor changes throughout an entire season, a smaller study sample was selected to participate in a prospective follow-up design.

3.1 Recruitment and subjects

All players in the present study were considered as elite players based on participation on teams playing qualification for the best national league at their age (16 years old girls/boys: "BRING League" and 18 years old girls/boys: "LERØY League"). Some subjects played in the National Norwegian First Division League and Elite League. Players from NTG were recruited by contacting coaches/teachers at NTG, and players attending regular public high schools by contacting coaches on each team. Before commencing the study each player received a written invitation, which contained detailed information about the experimental procedures and the possible risks and benefits of the participating in the project. Additionally, they received a written consent, which informed the players that the study was voluntary. Players between 16 and 18 years needed a signed consent from their parents/guardians, but players over 18 years signed the consent themselves. At baseline, the players filled out a questionnaire to clear any medical disorders that might limit their full participation in the study. Injuries, which could result in total inability to perform any baseline testing, excluded the individual from the trial. Further, the individuals could not participate in other research projects.

Ninety-three young Norwegian male and female elite team handball players, aged 16.8 ± 0.9 years, participated in the study (26 males and 67 females). Of these, 49 players were attending NTG (14 males and 35 females), and 44 players were attending regular public high school (12 males and 32 females).

In addition, to the follow-up throughout the season 2017/18, 49 male and female players were invited to participate. Of these, 25 players were attending NTG (12 males and 13 females), and 24 players were attending regular public high school (11 males and 13 females). The selection was based on completed tests at baseline testing (T1). First priority was players who completed seven out of seven physical tests, then six out of seven tests and so on. Not all players who received an invitation to the follow-up wanted to continue in the study, and some players dropped-out before testing at midterm testing (T2). Therefore, only 31 male and female players participated in the follow-up: nine males from NTG, 3 males from non-NTG, 10 females from NTG and 9 females from non-NTG (figure 4). Due to injuries and illness, participating players varied between the tests and some players only attended at one part of the testing. Accurate number of attending players is presented in each table in section 4. Due to a small study-sample in the follow-up, the results could not be statistically analyzed.

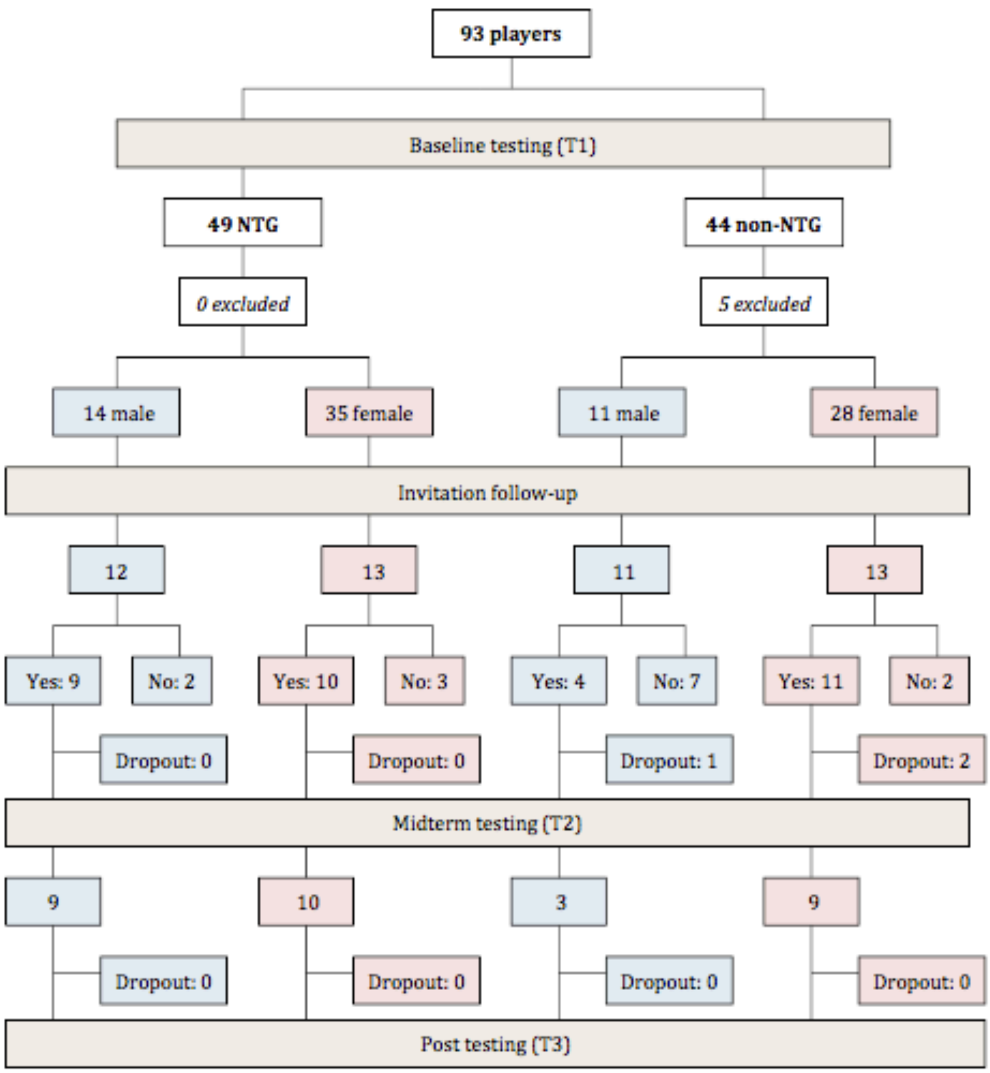


Figure 4: Flowchart over participating players: from recruitment to baseline testing (T1) and follow-up (T2 and T3).

3.2 Testing schedule

All included players completed baseline testing (T1) in September 2017. The follow-up group was tested two times during the season: at the end of the first competitive period (T2) in December 2017 and at the end of the second competitive period (T3) in April 2018 (figure 5). The testing session was divided into two days with minimum 48 hours restitution between. Day one: measurements of body composition, 10- and 20-meter sprint, jumping velocity (countermovement jump: CMJ), changes of directions (agility T-test) and running endurance (Yo-yo intermittent recovery test level 1,Yo-yo IR1). Day two: one-repetition-maximum (1RM) in squat and bench press.

Testing periods: T1 T2 T3

Month	August					September				October				November			
Week	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47

Month	December					January				February				Mars			
Week	48	49	50	51	52	1	2	3	4	5	6	7	8	9	10	11	12

Month	April				
Week	13	14	15	16	17

Figure 5: Testing schedule of baseline- (T1), midterm- (T2) and post-testing (T3).

3.3 Test methods

To examine physical fitness within the players, their aerobic capacity, speed, jumping velocity, changes of direction and maximal muscle strength, was tested. In addition, physical characteristics, including anthropometric measures and body composition, were measured. Two simple self-conducted questionnaires were designed to examine average training- and sleeping time and injury patterns.

3.3.1 Physical characteristics

The stature was measured using a telescopic stadiometer (SECA 220, Germany). Afterwards, their body composition was measured using bioelectrical impedance analysis (BIA) with 8- point tactile electrode: two in both hand and two on both feet (InBody 720, Biospace, Korea). First, body mass (kg) was calculated, where after stature and age was registered and the InBody began measuring: BMI

(kg/m^2), muscle mass (kg), total body fat (kg and %) and waist-hip-ratio (cm), which were used in the present study. It was important to standardize the procedure to get precise measurements. The players were instructed to refrain from participating in intense exercise the day before testing and refrain from any activity on the testing day. Further, they were instructed to maintain a normal diet and fluid intake before testing, except for fasting two hours before. After measuring body composition, the players had 15 minutes to eat before starting a 10-minute standardized warm-up. The warm-up consisted of low- to moderate-intensity running, some stretching exercises and 3-4 acceleration runs.

3.3.2 Sprint

Sprint performance was measured over a 20-meter distance using electronic timing gates (Smartspeed Pro, Fusion Sport, Australia) placed at 0, 10 and 20 meter in an indoor sports facility. Two cones were placed approximately two meters behind the last gate at 20 meters, and the players had to run maximal and not stop before passing the cones. The start marker was placed 30 centimeters behind the first electronic gate, so no false start occurred. By start, the players had to stand in a natural running position with their upper body slightly tilted forward, and with one foot in front of the other behind the start marker. The players were informed to start sprinting when they felt ready. If the player overstepped the start marker or leaned back to add speed, the run was disapproved. Running time was measured from 0-10 meter and from 10-20 meter. They had one practice sprint and three attempts with approximately two minutes recovery time between. Fastest measured time at both 10- and 20-meter was used in the analysis (Refsnes, 2010).

3.3.3 Jumping velocity

Maximal jumping velocity was measured using countermovement jump (CMJ) on a portable force platform (FP4, HUR Labs, Finland). The players started in an upright position, meanwhile holding their hands on the waist to exclude arm swing. From upright position they started a downward countermovement until they reach approximately a 90° angle in the knee, which immediately was followed by a maximal vertical jump. The players jumped after a three second countdown. To get an approved jump they had to keep their balance and stand still on the platform. They had one practice jump and three attempts. Highest measured jump was used in the analysis (Refsnes, 2010).

3.3.4 Changes of directions

Changes of directions were measured through agility T-test using electronic timing gates (Smartspeed Pro, Fusion Sport, Australia) placed at the zero line. The agility T-test used in the present study was a modified version of the original T-test, which was 9.14 meter long and 4.57 meter wide on each side of the middle cone (Semenick, 1990). Our T-test was 10 meter long and 5 meter wide on each side of the middle cone (figure 6). The start marker was 30 centimeters behind the zero line, so no false start occurred. Start position was identical as in the sprint-test, and when ready they started sprinting forward and touched cone B. Then they shuffled sideways to cone C and touched the cone with their left hand and shuffled sideways to the right and touched cone D with their right hand. Then they shuffled sideways back to cone B, touched the cone with their left hand and ran backwards passing the finish marker at cone A (figure 6). If the player overstepped the start marker, leaned back to add speed, did not touch the cones, did not had their outer foot in line with or past cone C and D or made a cross-step instead of sideways shuffle, it was a failed run. They had one practice run and three test attempts with approximately two minutes recovery time between. The fastest measured time was used in the analysis (Semenick, 1990).

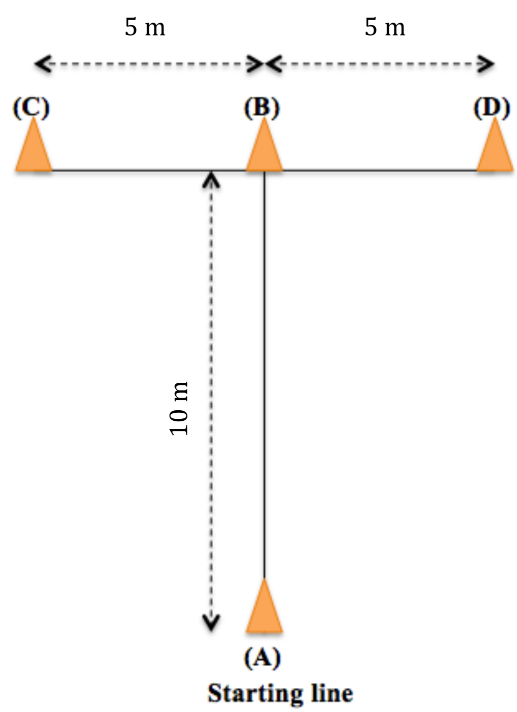


Figure 6: Agility T-test. **A:** start and finish marker, **B:** first and forth turning marker, **C:** second turning marker, **D:** third turning marker.

3.3.5 Endurance running

Aerobic capacity was tested through Yo-Yo IR1 and consisted of repeated 2 x 20 meter runs back and forth between start (B), turning (C), and finish marker (B) in an indoor sports facility. After running 2 x 20 meter the players had an active recovery period of ten seconds, where they walked or jogged to cone (A) five meter behind the finish marker (B) and back to start standing in a stationary position (B) (figure 7).

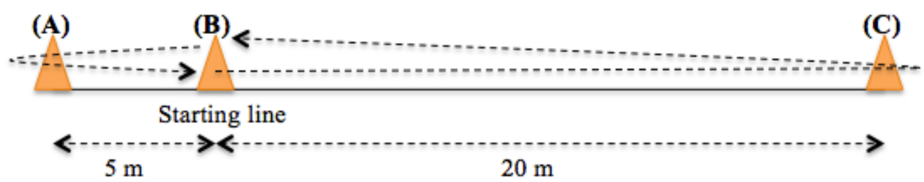


Figure 7: Yo-Yo IR1 test. **B:** start and finish marker, **C:** turning marker, **A:** recovery marker

The speed progressively increased controlled by audio bleeps from a tape recorder. The speed was 10-13 km·h^{-1} at the first four running bouts, followed by seven bouts at 13.5-14 km·h^{-1}. Afterwards the speed continued to increase by 0.5 km·h^{-1} after every 8th bouts until exhaustion. If the player failed to complete the running bout in time, he or she got a warning. If the player completed the next bout in time the warning was cleared. If the player failed to complete the run in time two times in a row he or she was out. The final score was the total distance covered after the second failed attempt or when the player stopped caused by exhaustion (Krustrup et al., 2003).

3.3.6 Maximal muscle strength

Maximal muscle strength was tested through one repetition maximum (1RM) in squat and bench press. Due to unawareness about the players' technical skills to perform 1RM testing, the tests were performed in a Smith-machine where the bar was attached in both sides of the rack. Some players did not have any experience of performing maximum lifting, or were not used perform squat or bench press as a part of their strength training. Because of this, some players got more attempts to reach their maximum load at baseline.

The players were divided into groups of three/four. They had five minutes warm-up on a bike before starting the squat warm-up series consisting of: six repetitions and three repetitions. The loads were individually calculated from earlier tests or training. The test was standardized to the depth where the ankle, knee and hip joint formed a 90° angle. Every player was instructed to perform a squat in the Smith-machine with the bar without loads, to visually observe the exact depth. To remember the depth of each player, tape with the players' number was used. An elastic band was used to make sure that the players reached the correct depth. The attempt was approved when their hamstring touched the string and successfully completed the lift back to an upright position. A person responsible for testing observed the string to make sure of approved depth. Whenever the depth was reached he or she said: "GO". For safety reasons, another person responsible for testing was spotting behind the player without touching, unless help was needed. The players got 3-4 attempts with approximately two minutes recovery time between. Heaviest measured squat was recorded in the analysis (Refsnes, 2010).

In 1RM bench press the players were instructed to start a downward movement from fully extended elbows until contact with the chest, and further pressing the bar back to starting position. To standardize the grip the players measured one thump length from the start of the rough part on the bar (approximately 90° angle in the elbow). The bar had to touch the chest, their butt had to be in contact with the bench and their feet in contact with the floor throughout the whole lift to get an approved lift. For safety reasons, a person responsible for testing was spotting the bar without touching, unless help was needed. The players went through identical warm-up series as in squat, followed by three 1RM attempts with approximately two minutes recovery time between. Heaviest measured press was recorded in the analysis (Refsnes, 2010).

3.3.7 Questionnaire

A simple self-conducted questionnaire was designed to collect information about the players' background (name, birthdate, training experience, school, grade), average training hours/week and sleeping hours/night (weekdays and weekends) in addition to health status (appendix 1). Further, patterns of injury incidence, type and location, and duration were observed during follow-up (appendix 2).

3.4 Validity and reliability

High quality scientific research depends on whether validity and reliability is high or not (Benestad & Laake, 2008). There are multiple types of validity but mostly we focus on: construct validity, internal and external validity. Construct validity measures whether the tests reflect what it claims to and in which extent (Benestad & Laake, 2008). First our problem got operationalized and then relevant tests measuring physical characteristic and physical fitness in junior elite team handball players were selected (Benestad & Laake, 2008).

Internal and external validity indicates whether our conclusion is valid or not. Internal validity is the extent to which the conclusion has causal inference to the population we examine. Internal validity questions if there could be alternative causes explaining our observations and results. In contrast, external validity measures the degree of which it is possible to generalize the results to populations or other contexts (Benestad et al., 2008). But before we can talk about validity in a study, the tests have to be reliable. If the tests are not reliable, they cannot be valid (Benestad et al., 2008). Reliability concerns the extent of credibility and accuracy when performing a test. If the test has small variation it got high accuracy, and opposite, high variation causes low accuracy (Benestad et al., 2008). To prevent high variation, the present study standardized every test, but it was possible that some measurement errors could occur. To evaluate accuracy research differentiates between repeatability and reproducibility (Benestad et al., 2008). In short terms: repeatability concerns the extent in which it is possible get the same results if the measurements is recreated under identical test conditions. Reproducibility is the degree of variation if the test conditions changes (Benestad et al., 2008).

If we take a closer look at the test selected to examine our scientific problem, measuring body composition in young adults, InBody appear to be a highly accepted method showing a strong correlation to Dual-Energy X-ray Absorptiometry (DEXA), which is considered the gold standard for measuring body composition (Jensky-Squires, Dieli-Conwright, Rossuello, Erceg, McCauley & Schroeder, 2008). However, some studies observed that BIA tended to over- and underestimate body fat percentage (Sun et al., 2005; Hosking, Metcalf, Jeffery, Voss & Wilkin, 2006), and overestimate fat mass and underestimate lean soft tissue mass (Kim, Shinkai, Murayama & Mori, 2015). In contrast, Jensky-Squires et al. did not find any over- and underestimating in body fat percentage in their validation study (Jensky-Squires et al., 2008). When measuring sprint performance, timing gates are found to reliably assess speed and distance (Waldron, Worsfold, Twist & Lamb, 2011). Research shows that a portable force platform provides valid measures of vertical jumping performance, hereunder CMJ, comparing to other vertical jump measurement devices (Buckthorpe, Morris & Folland, 2012). Agility T-test is highly reliable and measures a combination of different component, including leg speed, leg power and agility (Pauole, Madole, Garhammer, Lacourse, Rozenek, 2000). Agility T-test is considered suitable in sports like team handball due to the high amount of recreational activity and change of directions (Pauole et al., 2000). Yo-yo IR1 has high reproducibility and sensitivity, and gives information about cardiorespiratory fitness within athletes in intermittent sports like team handball (Krustrup et al., 2003). When measuring maximal muscle strength, a standardized 1RM was preferred, because it is considered the gold standard for assessing muscle strength in non-laboratory settings (Levinger, Goodman, Hare, Jerums, Toia & Selig, 2009). Multiple research support that standardized 1RM testing has high reliability when testing both upper and lower limbs, and it provides valid measures of muscle strength in young adults (Verdijk, Loon, Meijer, Savelberg, 2009; Levinger et al., 2009; Seo et al., 2012).

3.5 Statistical analysis

All raw data was transferred and analyzed in SPSS version 24 (IBM, United States). Assumptions of normal distribution were checked using Kolmogorov-Smirnov. All measured variables were normally distributed except body mass, muscle mass and Yo-yo IR1. By observing histograms in those three variables, accepted normally distributed curves appeared, and the variables were considered normally distributed. Independent sample *t*-tests were applied to examine possible differences in mean scores between NTG and non-NTG players, divided into male and female players. Criterion to establish statistical significance was $p < 0.05$. The results were expressed in means ± standard deviation (SD). Due to a small study-sample in the follow-up group the results could not be statistically analyzed.

3.6 Ethics

The Internal Ethics Committee at the Norwegian School of Sport Science and the Norwegian Centre of Research Data approved the present study in June 2017 (appendix 3). The study is carried out in accordance with the declaration of Helsinki, to account for the welfare of the participants, and it is carried out in accordance with the Vancouver Protocol, for publishing the results in journals.

The study needed written informed consent from all players, as well as their parents if they were between 16-18 years. The consent contained information about the aim of the study, duration, testing producers and voluntary participation. Further, we informed the players that the results and the information would be saved until 2022 and then anonymized. As a master degree student, I have the ethical responsibility to support the relevance of the results for the society and avoidance of duplication. It is important that unwanted results are not detained or manipulated, and that I am honest about which statistical analyses that are applied (Holm & Hofmann, 2013).

4. Results

4.1 Results baseline testing, T1

4.1.1 Physical characteristics

Physical characteristics and age of all players are presented in table 1. Mean age at T1 was 16.7 ± 0.9 years for male players, and 16.9 ± 0.9 years for female players. In general, male players had significantly higher stature, body mass and muscle mass (kg) compared to the female players ($p<0.001$). Female players had significantly higher body fat (kg and %) compared to the male players ($p <0.001$). There were no significant differences in BMI and WHR between male and female players.

Physical characteristics and age of all players divided into groups of NTG and non-NTG are presented in table 2. Mean age was 16.6 ± 0.9 years for male NTG players and 16.8 ± 0.8 years for non-NTG players. Mean age of the female NTG players was 16.6 ± 1.0 years and 17.2 ± 0.7 years for non-NTG players. No significant differences in physical characteristics were observed between NTG and non-NTG in neither male nor female players. However, a significant difference in waist-hip-ratio (WHR) was found between female players (table 2).

Table 1: Physical characteristics of all players divided into sexes. Number of participants (*n*), age (years), stature (cm), body mass (kg), BMI (kg/m^2), muscle mass (kg), body fat (kg), body fat (%) and WHR (cm). Results are given as mean ± SD.

	Male players (*n* = 25)	Female players (*n* = 62)
Age (years)	16.7 ± 0.9	16.9 ± 0.9
Stature (cm)	183.3 ± 6.3	169.9 ± 6.5***
Body mass (kg)	76.2 ± 9.6	67.3 ± 8.7***
BMI (kg/m^2)	22.7 ± 2.8	23.3 ± 2.6
Muscle mass (kg)	38.3 ± 3.7	28.7 ± 3.1***
Body fat (kg)	9.0 ± 4.5	15.8 ± 5.8***
Body fat (%)	11.4 ± 4.6	23.1 ± 5.9***
WHR (cm)	0.86 ± 0.04	0.87 ± 0.04

Statistic significant difference between male and female players ***p <0.001
SD = standard deviation; BMI = Body Mass Index; WHR = waist-hip-ratio

Table 2: Physical characteristics of male and female players divided into groups. Number of participants (*n*), age (years) stature (cm), body mass (kg), BMI (kg/m^2), muscle mass (kg), body fat (kg), body fat (%) and WHR (cm). Results are given as mean ± SD.

	Male players		Female players	
	NTG (*n* = 14)	non-NTG (*n* = 11)	NTG (*n* = 35)	non-NTG (*n* = 27)
Age (years)	16.6 ± 0.9	16.8 ± 0.8	16.6 ± 1.0	17.2 ± 0.7
Stature (cm)	184.2 ± 7.4	182.2 ± 4.8	171.3 ± 6.7	168.1 ± 5.8
Body mass (kg)	76.0 ± 9.4	76.5 ± 10.3	68.5 ± 9.4	65.8 ± 7.7
BMI (kg/m^2)	22.4 ± 2.2	23.1 ± 3.5	23.3 ± 2.8	23.3 ± 2.3
Muscle mass (kg)	38.7 ± 4.2	37.8 ± 3.2	29.2 ± 3.2	28.1 ± 3.0
Body fat (kg)	8.3 ± 3.7	10.0 ± 5.4	16.2 ± 6.2	15.4 ± 5.2
Body fat (%)	10.6 ± 3.9	12.5 ± 5.3	23.2 ± 6.1	23.0 ± 5.7
WHR (cm)	0.86 ± 0.04	0.85 ± 0.04	0.88 ± 0.04	0.86 ± 0.03*

Statistic significant difference between NTG and non-NTG *p <0.05
SD = standard deviation; BMI = Body Mass Index; WHR = waist-hip-ratio.

4.1.2 Training and sleeping time

Average training time/week among male NTG players was 12.9 ± 3.0 hours/week and 8.9 ± 3.3 hours/week for non-NTG players. Female NTG players registered 14.6 ± 1.4 hours/week and non-NTG players registered 11.5 ± 2.8 hours/week. A significant difference in average training hours/week was found in both male and female players (figure 8). NTG players had in average 7.1 more hours of training /week (35 %) than non-NTG players.

Figure 8 shows that female NTG players (9.4 ± 0.8 hours/night) slept significantly more per night in the weekends compared to non-NTG players (8.4 ± 1.2 hours/night). In weekdays female NTG players slept 7.7 ± 0.7 hours/night and non-NTG players slept 7.3 ± 0.8 hours/night. Male NTG players slept significantly more in weekdays (7.8 ± 0.6 hours/ night) than non-NTG players (7.2 ± 0.8 hours/night). In weekends, male non-NTG players slept 9.5 ± 1.1 hours/night whereas NTG players slept 9.3 ± 1.2 hours/night (figure 8). In average, during a whole week (including weekdays and weekend), NTG players slept 1.8 hours (5.5 %) more than non-NTG players.

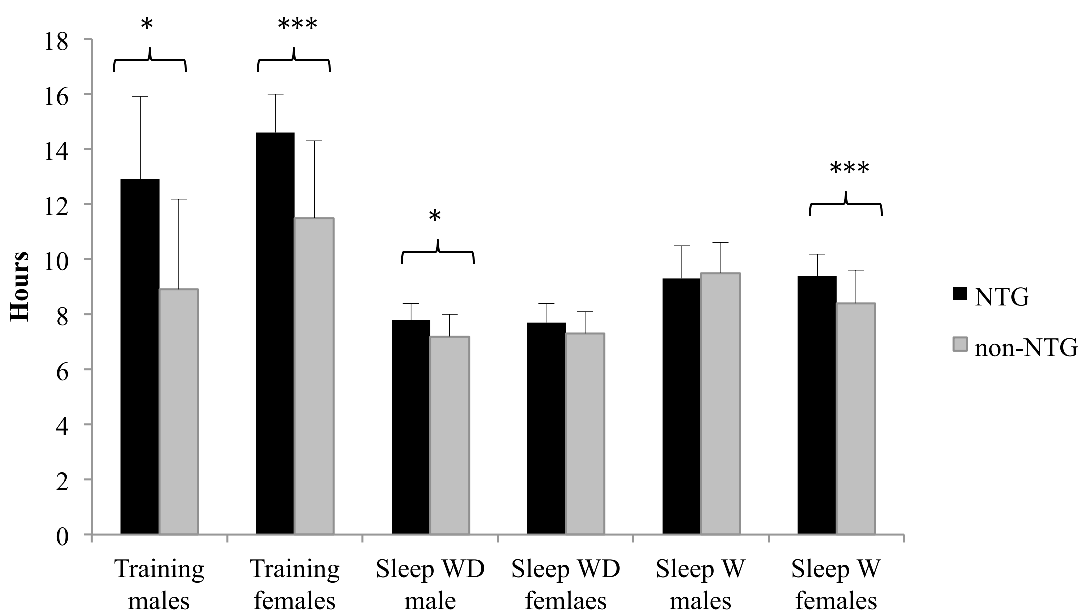


Figure 8: Training hours/week, sleeping hours/night in weekdays (WD) and weekends (W), divided into groups and sexes. Results are given as mean ± standard deviation.
Statistical significant difference between NTG players and non-NTG players **p* <0.05, ****p* <0.001.

4.1.3 Physical fitness

Physical fitness in all players at T1 is illustrated in table 3. In general, male players ran significant faster, jumped higher, covered a longer running distance and were stronger compared to the female players (p <0.001). Male NTG players ran significant faster compared to non-NTG players at 10-meter sprint (p <0.05) and 20-meter sprint (p<0.001). There were no significant differences in the remaining physical fitness tests (table 4). Female NTG players performed significantly better in Yo-yo IR1 (p <0.001) and bench-press (p <0.05) than non-NTG players (table 4).

Table 3: Physical fitness test in all players divided into sexes. Number of participants (n), 10- and 20-meter sprint (s), agility (s), CMJ (cm), yo-yo IR1 (m), squat (kg) and bench press (kg). Results are given as mean ± SD.

	Male players	Female players
10-m sprint (s)	n = 25 1.87 ± 0.07	n = 56 2.06 ± 0.09***
20-m sprint (s)	n = 25 3.16 ± 0.11	n = 56 3.48 ± 0.20***
Agility (s)	n = 25 10.65 ± 0.55	n = 54 11.84 ± 0.64***
CMJ (cm)	n = 25 35.16 ± 5.91	n = 57 25.92 ± 4.84***
Yo-yo IR1 (m)	n = 24 1141.67 ± 337.87	n = 60 732.33 ± 268.81***
Squat (kg)	n = 20 107.13 ± 13.80	n = 41 77.56 ± 15.66***
Bench press (kg)	n = 22 78.10 ± 13.47	n = 44 49.15 ± 7.76***

Statistic significant difference between male and female players ***p <0.001
SD = standard deviation, CMJ = countermovement jump
Yo-yo IR1 = Yo-Yo Intermittent Recovery Test Level 1.

Table 4: Physical fitness test in male and female players divided into groups. Number of participants (*n*), 10- and 20-meter sprint (s), agility (s), CMJ (cm), yo-yo IR1 (m), squat (kg) and bench press (kg). Results are given as mean ± SD.

	Male players		Female players	
	NTG	non-NTG	NTG	non-NTG
10-m sprint (s)	*n* = 14 1.85 ± 0.06	*n* = 11 1.91 ± 0.06*	*n* = 28 2.08 ± 0.10	*n* = 28 2.04 ± 0.08
20-m sprint (s)	*n* = 14 3.11 ± 0.10	*n* = 11 3.22 ± 0.85**	*n* = 28 3.49 ± 0.25	*n* = 28 3.48 ± 0.14
Agility (s)	*n* = 14 10.76 ± 0.59	*n* = 11 10.51 ± 0.48	*n* = 26 11.75 ± 0.59	*n* = 28 11.93 ± 0.69
CMJ (cm)	*n* = 14 34.27 ± 4.66	*n* = 11 36.30 ± 7.29	*n* = 30 25.58 ± 4.40	*n* = 27 26.31 ± 5.35
Yo-yo IR1 (m)	*n* = 13 1073.85 ± 318.16	*n* = 11 1221.82 ± 357.82	*n* = 29 814.48 ± 323.19	*n* = 31 655.48 ± 178.86**
Squat (kg)	*n* = 8 104.69 ± 8.39	*n* = 12 108.75 ± 16.63	*n* = 15 80.17 ± 15.25	*n* = 15 76.06 ± 15.99
Bench press (kg)	*n* = 10 77.50 ± 14.04	*n* = 10 78.54 ± 13.59	*n* = 26 53.00 ± 8.82	*n* = 29 47.16 ± 6.43*

Statistic significant difference between NTG and non-NTG *$p < 0.05$, **$p < 0.01$.
SD = standard deviation; CMJ = countermovement jump; Yo-yo IR1 = Yo-Yo Intermittent Recovery Test Level 1.

4.2 Results follow-up

4.2.1 Physical characteristics

Changes of physical characteristics from T1 to T2 are presented in table 5, and from T1 to T3 in table 6. As mentioned, it differs which players who participated. Therefore, the results from T1 to T2 could not be compared with the results from T1 to T3. Some of the results showed minor changes, while other results stagnated. It seems that there was an increase in stature in all groups, however there it appeared that the male players have grown more throughout the season than the female players.

Both NTG and non-NTG male players increased muscle mass and reduced body fat (kg and %) during the entire season. Female players, both NTG and non-NTG players, reduced body mass and body fat (kg and %) from T1 to T2 (table 5). Only small changes from T1 to T3 were observed in female players, but it seems like they increased body mass and muscle mass and reduced body fat in kg and % (table 6). Female NTG and non-NTG players appeared to be similar in physical characteristics at all three test points (table 5 & 6). It was not possible to compare male players, because it was unsure whether the results gave an unrealistic picture due to the small study-sample.

Table 5: Physical characteristics in male and female players divided into groups from T1-T2. Number of participants (*n*), stature (cm), body mass (kg), BMI (kg/m^2), muscle mass (kg), body fat (kg), body fat (%) and WHR (cm). Results are given as mean ± SD.

	Male players			Female players		
	n	T1	T2	*n*	T1	T2
Stature (cm)						
NTG	5	187.3 ± 9.5	188.9 ± 9.6	7	172.1 ± 4.9	172.8 ± 4.8
non-NTG	3	178.6 ± 2.2	179.5 ± 1.8	8	170.2 ± 4.3	170.7 ± 4.4
Body mass (kg)						
NTG	5	78.4 ± 12.0	78.4 ± 13.9	7	67.9 ± 9.9	66.3 ± 9.8
non-NTG	3	75.7 ± 9.6	76.4 ± 10.2	8	67.9 ± 4.8	66.3 ±5.1
BMI (kg/m^2)						
NTG	5	22.2 ± 1.3	21.8 ± 1.8	7	23.0 ± 4.1	22.3 ± 4.1
non-NTG	3	23.8 ± 3.4	23.8 ± 3.3	8	23.4 ± 1.4	22.8 ± 1.5
Muscle mass (kg)						
NTG	5	40.1 ± 5.7	41.4 ± 6.6	7	29.9 ± 2.3	29.7 ± 2.4
non-NTG	3	36.6 ± 3.2	38.6 ± 3.6	8	29.5 ± 3.0	29.7 ± 2.6
Body fat (kg)						
NTG	5	8.2 ± 2.8	6.2 ± 2.7	7	15.1 ± 9.2	13.4 ± 9.8
non-NTG	3	11.0 ± 4.1	8.6 ± 4.4	8	15.2 ± 3.9	13.2 ± 3.7
Body fat (%)						
NTG	5	10.3 ± 2.5	7.6 ± 2.2	7	21.3 ± 9.0	19.2 ± 10.0
non-NTG	3	14.2 ± 3.8	10.9 ± 4.3	8	22.3 ± 5.7	19.9 ± 5.1
WHR (cm)						
NTG	5	0.86 ± 0.03	0.86 ± 0.03	7	0.87 ± 0.05	0.86 ± 0.05
non-NTG	3	0.85 ± 0.05	0.86 ± 0.05	8	0.86 ± 0.03	0.85 ± 0.03

BMI = Body Mass Index; WHR = waist-hip-ratio, SD = standard deviation.

Table 6: Physical characteristics in male and female players divided into groups from T1-T3. Number of participants (*n*), stature (cm), body mass (kg), BMI (kg/m^2), muscle mass (kg), body fat (kg), body fat (%) and WHR. Results are given as mean ± SD.

	Male players			Female players		
	n	T1	T3	*n*	T1	T3
Stature (cm)						
NTG	6	187.3 ± 8.6	189.3 ± 9.0	8	173.7 ± 6.1	175.1 ± 6.2
non-NTG	2	178.7 ± 3.1	180.2 ± 4.0	6	168.8 ± 3.9	169.7 ± 3.9
Body mass (kg)						
NTG	6	75.5 ± 13.6	78.0 ± 13.3	8	70.8 ± 14.0	71.1 ± 13.4
non-NTG	2	71.5 ± 8.6	76.1 ± 6.2	6	66.7 ± 4.1	67.7 ± 5.1
BMI (kg/m^2)						
NTG	6	21.4 ± 1.9	21.6 ± 2.4	8	23.5 ± 4.3	23.2 ± 4.3
non-NTG	2	22.5 ± 3.5	23.5 ± 3.0	6	23.4 ± 1.7	23.5 ± 2.1
Muscle mass (kg)						
NTG	6	39.5 ± 6.1	41.4 ± 7.6	8	30.4 ± 3.8	31.3 ± 4.3
non-NTG	2	35.3 ± 3.0	38.6 ± 2.3	6	28.8 ± 3.2	29.5 ± 2.9
Body fat (kg)						
NTG	6	6.5 ± 3.5	5.7 ± 2.9	8	16.5 ± 9.9	15.5 ± 10.1
non-NTG	2	9.1 ± 3.5	8.4 ± 2.8	6	15.1 ± 4.1	15.0 ± 4.9
Body fat (%)						
NTG	6	8.1 ± 3.3	7.0 ± 2.8	8	22.1 ± 8.9	20.7 ± 9.5
non-NTG	2	12.5 ± 3.4	10.9 ± 2.8	6	22.7 ± 6.2	22.0 ± 6.1
WHR (cm)						
NTG	6	0.84 ± 0.03	0.84 ± 0.03	8	0.88 ± 0.05	0.88 ± 0.05
non-NTG	2	0.83 ± 0.05	0.86 ± 0.05	6	0.86 ± 0.03	0.86 ± 0.03

BMI = Body Mass Index; WHR = waist-hip-ratio, SD = standard deviation.

4.2.2 Training and sleeping time

NTG players in the follow-up group had significantly more training hours/week ($p < 0.01$) at T1 compared to non-NTG. In addition, NTG players slept significantly more hours per night in the weekends ($p < 0.05$) than non-NTG players at T1. However, no significant differences between the groups were observed in training hours/week and sleeping hours/night at T2 and T3. Both male and female NTG players seemed to have more training hours/week and sleeping hours/night during a whole week than non-NTG players at T2. In contrast, it appeared that female non-NTG players had more hours of training per week than NTG players at T3, but male NTG players still registered more training hours/week compared to non-NTG players. Female NTG players still slept more per night during a week than non-NTG players. However, the male players had similar sleeping hours/night in the weekdays at T3, but male non-NTG players appeared to sleep more per night in the weekends than NTG players.

4.2.3 Physical fitness

Almost all groups ran slightly faster in 10- and 20-meter sprint and agility, and almost all groups improved their running distance in yo-yo IR1 from T1 to T2 (table 7). The most noticeable changes from T1 to T2 in male players were an increase in CMJ, squat and bench press. Female players had minor improvements in most the tests, but NTG players had a large increase in squat (table 7). Comparing NTG and non-NTG players from T1 to T2, female players seemed to be equally fast in sprint, and had almost the same jumping-height. However, NTG players appeared to be faster at agility, covered a longer running distance and were stronger in squat.

The changes from T1 to T3 seemed to be minor in almost all the tests in general. The most noticeable changes among male players were in jumping height. In addition, male NTG players increased in squat and running distance. Only one player participated from non-NTG in maximal strength testing, so we cannot say anything about the group. There were no changes in physical fitness from T1 to T3 among the female players in general, besides an improvement of five cm in CMJ in the NTG players (table 8). Comparing female NTG and non-NTG players from T1 to T3, they seemed to be similar in almost all tests except running endurance, in favor of female NTG players (table 8).

Table 7: Physical performance test in male and female players divided into groups from T1-T2. Number of participants (*n*), 10- and 20-meter sprint (s), agility (s), CMJ (cm), yo-yo IR1 (m), squat (kg) and bench press (kg). Results are given as mean ± SD.

	Male players			Female players		
	n	T1	T2	*n*	T1	T2
10-m sprint (s)						
NTG	5	1.84 ± 0.08	1.87 ± 0.08	6	2.07 ± 0.13	2.05 ± 0.14
non-NTG	3	1.90 ± 0.04	1.90 ± 0.05	8	2.05 ± 0.11	2.04 ± 0.10
20-m sprint (s)						
NTG	5	3.12 ± 0.14	3.14 ± 0.12	6	3.50 ± 0.23	3.47 ± 0.24
non-NTG	3	3.22 ± 0.09	3.20 ± 0.11	8	3.49 ± 0.18	3.47 ± 0.15
Agility (s)						
NTG	5	10.58 ± 0.77	10.34 ± 0.67	5	11.32 ± 0.30	10.94 ± 0.40
non-NTG	3	10.98 ± 0.66	10.47 ± 0.49	8	12.22 ± 0.95	11.82 ± 0.60
CMJ (cm)						
NTG	5	32.75 ± 5.46	36.33 ± 5.97	7	25.04 ± 3.92	28.08 ± 3.26
non-NTG	3	33.25 ± 8.03	40.28 ± 10.27	8	27.53 ± 3.46	29.23 ± 4.27
Yo-yo IR1 (m)						
NTG	4	995.00 ± 203.00	1040.00 ± 195.96	3	1213.33 ± 100.66	1286.67 ± 70.24
non-NTG	3	1393.33 ± 117.19	1120.00 ± 120.00	8	675.00 ± 168.95	755.00 ± 166.22
Squat (kg)						
NTG	3	103.33 ± 12.58	108.33 ± 18.09	6	84.58 ± 17.13	91.67 ± 23.38
non-NTG	2	97.50 ± 10.61	103.75 ± 12.37	7	83.21 ± 18.47	84.29 ± 17.18
Bench press (kg)						
NTG	4	75.00 ± 18.71	79.38 ± 17.37	6	52.86 ± 10.05	56.07 ± 8.76
non-NTG	2	72.50 ± 17.68	78.75 ± 19.45	7	53.57 ± 4.76	55.71 ± 5.90

CMJ = countermovement jump; Yo-yo IR1 = Yo-Yo Intermittent Recovery Test Level 1; SD = standard deviation.

Table 8: Physical performance test in male and female players divided into groups from T1-T3. Number of participants (*n*), 10- and 20-meter sprint (s), agility (s), CMJ (cm), yo-yo IR1 (m), squat (kg) and bench press (kg). Results are given as mean ± SD.

	Male players			Female players		
	n	T1	T3	*n*	T1	T3
10-m sprint (s)						
NTG	6	1.90 ± 0.03	1.88 ± 0.05	6	2.07 ± 0.14	2.05 ± 0.56
non-NTG	2	1.88 ± 0.03	1.71 ± 0.10	5	2.05 ± 0.15	1.98 ± 0.09
20-m sprint (s)						
NTG	6	3.19 ± 0.08	3.16 ± 0.06	6	3.50 ± 0.22	3.50 ± 0.23
non-NTG	2	3.17 ± 0.03	2.98 ± 0.10	5	3.48 ± 0.23	3.43 ± 0.16
Agility (s)						
NTG	6	10.81 ± 0.60	10.27 ± 0.41	6	11.67 ± 0.52	11.37 ± 0.61
non-NTG	2	10.83 ± 0.86	10.30 ± 0.24	4	11.82 ± 1.31	11.42 ± 0.95
CMJ (cm)						
NTG	6	34.45 ± 5.42	39.96 ± 3.40	7	23.41 ± 3.58	28.57 ± 4.88
non-NTG	2	36.40 ± 8.34	38.08 ± 9.38	5	28.58 ± 4.22	30.88 ± 3.16
Yo-yo IR1 (m)						
NTG	6	1276.67 ± 248.01	1533.33 ± 380.88	4	1290.00 ± 173.97	1260.00 ± 154.91
non-NTG	2	1370.00 ± 155.56	1390.00 ± 127.28	3	680.00 ± 200.00	760.00 ± 80.00
Squat (kg)						
NTG	7	103.93 ± 8.76	120.00 ± 16.89	8	83.13 ± 14.87	85.63 ± 20.91
non-NTG	1	105.00 ± 0.00	122.50 ± 0.00	4	84.38 ± 26.88	87.50 ± 25.98
Bench press (kg)						
NTG	5	73.00 ± 16.05	72.50 ± 20.00	8	52.50 ± 9.35	47.75 ± 10.08
non-NTG	1	60.00 ± 0.00	65.00 ± 0.00	6	51.25 ± 6.47	49.17 ± 8.76

CMJ = countermovement jump; Yo-yo IR1 = Yo-Yo Intermittent Recovery Test Level 1; SD = standard deviation.

4.2.4 Injuries

Injury incidence from T1 to T2 and from T2 to T3 is presented in figure 9. Number of injuries is not the same as number of participants, because some players registered more than one injury. It is observed that NTG players had a higher injury incidence from T1 to T2 than non-NTG players (Figure 9), and NTG players registered almost five times as many injuries compared to non-NTG players. From T2 to T3 the number of injuries had increased by three times among non-NTG players, but decreased to half as many injuries among NTG players. However, NTG players registered in total a higher injury incidence throughout the season (figure 9).

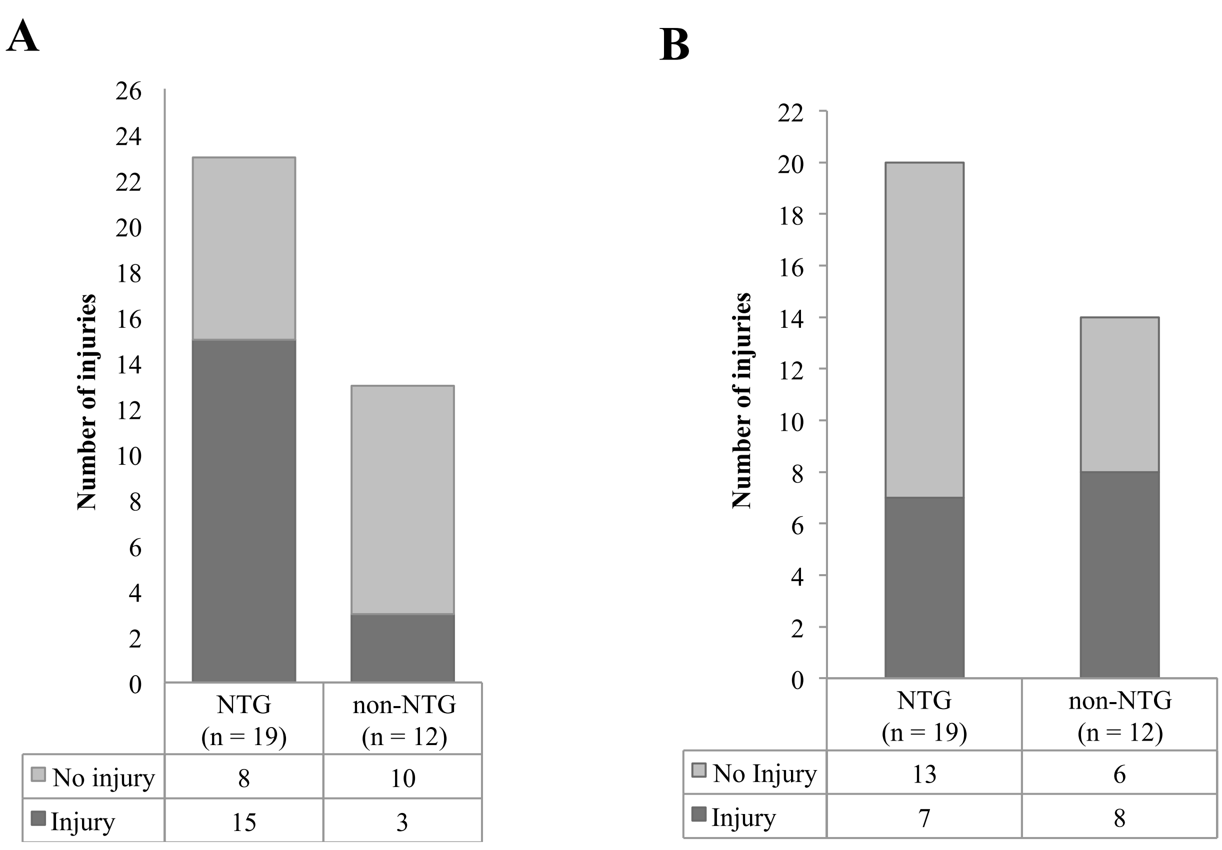
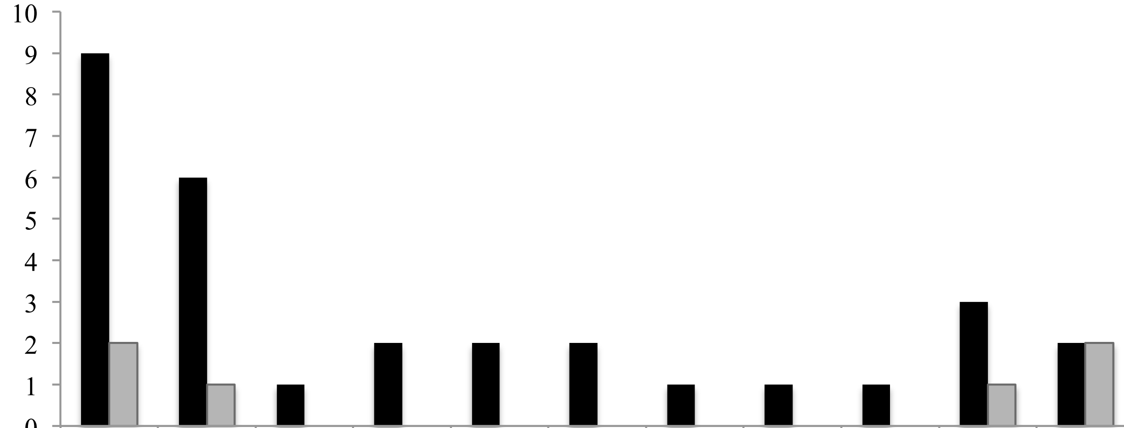


Figure 9: Injury incidence (number of injuries), divded into groups (*n:* number of participants). **A**: from T1 to T2, **B**: from T2 to T3.

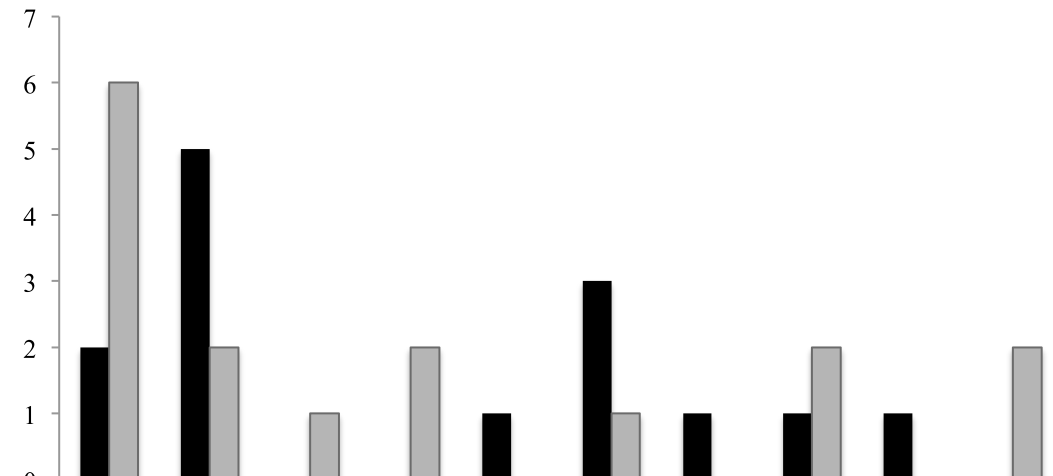
Players in both groups registered more acute injuries compared to overuse injuries from T1 to T2. The locaton of the injuries varied among NTG players, but most injuries were located in the lower leg and ankle (figure 10). Ten out of 15 injuires (66.6 %) were short term injuires with a duration of 1-4 weeks, and 5 out of 15 (33.3 %) injuies had a duration of 1-3 month (figure 11).
NTG players had higher incidence of overuse injuires from T2 to T3, but non-NTG players registered more acute injuies. The locaton of injuries varied in both groups, but in total, most injuries were located in the back and knee (figure 10). NTG players did not register any short term injuries from T2 to T3, but the majority of the injuries had a 3-5 month duration. However, non-NTG players registered mostly 1-4 weeks and 1-3 month of duration and only one long term injury (figure 11).

A



	Acute	Overuse	Head	Back	Tailbone	Hip	Groin	Thigh	Knee	Lower leg	Ankle
■ NTG (n = 19)	9	6	1	2	2	2	1	1	1	3	2
□ non-NTG (n = 12)	2	1	0	0	0	0	0	0	0	1	2

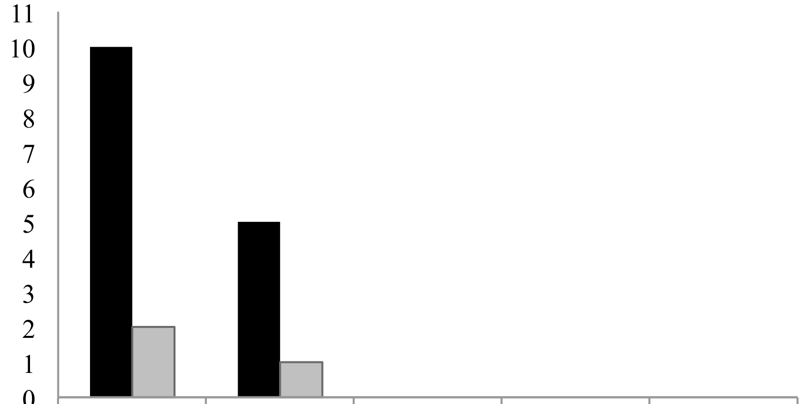
B



	Acute	Overuse	Head	Shoulder	Elbow	Back	Hip	Knee	Lower leg	Ankle
■ NTG (n = 19)	2	5	0	0	1	3	1	1	1	0
□ non-NTG (n = 12)	6	2	1	2	0	1	0	2	0	2

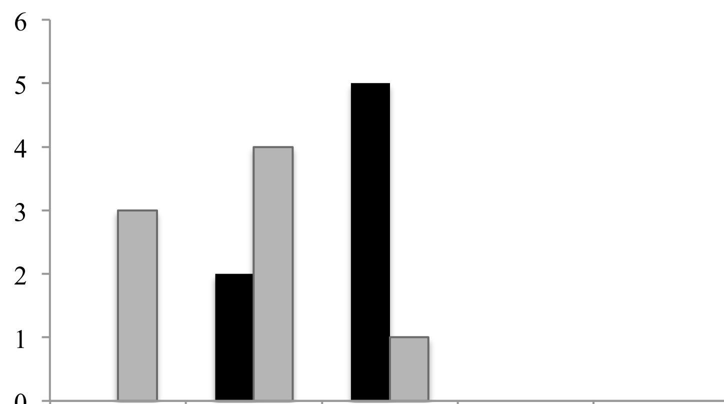
Figure 10: Injury type: acute or overuse (number of injuries) and location of the injury (number of injuries), divded into groups (*n* = number of participants). **A:** from T1 to T2, **B:** from T2 to T3.

A



	1-4 weeks	1-3 month	3-6 month	6-12 month	> 12 month
NTG (n = 19)	10	5	0	0	0
non-NTG (n = 12)	2	1	0	0	0

B



	1-4 weeks	1-3 month	3-6 month	6-12 month	> 12 month
NTG (n = 19)	0	2	5	0	0
non-NTG (n = 12)	3	4	1	0	0

Figure 11: Injury duration (number of injuries), divded into groups (*n* = number of participants). **A:** from T1 to T2, **B:** from T2 to T3.

5. Discussion

The main findings in the present study showed significant differences in physical characteristics and fitness were observed between sexes, in favor of the male players (table 1 & 3). There were no significant differences in physical characteristics between NTG and non-NTG players within neither males nor females (table 2). Further, two out of seven variables of physical fitness showed significant difference between NTG and non-NTG players, in favor of NTG players (table 4). NTG players had significantly more training hours/week than non-NTG players. Male NTG players slept significantly more per night in weekdays compared to non-NTG players, and female NTG players slept significantly more per night during weekends than non-NTG players (figure 8).

Increased stature was observed in all follow-up groups throughout the season (table 5 & 6). Reduced body mass and body fat (kg and %) were observed in female players from baseline (T1) to midterm testing (T2), but increased body mass and muscle mass and reduced body fat (kg and %) were observed from T1 to posttest T3 (table 5 & 6). Male players increased body mass and muscle mass, and reduced body fat (kg and %) throughout the entire season (table 5 & 6). Most variables in physical fitness had minor changes throughout the season in all groups, and only a few variables had greater changes (table 7 & 8). NTG players had higher total injury incidence during the entire season than non-NTG players (figure 9).

5.1 Physical characteristics

Our results indicated that male junior elite players in the present study had higher stature and body mass than male players at the same age from Belgium (Matthys et al., 2013). In addition, had they higher stature and body mass than Greek and Belgium players who were 1-2 years younger (Zapartidis et al., 2009; Matthys et al., 2012), and they were higher but had lower body mass than Norwegian players younger than 16 years (Ingebrigtsen et al., 2013). Comparing to Norwegian elite players younger than 18 years, male players in the present study had lower stature but same body mass (Ingebrigtsen et al., 2013). Further, male senior elite team handball players from Denmark and Portugal had higher stature and over 10 kg greater body mass than the male junior elite players in the present study (Michalsik et al., 2015a; Póvoas et al., 2012). In terms of the female junior elite players who participated in the present study, the results revealed that they had higher stature and body mass compared to players classified as non-elite and elite at the same age (Moss et al., 2015). Non-elite players were recruited from Great Britain, and elite players competed in the highest and second highest league of their age in Denmark (Liga), Norway (Bring series) and Spain (Catalan league). Players, who were classified as top-elite players, were considerable higher in stature and body mass compared to elite and non-elite players, and also female players in the present study (Moss et al., 2015). All top-elite players in Moss et al.'s study competed for the best Danish teams (U17/U19) and performed at international level: European and World Youth Championship (Moss et al., 2015). Compared to other Norwegian junior elite players younger than 18 years, female players in the present study had similar stature, but the body mass was in average five kilograms higher (Ingebrigtsen et al., 2013). Younger players, U15 and U14, had lower stature and body mass (Ingebrigtsen et al., 2013; Zapartidis et al., 2009) and senior top-elite players had higher stature and body mass (Michalsik et al., 2015a; Michalsik et al., 2015b).

These findings connect anthropometrical characteristics, like stature and body mass, to performance. Since team handball is a tough physical contact sport, with a high amount of physical confrontations (section 2.4; Michalsik et al., 2015a; Póvoas et al., 2014; Póvoas et al., 2012), research suggests that higher and heavier players have an advantage in elite team handball (Michalsik et al., 2015a). It is revealed that junior top-elite team handball players were taller and had higher body mass compared to elite and non-elite players, as well as the junior elite players in this study (Moss et al., 2015; Zapartidis et al., 2009). In addition, existing research illustrates the variety in anthropometrical characteristics between ages, and senior elite players seem to have higher stature and body mass than junior elite players. However, some junior players participate in training and competitions with senior players, but no studies have investigated whether these players are favorable because of their anthropometrical characteristics and maturation, or because of other factors like physical fitness and their technical and tactical skills.

When comparing male and female junior elite players, findings in the present study revealed significant differences in physical characteristics, in favor of the male players. To our knowledge, only one previous study has directly compared physical characteristics between male and female elite team handball players. Michalsik et al. confirmed our findings, however, they only included stature and body mass (Michalsik et al., 2015a). Although there are genetically differences between males and females in nature (section 2.5; Malina et al., 2004), it is an advantage that male team handball players have higher stature and greater body mass in order to withstand tough tackles, since male players received and performed more tackles during a match than female players (Michalsik et al., 2015a).

An important issue when comparing physical characteristics is that the majority of previous studies who just include body stature and body mass, and few included lean mass and fat percentage. To give a more detailed insight of physical characteristics in junior elite team handball players, the present study examined the composition of body fat (kg and %), and muscle mass (kg). More specific research with improved methodology is needed to discuss and determine whether it is only anthropometrical factors, as stature and body mass, or also other factors like muscle mass (kg) and body fat (kg and %) that possible could have an impact on performance in junior elite team handball players. This will be discussed further in section 5.2.

5.2 Physical fitness

As mentioned, sprinting, jumping, maximal strength, changes of directions and endurance running seem to be the main physical demands in elite team handball (Michalsik et al., 2013; Wagner et al., 2014; Michalsik et al., 2014; Póvoas et al., 2014; Póvoas et al., 2012). It was challenging to compare our results of physical fitness to other studies examining junior elite team handball players, since previous literature is few and limited in some methodology approaches. In addition, the methodological approaches vary between studies. The majority includes sprint, jumping, endurance running, agility and strength to examine physical fitness. However, the number of factors included varies substantial between studies. To our knowledge, the present study is the first to include all factors aiming to explore physical fitness in junior elite team handball players.

The results in the present study showed that male junior elite players ran faster at 10- and 20-meter sprint compared to male players at the same age from Belgium (Matthys et al., 2013), and faster over a 10-meter distance compared to other Norwegian elite players younger than 18 years (Ingebrigtsen et al., 2013). Further, male players in the present study ran faster at 10- and 20-meter sprint than younger players (younger than 16 years) from Belgium and Norway (Matthys et al., 2012; Matthys et al., 2013; Ingebrigtsen et al., 2013).

Moss et al. used almost similar methodological approaches as in the present study to examine physical fitness in female team handball players. The results indicate that female junior elite players in the present study ran faster at 10- and 20-meter sprint compared to non-elite and elite players, but slightly slower at both distances than top-elite players (Moss et al., 2015). In addition, another study including female junior elite players only from Norway revealed that the female players in this study was almost equally fast compared to female players younger than 18 years, and faster than players younger than 16 years at a 10-meter sprinting distance (Ingebrigtsen et al., 2013).

The majority of studies examining physical fitness have applied CMJ as a measure of jumping velocity. The results from the present study will be compared to other studies where arm swing was not allowed. Observation in the present study showed that male players seemed to jump higher compared to other Norwegian male players younger than 18 and 16 years (Ingebrigtsen et al., 2013). Further, male junior elite players jumped substantial lower compared to senior top-elite players from Denmark (Michalsik et al., 2015c). In terms of the female junior elite players in the present study, they jumped lower compared to non-elite, elite and top-elite players at the same age (Ingebrigtsen et al., 2013, Moss et al., 2015). However, they appeared to jump higher than female players younger than 16 years from Norway did (Ingebrigtsen et al., 2013).

Only a few studies have reported results from agility T-test. The test has been found to be suitable in sports like team handball, since it is a sport with high amount of recreational activity and the constant changes of directions (Pauole et al., 2000). The results of agility performance in the present study can be compared to other studies but only in some extent, due to minor modifications of the original T-test. Sassi et al. 2009 included physical education students at university (mean age females: 22.6 ± 1.4 years, males: 22.4 ± 1.5 years), who played team handball, football, basketball or volleyball. They were not defined as elite, but their average training load was approximately 16 hours/week. Compared to them, female junior elite team handball players in the present study completed the agility T-test faster than the female university players (Sassi, Dardouri, Yahmed, Gmada, Mahfoudhi & Gharbi, 2009). Further, the male elite team handball players in the present study ran slightly slower compared to male university players (Sassi et al., 2009). Negre et al. tested agility among young male team handball players (mean age: 12.5 ± 1.7 years), who were involved in national first division events in Tunisia. Results from the present study indicate that male junior elite team handball players in the present study had faster directional changes in agility T-test than younger male team handball players from Tunisia (Negra, Chaabene, Hammami, Amara, Sammoud, Mkaouer & Hachana, 2016).

The majority of earlier team handball studies have examined endurance running, but the methodological approaches vary. The present study used Yo-Yo IR1, and as far as we know, two other team handball studies on females applied similar test (Moss et al., 2015; Michalsik et al., 2014) and only one study on male players (Souhail, Castagna, Mohamed, Younes & Chamari, 2010). Our results showed that female elite team handball players from the present study ran shorter than non-elite, elite and top-elite players at the same age (Moss et al., 2015). Further results revealed that top-elite players from Moss et al. 2015 ran 1663 ± 327 meters more than the female elite team handball players in the present study 732.33 ± 268.81 meters. Results from Yo-Yo IR1 among Danish female senior elite players showed that Danish senior players ran twice as long, 1436 ± 222 meters, than the female junior elite players in the present study (Michalsik et al., 2014). Souhail et al. examined endurance running in young team handball male players (mean age: 14.3 ± 0.5 years) from Tunisia, by using Yo-Yo IR1. The male junior elite players in the present study covered a shorter distance, 1141.67 ± 337.87 meters, compared to younger Tunisian male players, 1831 ± 373 meters (Souhail et al., 2010).

Earlier research suggest that high values of maximal strength and muscle power is important to hit, block, push and hold during playing actions, and it may be essential for successful participation in team handball at elite-level (Gorostiaga et al., 2005; Granados et al., 2007; Granados et al., 2013). Maximum muscle strength has been examined in several research studies. However, all studies, to our knowledge, only included 1RM in bench press. Those studies that included strength testing on lower limbs used other methodological approaches, or presented the results as average power output and not as absolute values. To our knowledge, no previous studies have used 1RM testing among junior elite team handball players. Therefore, the results from the present study will be compared to findings in senior elite team handball players. Granados et al. examined 1RM bench press throughout an entire season in female senior elite players (Granados, Izquierdo, Ibánez, Ruesta & Gorostiaga, 2008). Since Granados had a three-time point of 1RM bench press testing, we made some calculations to compare the strength in average. The results showed that female players in the present study in average were stronger than Spanish senior elite players (Granados et al., 2008). In a study by Granados et al., they tested 1RM on both senior amateur team handball players and elite players (Granados et al., 2007). Results indicated that female players in the present study were slightly stronger than senior elite players from Spain (Granados et al., 2007). In addition, female players in the present study (49.15 ± 7.76 kg) lifted approximately 12 kg more in 1RM bench press compared to senior amateur players (36.7 ± 4.6 kg) from Spain (Granados et al., 2007). Granados et al. 2013 examined Spanish national and international senior elite team handball players. Comparing the results from the present study, our female junior elite players were slightly weaker in 1RM bench press than national Spanish elite players, and they lifted 10 kg less than to international players (59.6 ± 7.4 kg) from Spain (Granados et al., 2013). In contrast, the male junior elite players in our study lifted approximately 30 kg less in 1RM bench press compared to Spanish senior elite team handball players (Gorostiaga et al., 2005; Gorostiaga et al., 2006). When comparing to amateur senior team handball players (82.5 ± 14.8 kg), male junior elite players in the present study (78.10 ± 13.47 kg) were only slightly weaker in 1RM bench press (Gorostiaga et al., 2005).

Differences in physical fitness have shown to be relative marked between playing levels, both within junior team handball players and senior team handball players (Zapartidis et al., 2009; Moss et al., 2015; Gorostiaga et al., 2007; Granados et al., 2007; Granados et al., 2013; Massuca et al., 2013). Among junior male players, selected players to the preliminary national team outperformed non-selected players in all physical fitness tests: standing long jump, 30-m sprint, ball velocity and VO_{2max} (Zapartidis et al., 2009). However, in female players, selected players only outperformed non-selected players in standing long jump and ball velocity (Zapartidis et al., 2009). In addition, Moss et al. 2015 examined differences between playing levels in junior female players, and did not find any differences between non-elite and elite players in physical fitness, besides elite players had better throwing velocity than non-elite players (Moss et al., 2015). However, top-elite players outperformed both elite and non-elite players in all physical fitness tests (Moss et al., 2015).

When comparing male and female junior elite players, findings in the present study revealed significant differences in all physical fitness tests, in favor of the male players. To our knowledge, only one precious study has directly compared physical fitness between senior male and female players. Results from Michalsik et al. 2015a showed that male players perform more high-intensive, strength-related playing actions, and received and performed more tackles compared to female players during an entire match (Michalsik et al., 2015a). Male players also performed more high-intensive running and high-intense technical playing actions compared to female players (Michalsik et al., 2015a). However, female players cover a larger total distance and thus getting a higher relative workload than male players (Michalsik et al., 2015a).

To sum up; the results showed that it varies whether the male and female players junior elite players in the present study performed better in physical fitness tests compared to junior elite players from other studies at the same age. When comparing junior players to senior players, there was a substantial difference in male players, in favor of senior players. In female players, junior elite players in the present study performed almost similar in most tests compared to senior elite players, and better and worse in some tests. A possible explanation of why greater differences have been observed between male junior and senior players compared to female players could be, that female players mature earlier (section 2.5; Armstrong et al., 1997; Malina et al., 2004; Hauspie et al., 1980). Strength in females stagnates before puberty, and males tend to become stronger compared to females (section 2.5; Stratton et al., 2014; Catley et al., 2013). Differences between sexes appeared to increase by age, and the magnitude of age-related changes was higher among males compared to females during puberty (Catley et al., 2013). Playing level also seemed to affect the results in physical fitness. Top-elite players outperformed both elite and non-elite players among female junior players, but no differences were found between elite and non-elite players. Further, male selected players outperformed non-selected players in all physical fitness tests The reason could be that top-elite players was found to be higher and heavier, and research have connected a greater stature and body mass with increased physical fitness and performance in elite team handball (Moss et al., 2015; Zapartidis et al., 2009). These findings prove the importance of individual performance of sprinting, jumping, strength, changes of directions and endurance running in elite team handball. However, research suggested that other factors like cognitive factors; hereunder attention, anticipation, reaction, decision making, executive functioning, mental skills and personality, psychosocial behavior, motivation and tactical skills have an impact on performance in elite team handball (Wagner et al., 2014). Therefore, more research is needed.

5.3 NTG vs. non-NTG players

To our knowledge, this was the first study to examine and compare young elite team handball players attending private elite sport high schools and elite team handball players attending regular public high schools. Therefor our results, when investigating the two groups, could not directly be compared to other studies. The hypothesis in the present study was that NTG players had better physical fitness and physical characteristics compared to non-NTG players, but our findings did not meet the hypothesis.

As earlier mentioned, performance in team handball is influenced by several factors, and especially physical characteristics and physical fitness seem to be important at elite level (Michalsik et al., 2013; Póvoas et al., 2014). So why is it that even though NTG players had significantly more training hours/week than non-NTG players, the results showed no differences in physical characteristics and only a couple of significantly differences in physical fitness? In section 2.6, we saw that the total workload had an impact on training effect, and that the training effect increased with higher amount of total workload in a session (Paulsen et al, 2010). However, too high increase in workload may cause stagnation and decrease of the training effect, but it was individual when this point occurred (section 2.6; Paulsen et al., 2010). If we connect the findings in the present study to the theory, a possible explanation could be that the total workload among NTG players is too high, and therefor do not have a positive effect on their physical fitness. Instead it is possible that the high training load could have caused their physical fitness to stagnate and in worst-case decrease. However, we cannot say with certainty if that was the reason due to insufficient information in the questionnaire.

Another possible explanation could be the type of training the players undergo, but since we have no specific information about this, we cannot say anything with certainty. However, researchers suggest that specific training is important to improve specific performance in team handball (Jensen, Jacobsen, Hetland & Tveit, 1997; Luteberget, Raastad, Seynnes & Spencer, 2015). Further, research suggests that planning of specific training during different periods is important to performance in team handball (Jensen et al., 1997). Jensen et al. examine the effect of a specific training program on performance in female senior elite team handball players from the Norwegian National Team (Jensen et al., 1997). They used specific training program consisting of combined endurance, strength and sprint training in specific periods during the season to examine the effect on maximal oxygen uptake, maximal isometric strength and maximal running velocity (Jensen et al., 1997). The results showed that specified training program in specific periods during the season increased both maximal oxygen uptake and maximal running velocity in the period with important tournaments (Jensen et al., 1997). Luteberget et al. 2015 examined the effect of traditional physical training (TPT) and resisted sprint training (RST) to specific improve acceleration in female team handball players who played in the First National Division in Norway (Luteberget et al., 2015). The results in their study revealed that TST improved acceleration in 10-meter sprint, and both TST and RST improved acceleration in 30-meter sprint (Luteberget et al., 2015).

Restitution can also be a possible explanation behind the findings in the present study. Due to our findings in figure 8, it can be discussed whether NTG players get enough sleep and restitution compared to the high amount of training hours/week. The American Academy of Sleep Medicine recommends teenagers, aged 13 to 18 years, to sleep eight to 10 hours per 24 hours on a regular basis to uphold optimal health (Paruthi et al., 2016). Researchers indicate that sleep-loss over several days affect performance in young adults (Reilly & Piercy, 1994; Oliver, Costa, Laing, Bilzon & Walsh, 2009). Elite athletes and coaches identify sleep as an important factor to post-exercise recovery, in addition to optimal performance (Samuels 2008). However, scientific evidence is limited within elite athletes and more high quality research methodology is needed to support those speculations (Samuels, 2008). A study by Skein et al. examine the effect of 30 hours sleep deprivation on intermittent sprint performance and muscle glycogen in male team sport athletes (Skein, Duffield, Edge, Short & Mündel, 2011). The results in their study showed that sleep deprivation and reduced concentrations of muscle glycogen especially affected sprint performance and submaximal pacing during intermittent-sprint exercise in male team-sport athletes (Skein et al., 2011). Besides the amount of training time, which possibly can have an impact on the necessary amount of recovery in young elite athletes, it is likely that other external factors like; school, social life and family et cetera, can have an impact as well. However, we cannot say with certainty due to insufficient information in the questionnaire in the present study.

5.4 Development during the season

5.4.1 Physical characteristics and physical fitness

As mentioned, the study-sample of the follow-up group was small. Therefore, we can only discuss our observations, but no conclusion can be drawn from the discussion. Granados et al., examined changes in physical characteristics during a season in Spanish female senior elite team handball players (Granados et al., 2008). The present study observed reduced body fat (%), which is in consistent with the results from Granados et al. (Granados et al., 2008). However, Granados et al. only showed small changes in body mass throughout the season, and the stature was only measured at baseline testing. In addition, the results from Granados et al. indicated reduced fat-free mass throughout the season (Granados et al., 2008). Male junior elite players in the present study, increased muscle mass and reduce body fat (kg and %) throughout the season. This is in agreement with Spanish male senior elite team handball players (Gorostiage et al., 2006). However, Gorostiaga et al. did not find any change in body fat (%), but the results in their study showed an increase in fat-free mass during the season (Gorostiage et al., 2006). Changes in the body composition are often associated with several factors, for example; training duration and nutritional status (Milesis, Pollock, Bah, Ayres, Ward & Linnerud, 1976; Garthe, Raastad, Refsnes, Koivisto & Sundgot-Borgen, 2011).

Not all the results from the follow-up in the present study can be directly compared to other studies, since the methodological approaches in physical fitness vary. However, it is possible to compare changes in 1RM bench press. Granados et al. observed 11.3 % increase in 1RM bench press among Spanish female senior elite players from the beginning of the season to the end of the season (Granados et al., 2008). The result from Granados et al. is not in agreement with the results in the present study, since female junior elite players decreased 7 % in 1RM bench press from T1 to T3. Within Spanish senior elite male players, Gorostiaga et al. observed a minor increase of 1.9 % in 1RM bench press from the beginning of the season to the end of the season (Gorostiaga et al. 2006). The results from Gorostiaga et al. are consistent with the results in the present study, since junior male elite players increased 3 % in 1RM bench press from T1 to T3. Even though it was not possible to compare the remaining results from the physical fitness tests in the present study to other studies, Granados et al. and Gorostiaga et al. examined maximal sprint velocity over 5- and 15-meter distance. No changes throughout the season were observed in both male and female senior elite players from Spain (Granados et al., 2008; Gorostiaga et al. 2006). In both studies they discussed that their findings could be affected by a decrease in specific sprint training and a progressive increase of training volume in other training types during the season (Granados et al., 2008; Gorostiaga et al. 2006). In contrast, Jensen et al. showed that maximal running velocity increased during the season among senior elite female players from Norway (Jensen et al., 1997). However, further observation showed that even though the players uphold 1-2 sprint sessions each week, the maximal running velocity tended to decrease during a period with a high volume of strength training (Jensen et al., 1997). Jensen et al. suggested that a decrease in the total volume of strength training could be important to increase maximal running velocity during the season (Jensen et al., 1997). More research is necessary to view exact changes in physical characteristics and physical fitness in team handball players during a season, especially in young team handball players.

5.4.2 Injuries during the season

Previous research have examined the patterns and incidence of injuries in young male and female team handball players (Olsen, Myklebust, Engebretsen & Bahr, 2006; Rosen, Heijne, Frohm, Fridén & Kottorp, 2018). Olsen et al. investigated injury patterns and incidence in 1080 Norwegian amateur team handball players during a season (Olsen et al., 2006). The results revealed that 118 injuries affected 97 of 428 players (23 %). Of these, 79 % were acute injuries and 21 % were overuse injuries (Olsen et al., 2006). The most common acute injuries were located in the knee and ankle, and they accounted for half of the acute injuries. The most common overuse injuries were located in lower legs, knee and back (Olsen et al., 2006). These findings consistent with the results in the present study, because most injuries were registered in lower legs, ankle, knee and back. However, the results in the present study did not directly connect location of injury with type of injury (acute or overuse). An interesting finding in Olsen et al. was that the injury rate was higher during matches than training. Furthermore, most injuries occurred in a contact situation with an opposite player in attack actions, and most injuries were registered in backcourt and wing players (Olsen et al., 2006). Rosen et al. examined injury patterns and incidence among Swedish elite athletes aged 16-18 years, competing in multiple sports, including team handball (Rosen et al., 2018). Their results showed that team handball (47.6 %) had the highest proportion of injuries compared to all other sports included in the study: orienteers, athletic athletes, freestyle skiers, downhill skiers, ski orienteers and cross-country skiers (Rosen et al., 2018). This is nearly in agreement with Moseid et al. 2017., who observed that team sport athletes (basketball, floorball, team handball, ice hockey, soccer and volleyball) had highest injury incidence compared to technical and endurance sport athletes (Moseid, Myklebust, Fagerland, Clarsen & Bahr, 2017). In addition, team sport athletes reported more acute injuries than overuse injuries, and compared to technical and endurance sports, team sports had highest incidence of both acute and overuse injuries (Moseid et al., 2017). Rosen et al. did not differ between acute and overuse injuries, but most injuries were located in the knee, thigh, lower legs, foot and shoulder (Rosen et al., 2018). As in consistent with Olsen et al., the injury incidence rate was higher during matches than training (Rosen et al., 2018). An interesting finding in Rosen et al. 2018 revealed that team handball players had the highest volume of training per week and the highest amount of competitive hours per week compared to all other sports included in the study (Rosen et al., 2018). As known, team handball is an intermittent sport with several physical confrontations during a match and training (section 2.4; Michalsik et al., 2015a). The theory explained that the training and competition loads contributed directly to higher injury risk, because the athletes have higher exposure to injurious situations (section 2.6; Windt et al., 2017a). In addition, the theory explained that the risk of injuries was lower among individuals with higher physical fitness compared to individuals with lower physical fitness (section 2.6; Windt et al., 2017b). As mentioned, Møller et al. examined the relationship between training and competition loads, and development of injuries (section 2.6; Møller et al., 2017). The results revealed that players who increased team handball load with >60 % had a higher shoulder injury rate than players increasing or decreasing <20 % (Møller et al., 2017). Both Møller et al. 2017 and Rosen et al. 2018 support the theory, that the total volume of team handball, training and competition loads has an impact on injury risk, and can be connected to the findings in the present study.

As mentioned, NTG players registered almost five times as many injuries than non-NTG players in the first half of the competitive period. A possible explanation could be a rapid spike in workload ratio over a short period of time. As known, NTG players registered significantly higher amount of training volume than non-NTG players did. If this volume of total workload increased rapidly over a short period of time, it could cause an increase of neuromuscular fatigue, and thereby an increased risk of injuries (Windt et al., 2017a). In addition, it is possible that NTG players had a higher exposure to injurious situations, but since the type of training was not registered, further analysis is needed to examine that.

5.5 Strengths and limitations

5.5.1 Study design

The primary aim of the present study was to examine physical characteristics and physical fitness in junior elite team handball players through a cross-sectional study design. In cross-sectional studies data get collected at one time point (Thelle & Laake, 2008). The benefits of using a cross-sectional study design are that it is possible to examine several variables on a large study-sample, and the methods can easily be controlled and standardized (Thelle et al., 2008). However, cross-sectional studies cannot state anything about risk and causality over time (Thelle et al., 2008). In addition, the present study used a follow-up design to observe changes over time, and hereby it was possible to discuss causality

(Thelle et al., 2008). Therefore, the study design in the present study was considered a methodological strength, due to collect and examine these specific types of data and answer the research question.

To our knowledge, the present study was the first to investigate possible differences in physical characteristics and physical fitness between youth elite players attending private elite sport high schools, and elite players attending regular public high schools. Previous researchers have examined physical characteristics and fitness in young elite team handball players. However, previous research is limited, which affected the comparison to our result. Further, some studies examined changes in physical characteristics, physical fitness and injuries during an entire season, but most findings were observed in senior elite players. In general, more research is needed in junior elite team handball players.

5.5.2 Subjects

The present study included in total 93 Norwegian male (n = 26) and female (n = 67) elite team handball players. There were no significant differences in number of participants and mean age, when the players were divided into groups and sexes. However, more female players than male players participated in the present study. This selection bias could have affected our findings when comparing male and female players. However, the present study did find significant difference in physical characteristics and physical fitness between male and female players, in favor of the male players, which was expected (section 2.5; Malina et al., 2004; Hauspie et al., 1980) and in agreement with previous research (section 5.1 and 5.2; Michalsik et al., 2015a).

Due to a limited number of students at NTG, we first recruited players from NTG. NTG Bærum had both male and female players in their program that agreed to participate. However, NTG Lillehammer had only female players, which caused the selection bias. When we knew the number of players from NTG that agreed to participate, we started to recruit the same number of non-NTG players. Since we were able to recruit almost equally many NTG and non-NTG players, it was considered as a methodological strength due to the internal validity, in addition to the comparison between groups. It was specified that non-NTG players attended regular public high schools, but some players attended sport specific public high schools, which could have affected our result when we compared NTG and non-NTG.

We selected players to further follow-up based on the total number of completed tests at baseline. Unfortunately, not all invited players agreed to continue in the study, which affected the total number of players in the follow-up group, and therefore the internal validity and external validity were reduced. A large number of male non-NTG players did not agree to further participation, which affected the selection bias. During follow-up we experienced a high incidence of injuries that caused players to refrain from one or several physical fitness tests. When all raw data was collected, we observed that the study sample was too small to perform any statistical analysis. Therefore, the findings in the follow-up were only expressed as observations of a few cases, which affected the internal and external validity of the study. Thus, it was not possible to make a concrete conclusion of the follow-up results in the present study.

5.5.3 Test methods

In terms to select best possible test methods to answer our scientific questions, we examined background information about physical demands in team handball, and observed which methods that were used in previous literature. In addition, all procedures in the present study were selected due to their high reliability, reproducibility and sensitivity (section 3.4; Krustrup et al., 2003; Waldron et al., 2011; Buckthorpe et al., 2012; Pauole et al., 2000; Levinger et al., 2009; Verdijk et al., 2009; Seo et al., 2012; Jensky-Squires et al., 2008). As mentioned, the procedures vary between studies, but most previous literature investigating physical fitness, examined running speed, running endurance, jumping performance, agility and strength. Only one used almost similar test protocol as the present study, however, they only examined female junior elite team handball players (Moss et al., 2015). Other studies have included one or more variables, which were comparable to the present study, but the majority of the results were collected on senior elite team handball players.

In terms of physical characteristics, the present study is the first, to our knowledge, to use bioelectrical impedance analysis to examine body composition in junior elite team handball players. Previous research used lower methodological approaches, and the majority only included anthropometrical measures as stature, body mass and BMI. Although over- and underestimation possibly could occur when using BIA, it is a highly accepted method to test body composition within young adults (section 3.4; Jensky-Squires et al., 2008). It is therefore considered a methodological strength in the present study, and more research should apply BIA when examine physical characteristics in junior elite team handball players.

The self-conducted questionnaires in the present study, both had strength and limitations. Questionnaire 1 gave us exact information about personal background (name, birthday, school, grade and team). In addition, we wanted to examine average training time/week, sleeping time/night, injury patterns and incidence, but the collection was retrospective and depended on the players' subjective memory, and the questionnaire was not validated.

5.6 Future research

In future research it is preferable to have equally many male and female players. Further, it will strengthen the outcome of the study with a larger study sample as well as the external validity (Thelle et al., 2008). However, sample-size varies between researches. An example where both male and female players were included, Michalsik et al. 2015a included 82 female players and 83 male players whereas Ingebrigtsen et al. 2013 included 29 female players and 29 male players. My recommendation is to calculate exact sample-size in future research. In addition, future research should include all players from baseline testing in the follow-up study to observe statistical changes during the season. Out from experience, future research should just perform pre- and post testing.

In addition, future research should apply a validated questionnaire. Rosen et al. 2018 used a weekly questionnaire containing a validated and translated version of the Oslo Sports Trauma Research Centre (OSTRC) Overuse Injury Questionnaire (Ekman, Frohm, Ek, Hagberg, Wirén & Heijne, 2015), as well as questions used by Jacobsson et al. (Jacobsson, Timpka, Kowalski, Nilsson, Ekberg, Dahlström & Renström, 2013), in an athletic surveillance study. More specific information about training type and duration, sleeping patterns and influence of other external factors could be interesting to examine further in future research.

5.7 Practical applications

This study was performed in Norwegian junior elite team handball players. All players were considered as elite players based on participation on teams playing qualification for the best national league at their age (girls/boys-16: the "BRING League" and girls/boys-18: the "LERØY League"). In addition, some players played in the Norwegian National First Division League and Elite League at senior level, as well as national teams at their age. The results from baseline testing in the present study can be compared to other team handball players at the same playing level and age. However, the methodological approaches have to be similar in case to draw exact parallels. Due to a small sample-size and selection bias, the results from the follow-up cannot be compared to others, even though the methodological approach was considered as an accepted method to examine changes during a season.

Findings in the present study can help coaches to evaluate training programs in junior elite team handball, in addition to specify which physical qualities that are important for performance. Several researchers have shown that sprinting, jumping, maximal strength, changes of directions and endurance running are the main physical demands for performance in elite team handball (section 5.2; Michalsik et al., 2013; Wagner et al., 2014; Michalsik et al., 2014; Póvoas et al., 2014; Póvoas et al., 2012). Especially maximal strength and muscle power seem to be important to hit, block, push and hold during playing actions, and it may be essential for successful participation in team handball at elite-level (section 5.2; Gorostiaga et al., 2005; Granados et al., 2007; Granados et al., 2013). In addition, anthropometrical characteristics seem to have an importance for performance in junior elite team handball, and it is suggested that a higher and heavier player has an advantage, since team handball is a tough physical contact sport, with a high amount of physical confrontations (section 5.1; Michalsik et al., 2015a).

Our research, in addition to previous research, demonstrated that a rapid increase in total workload could negatively affect training effect and increase injury risk in junior elite team handball players (section 2.6; Paulsen et al., 2010; Windt et al., 2017a). Therefore, total workload needs to increase progressively and planned weekly by coaches and players in collaboration.

6. Conclusion

The results from the present study showed a significant difference in physical characteristics and physical fitness between junior elite male and female team handball players, in favor of the male players. No differences in physical characteristics were found between NTG and non-NTG players in neither male nor female players. Only two out of seven physical fitness tests revealed significant differences between NTG and non-NTG players in both sexes at baseline, in favor of NTG players. Total injury incidence throughout the competitive season was higher in NTG players than in non-NTG players.

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Appendix

Appendix 1: Questionnaire at baseline testing (T1)

A. Bakgrunn, treningsstatus og søvnmengde

Navn:	
Kjønn (gutt/jente):	
Fødselsdato:	
Telefon:	
Skole og trin:	
Når begynte du med håndball?	
Hvilket lag spiller du for (nivå)?	
Antall treningstimer per uke:	
Gjennomsnittlig antall timer søvn i ukedagene:	
Gjennomsnittlig antall timer søvn i helgene:	

B. Helserelatert spørsmål

		JA	NEI
1.	Kjenner du til at du har en hjertesykdom?	☐	☐
2.	Hender det du får brystsmerter i hvile eller i forbindelse med fysisk aktivitet?	☐	☐
3.	Kjenner du til at du har høyt blodtrykk?	☐	☐
4.	Bruker du for tiden medisiner for høyt blodtrykk eller hjertesykdom (f.eks. vanndrivende tabletter)	☐	☐
5.	Har noen av dine foreldre eller søsken fått hjerteinfarkt eller dødd plutselig (før 55 år for menn og 65 for kvinner)	☐	☐
6.	Røyker du?	☐	☐
7.	Kjenner du til om du har høyt kolesterolnivå i blodet?	☐	☐
8.	Har du besvimt i løpet av de siste 6 måneder?	☐	☐
9.	Hender det du mister balansen på grunn av svimmelhet?	☐	☐
10.	Har du sukkersyke (diabetes)?	☐	☐
11.	Kjenner du til noen annen grunn til at din deltakelse i prosjektet kan medføre helse- eller skadesrisiko?	☐	☐

Appendix 2: Questionnaire at T2-T3 including patterns of injuries

ID-nummer	
Antall treningstimer per uke	
Gjennomsnittlig antall timer søvn (per natt) i ukedagene	
Gjennomsnittlig antall timer søvn (per natt) i helgene	
Har du pådratt deg en skade, som hindret deg i å trene/spille håndball, fra baseline testingen til nå?	☐ Ja ☐ Nei
Hvis du krysset ja i forrige spørsmål: Hvilket type skade?	☐ Akutt skade Skader som oppstår plutselig. Eks: ankelforstuing, strekk i muskelen, leddbåndskade, brudd av knokkel. ☐ Belastningsskade Slitasje-skade/overbelastningsskade som har utviklet seg over tid. Eks: betennelse i diverse ledd og sener (beinhinnebetennelse) og tretthetsbrudd.
Hvor er skaden lokalisert?	
Hvor lang en periode var/er du ute med skade?	☐ 1-4 uker ☐ 1-3 måneder ☐ 3-6 måneder ☐ 6-12 måneder ☐ > 12 måneder

Appendix 3: Approval of data storage from the Norwegian Center of Research Data

NSD

Trine Stensrud
Seksjon for idrettsmedisinske fag Norges idrettshøgskole
Postboks 4014 Ullevål Stadion
0806 OSLO

Vår dato: 20.06.2017 Vår ref: 54575 / 3 / BGH Deres dato: Deres ref:

TILBAKEMELDING PÅ MELDING OM BEHANDLING AV PERSONOPPLYSNINGER

Vi viser til melding om behandling av personopplysninger, mottatt 30.05.2017. Meldingen gjelder prosjektet:

54575	*Fysisk form blant norske junior-elite håndballspillere*
Behandlingsansvarlig	*Norges idrettshøgskole, ved institusjonens øverste leder*
Daglig ansvarlig	*Trine Stensrud*
Student	*Camilla Aalkjær*

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, 15.08.2022, rette en henvendelse angående status for behandlingen av personopplysninger.

Vennlig hilsen

Kjersti Haugstvedt

Belinda Gloppen Helle

Kontaktperson: Belinda Gloppen Helle tlf: 55 58 28 74
Vedlegg: Prosjektvurdering

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

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