UNIVERSITETET I AGDER

Prevalence and associations of injury and illness among high school elite sport-students in the south of Norway

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Abstract

Introduction

Youth participating in sports are often associated with a healthy lifestyle, however illness and injuries are frequently reported in sports. The aims for this master thesis were; (1) to examine the prevalence of sport injuries and illnesses among elite sport students at high school with regard to sport group and (2) to examine anthropometry, bone health, performance variables, energy availability and sleep time with associations to sport injuries and illness prevalence in the same sample.

Methods

Thirty-six high school elite sport students, endurance athletes (n=24) and ball game athletes (n=12) [age: 16.3±0.2 years presented as mean and standard deviation if normal distributed; body mass index (BMI): 20.8±1.8 kg/m^2; body fat: 15.8% (10.7-24.7%) presented as median and interquartile rage if non-normal distributed; fat-free mass (FFM): 15.41 kg (47.7-60.6 kg)] were recruited. Test protocol included assessment of anthropometry, body composition, performance variables, energy availability, restitution, injuries and illnesses retrospective registration for the past six months. A total of 34 subjects were included in the analysis.

Results

Sixteen subjects experienced a total of 30 injuries (injury rate 0.88, 95% confidence interval (CI) 0.47–1.29). Twenty-eight subjects were exposed to a total of 78 illnesses (illness rate 2.29, 95% CI 1.66 to 2.93). No risk factors associated significantly with injury or illness.

Conclusion

Prevalence of injury were higher in ball game sports versus endurance sports, while endurance sports had highest prevalence of illness. Neither anthropometry, bone health, performance variables, energy availability or sleep time were found associated with prevalence of injury or illness in this sample of participants.

Keywords

Adolescent, athlete health, bone health, energy deficiency, VO_{2max}*, reaction time, sleep*

Sammendrag

Introduksjon

Ungdom som deltar i idrett er ofte assosiert med god helse, men sykdom og skader blir ofte rapportert i idrett. Formålet med denne studien var; 1) å undersøke forekomsten av idrettsskader og sykdom blant unge toppidrettsstudenter på videregående skole i forhold til kjønn og idrettsgruppe; 2) å undersøke kroppssammensetning, beinhelse, prestasjonsvariabler, energi tilgjengelighet og søvnkvantitet som risikofaktorer for idrettsskader og sykdom.

Metode

Totalt 36 toppidrettsstudenter på videregående skole, fordelt som utholdenhetsutøvere (n=24) og ball utøvere (n=12) [alder: 16.3±0.2 år; kroppsmasse indeks (KMI): 20.8±1.8 kg/m^2; kropps fett: 15.8% (10.7-24.7%); fett-fri masse (FFM): 15.41 kg (47.7-60.6 kg presentert som gjennomsnitt med standard avvik og som median med interkvartil bredde] ble rekruttert. Testprotokoll inkluderte måling av kroppssammensetning, energi tilgjengelighet, prestasjonsvariabler, restitusjon, skader og sykdom. Totalt ble 34 subjekter inkludert i analysen.

Resultater

Seksten subjekter rapporterte totalt 30 idrettsskader tilsvarende en skadefrekvens på 0.88 (95% konfidens intervall (KI) 0.47–1.29) i løpet av de seks månedene registreringen tok for seg. Totalt 28 subjekter hadde vært utsatt for totalt 78 sykdomstilfeller tilsvarende en sykdomsfrekvens på 2.29 (95% KI 1.66 to 2.93) i samme periode. Ingen risikofaktorer for idrettsskader og sykdom ble funnet signifikante.

Konklusjon

Forekomsten av idrettsskader var høyere i ballidrettsgruppen i forhold til gruppen av utholdenhetsidretter, men utholdenhetsgruppen hadde høyere forekomst av sykdom. Verken kroppssammensetning, beinhelse, prestasjonsvariabler, energi tilgjengelighet eller søvnkvantitet hadde en signifikant sammenheng med idrettsskader eller sykdom i utvalget som ble brukt i denne studien.

Nøkkelord

Tenåring, utøverhelse, beinhelse, energimangel, VO2max, reaksjonstid, søvn

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Contents

Abbreviations

BMC	Bone mineral content
BMD	Bone mineral density (g/cm^2)
BMI	Body mass index [weight (kg) divided by height squared (m^2)]
CI	Confidence interval
DEE	Daily energy expenditure
DXA	Dual-energy x-ray absorptiometry
EA	Energy availability
EEE	Exercise energy expenditure
EI	Energy intake
FFM	Fat-free mass
HR	Heart rate
Kcal	Kilocalorie
NEAT	Non-exercise activity thermogenesis
OR	Odds ratios
RED-S	Relative energy deficiency in sport
RMR	Resting metabolic rate
RT	Reaction time
SW	Sensewear
VO_{2max}	Maximal oxygen uptake ($L \cdot min^{-1}$ or $mL \cdot kg^{-1} \cdot min^{-1}$)
VO_{2peak}	Peak oxygen uptake ($L \cdot min^{-1}$ or $mL \cdot kg^{-1} \cdot min^{-1}$)

Part I

Theoretical backgrounds and methods

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1. Introduction

Illness and injuries occasionally occur in sport; the nature of sports probably never allows to completely deal with sport injuries. In Norway, sport injuries count for 17% of all injuries reported (Norsk Senter for Idrettsskadeforskning, 2017). Literature show that overall injury rates range from 0.71 to 28.2 per 1,000 hours of sport (Bengtsson, Ekstrand, Walden, & Hagglund, 2013; Egermann, Brocai, Lill, & Schmitt, 2003). Possible explanations of the wide range may be measurements in different sports, training versus competition, short tournament versus season, age of athletes, and different definitions of injury or injury rate. In the study of Peterson, Junge, Chomiak, Graf-Baumann, and Dvorak (2000) they claim that the incidence of injuries seems to increase suddenly from 14 years of age to the age of 16. Youth in sports are at a high risk for overuse injuries, because of a high volume of training, intensity, and the adolescent growth spurt (Müller, Hildebrandt, Müller, Oberhoffer, & Raschner, 2017). In the 2016 youth Olympic winter games Steffen et al. (2016) observed sport injuries and illnesses among the registered athletes (n=1083) where 102 athletes (51 females, 51 males) sustained 108 injuries with six athletes having two injury reports, corresponding to an injury risk of 9.5 injuries per 100 athlete. Regarding illness risk a total of 76 athletes (31 males, 45 females) sustained 81 illnesses, with five athletes having two illness reports, equaling to an illness risk of 7.2 illnesses per 100 athletes. Steffen et al. (2016) further reported that illness risk in these Olympic winter games was almost doubled for female compared with male athletes and that illness risk was highest in curling and in the Nordic skiing disciplines with biathlon, Nordic combined and cross-country skiers suffering from at least one illness case during the games.

In Norway, high school students choose a study program according to their area of interest, e.g., sport. Students who choose sports programs participate in more training hours and competition and may thereby be at a higher risk of sport injuries and illnesses than their peers. Illness and injuries may be a limiting factor in development of young athletes, in worst cases could an injury be the cause of an athletes' possibility to be physically active for the rest of one's life, due to the injury severity (Schneider, Yamamoto, Weidmann, & Bruhmann, 2012). To examine the occurrence and prevalence of sport injuries and illnesses might be interesting in a scientific point of view, but for athletes, coaches and health personnel it is also important to examine risk factors associated with sport injuries and illnesses. Early specialization, increased training intensity, increased training load, competence-based self-esteem, decreased sleeping volume, psychological stress and age are some risk factors to sport injuries and illnesses found in the literature (Logue et al., 2017; Myer et al., 2015; von Rosen, Frohm, Kottorp, Fridén, & Heijne, 2017; von Rosen, Heijne, & Frohm, 2016).

Mountjoy et al. (2014) also add RED-S (Relative Energy Deficiency in Sport) as a potential factor associated with injury and illnesses (Rauh, Barrack, & Nichols, 2014). RED-S is a clinical phenomenon that refers to an inadequacy of energy to support a range of different physiological body functions in order to achieve optimal health and performance for athletes (Mountjoy et al., 2014). RED-S is an expanded concept of the Female Athlete Triade to acknowledge a wider range of outcomes and the application to male athletes (Mountjoy et al., 2014). Energy deficiency, disordered eating and exercise addiction are factors that possibly can contribute to athletes developing RED-S. Energy deficiency or low energy availability (EA)(see section 2.5.4. for more information) refer to the balance between dietary intake and energy expenditure required for health and activities for daily living, growth and sporting activities (Mountjoy et al., 2014). Low EA appears to occur in weight sensitive sports due to the importance of leanness and/or weight in their role of performance (Mountjoy et al., 2014). Kemper et al. (2015) showed low percentage of fat in youth elite soccer players to associate with increased risk of injury. Despite the supposed relationship between anthropometry and risk of injury is apparent, research is both divergent and lacking (Kemper et al., 2015). Low EA is also recognized as an independent factor of poor bone health (Mountjoy et al., 2014). Poor bone health as well, is associated with increased risk of stress fractures and osteoporosis. This association however, is less investigated in youth sports and the relationship is to some degree uncertain (Mountjoy et al., 2014; Scofield & Hecht, 2012). Although RED-S is a syndrome thought to be a predictor for sport injuries and illnesses (Rauh et al., 2014) further research are needed on the prevalence of RED-S and the association with sport injuries and illnesses among elite high school students (Rauh et al., 2014; Rauh, Nichols, & Barrack, 2010).

The competitive demands for youth in elite-sports are typically higher due to the specialization and given pressure for successful performance during games, matches, meets or tournaments (Myer et al., 2015). Although studies have found significant associations to injury and illness with the performance variables VO_{2max} and reaction time, little research has been conducted on the relationship between these variables and injuries and illnesses in youth elite sports (Dvorak et al., 2000; Andrew Watson, Brickson, Brooks, & Dunn, 2017a; A. Watson, Brindle, Brickson, Allee, & Sanfilippo, 2017b). Due to the lack of research investigating these variables as risk factors for injury and illness they were included in this thesis. Studies have also reported decreased sleep time as a factor contributing to a higher risk of injury and illness, as well as an important factor in maintaining energy balance (Benedict et al., 2011; Logue et al., 2017; Penev, 2012; St-Onge, 2013; von Rosen, Frohm, Kottorp, Fridén, et al., 2017). Therefore, it is important to investigate the contribution of sleep time as a risk factor for injury and illness by itself and as a part of EA. The aims of this master thesis was therefore twofold; (1) to examine the prevalence of sport injuries and illnesses among elite sport students at high school with regard to sport group and (2) to examine anthropometry, bone health, performance variables, energy availability and sleep time with associations to sport injuries and illness prevalence.

1.1. Research question and null-hypothesis

Research question

Following research questions have been investigated:

A) What is the prevalence of sport injuries and illnesses among high school elite sport students with regard to sport groups?

B) Are there any associations between anthropometry, bone health, performance variables, energy availability or sleep time and prevalence of injuries or illness among high school elite sport students?

Null-hypothesis

This study's null-hypotheses are the following:

- High school sports students do not experience sport injuries or illnesses.
- Sport injuries and illnesses are not associated with anthropometry in high school elite sports students.
- Sport injuries and illnesses are not associated with bone health in high school elite sports students.
- Sport injuries and illnesses are not associated with performance variables in high school elite sports students.
- Sport injuries and illnesses are not associated with energy availability in high school elite sports students.
- Sport injuries and illnesses are not associated with sleeping time in high school sports elite students.

1.2. Term clarification

Injury and illness are defined according to the consensus statement of the Athletic Consensus Group (Timpka et al., 2014, p. 3); **illness** is "a physical or psychological complaint or manifestation by an athlete not related to injury, regardless of whether it received medical attention or its consequences with respect to impairments in connection with competition or training". **Injury** is defined as "a physical complaint or observable damage to body tissue produced by the transfer of energy experienced or sustained by an athlete during participation in training or competition, regardless of whether it received medical attention or its consequences with respect to impairments in connection with competition or training" (Timpka et al., 2014).

1.3. Delimitation of the thesis

This thesis will only look at the prevalence of sport injuries and illnesses, and possible associations to anthropometry, bone heath, performance variables, energy availability and sleeping time. However, the author recognize that the dynamics of illness and injury situations are complex with many other factors contributing and affecting each other. Due to the limitations in this thesis, components such as, but not limited to, muscle strength, opponent, clothing, warm-up program and trainings versus competition, will not be in focus.

2. Theoretical background

2.1. Injury and illness rate

Numerous authors have investigated frequency of injuries in youth sports (Benjamin Clarsen, Rønsen, Myklebust, Flørenes, & Bahr, 2014; Hansen, Eide, Omenaas, Engesaeter, & Viste, 2005; Junge, Chomiak, & Dvorak, 2000; Junge et al., 2008; Müller et al., 2017; Schneider et al., 2012; Tenforde et al., 2011), and frequencies of illness in youth sports, though illness is less studied compared to the surveillance of injury (Gabbett, Whyte, Hartwig, Wescombe, & Naughton, 2014; Müller et al., 2017; Steffen et al., 2016; Van Beijsterveldt et al., 2015). The results of these studies however, are inconsistent perhaps because of different age and skill levels of the groups investigated. Despite this, the high amount of research indicates that injury and illness prevalence are a problem in youth sports. The most basic expression of risk is incidence, which is defined as the number of new disease (or injury) that occur in a defined population during a given period of time. Incidence rates refers to the number of incident injuries divided by the total time-at-risk and usually multiplied by some *k* value (e.g. 1000) (Caine, Maffulli, & Caine, 2008). In addition to the mentioned inconsistences, some studies express rate of injury and illness incidence, as per 1000 hours of participating in sport, other studies express it as an average prevalence with 95% confidence interval (95% CI), injuries/illness per 1000 player-hours or per 1000 hours of games, i.e. competition (Junge et al., 2000). Because of the methodological inconsistences, the results cannot necessarily be compared, and challenge a conclusion or generalization regarding the incidence of injury and illness in sports among youth. However, injury and illness incidences per 1000 participation hours or per 1000 athletic exposures are most commonly used when reporting incidence rates (Caine et al., 2008).

2.2. Endurance sports

Common for endurance sports is to time peak fitness and maximize performances when they matter most (Seiler, 2010). Aerobic capacity is a known determinant for performance in endurance sports (Bassett Jr & Howley, 2000), and athletes who wish to reach top level in endurance sports need to maintain and improve their aerobic capacity. To both improve and maintain aerobic capacity athletes must participate in a large amount of training (Seiler, 2010). The large amount of training exposes the athletes for high risk of sport injuries and illnesses, specially the athletes risk of developing overuse injuries seems to be at a higher risk (Tenforde et al., 2011). Scofield and Hecht (2012) studied bone health in endurance athletes and stated that low bone mineral density (BMD) increases the risk of stress and fragility fractures, both while an athlete is competing actively and later in life. Endurance athletes in running, cycling, swimming, and triathlon have experienced low BMD and thereby could be at risk for stress injury (Scofield & Hecht, 2012). Due to the repetitive impact forces inherent in running, runners are at higher risk for stress fractures than other endurance athletes. Stress fractures occur when the normal remodeling and reparative properties are overwhelmed by increased load and strain leading to osteoclastic activity (bone resorption) that outplaces osteoblastic activity (new bone formation).

2.2.1. Injuries in endurance sports

In the study of von Rosen, Floström, Frohm, and Heijne (2017) on injury patterns in adolescent elite endurance athletes, they found injury incidence rates of 5.7 injuries per 1000 hours of sports in orienteering, 2.5 injuries per 1000 hours of sports in cross-country skiing, and 4.0 injuries per 1000 hours of sports in running (von Rosen, Floström, et al., 2017). Other studies have found overall injury incidence rates of 2.1/1000 hours of exposure in elite cross-country skiing aged 15-35, and in orienteering incidence rates of 18 injuries per 1000 hours of training (Ristolainen et al., 2010; von Rosen, Floström, et al., 2017; von Rosen et al., 2016). In the study of Ristolainen et al. (2010) the distribution of acute injuries and overuse injuries in cross-country skiing were highest in overuse injuries, corresponding to an injury rate of 1.35 overuse injuries per 1000 hours of exposure, while acute injuries accounted for 0.73 injuries per 1000 hours of exposure. The same tendency was shown in long-distance running with 1.01 acute injuries per 1000 hours of exposure, while overuse injuries accounted for an injury rate of 1.67 injuries per 1000 hours of exposure to sports (Ristolainen et al., 2010). Regarding injury location von Rosen, Floström, et al. (2017) reported that the majority of injuries in adolescent elite endurance sports occurred in the lower extremities; hence, in orienteering injuries in the foot (39.3%), knee (23.0%) and lower leg (13.1%) were mostly reported, in running injuries were located in the lower extremities (94.4%), the lower back (2.8%) and in the shoulder (2.8%), and in cross-country skiing injuries mostly occurred in the lower extremity (49.9%), the lower back (15.5%), in the shoulder (12.2%) and the hand (8.6%).

2.2.2. Illness in endurance sports

Soligard et al. (2015) highlighted in their study on sport injuries and illness in the Sochi 2014 Olympic Winter Games (Sochi 2014) risk of illness among elite athletes as equal to acute and chronic musculoskeletal disorders. In Sochi 2014 results showed an incidence rate of illness at 8.9 illnesses (95% CI 7.8 to 10.0) per 100 athletes. Illness prevalence in youth elite sports have shown endurance athletes exposed to a higher incidence of illness compared to technical and team sport athletes (Moseid, Myklebust, Fagerland, Clarsen, & Bahr, 2017). Steffen et al. (2016) reported from Lillehammer 2016 Youth Olympic Winter Games respiratory tract infections as the most common type of illness with 66 cases reported, corresponding to 81,5% of all illnesses reported. In the Innsbruck Winter Youth Olympic Games 2012 illness rate of 84.2 illnesses per 1000 athletes were reported, with 11% of all females and 6% of all men suffering from an illness. In both Sochi(2014) and Innsbruck (2012) illnesses in the respiratory system was most frequently reported, affected by 159 illnesses (64%) and 52 illnesses (61%) respectively. As in Lillehammer (2016) infection in respiratory tract was the most common cause of illness in both Sochi(2014) and Innsbruck (2012) with respectively 74% and 50% illnesses classified as infections (Ruedl et al., 2012; Soligard et al., 2015). In the study of von Rosen, Floström, et al. (2017) on adolescent elite endurance athletes they reported illness rate in orienteering, running and cross-country skiing as equally distributed with a prevalence of 15% in orienteering, 14% in running and 14.6% in cross-country skiing. Cold and flu was the illnesses most frequently reported in all three sports (von Rosen, Floström, et al., 2017).

2.3. Ball game sports

Handball is a sport characterized by a high playing tempo, rapid changes of movement, jumps with hard landings, frequent contact and collisions between players, as well as repetitive knee and shoulder stress (Bere et al., 2015). Studies report that knee and ankle injuries are most common locations of acute injuries in handball (Bere et al., 2015; Olsen, Myklebust, Engebretsen, & Bahr, 2006), while overuse injuries mostly occur in knee, lower leg and shoulder (Bere et al., 2015; B Clarsen et al., 2015; Myklebust, Hasslan, Bahr, & Steffen, 2013; Olsen et al., 2006). Studies also report that incidence of time-loss injuries in youth handball appears to be as high as at the senior level (Olsen et al., 2006). Soccer is one of the most popular sports in the world, and the demands of reaching and performing at top professional level is getting higher in terms of speed, physical demands, technical precision and tactical adaption (Haugaasen & Jordet, 2012). In soccer most commonly injured body parts are in the lower extremities; knee and ankle, as well as thigh (Haxhiu, Murtezani, Zahiti, Shalaj, & Sllamniku, 2015; Junge et al., 2000; Peterson et al., 2000). According to the study of Peterson et al. (2000) the majority of injuries in soccer is acute injuries, while overuse injuries varies from 9% to 34%.

2.3.1. Injury in ball game sports

Studies on injuries in adolescent ball game sports, report injury rates of 10.8 per 1000 hours of handball whereas knee and ankle accounted for half of the acute injuries. The most common acute injury type were ankle sprains, knee sprain and finger sprains. Of the reported injuries 21% were overuse injuries, lower leg pain (periostitis), low back pain, and knee pain as the most common overuse injury (Olsen et al., 2006). In adolescent soccer, Faude and Rössler (2015) reported injury rates between 2 and 7 injuries per 1000 hours of soccer. Injury rates increased in competition versus training and tended to increase with age. About three out of four injuries were acute injuries caused by a single traumatic event. The remaining injuries resulted from repetitive microtrauma, also known as overuse injuries (Faude & Rössler, 2015; Faude, Rößler, & Junge, 2013). Most injuries (60-90%) in youth soccer were located at the lower extremities with the ankle, knee, and thigh being the mostly affected. As in adult soccer, muscle-tendon injuries (strains), joint-ligament injuries (sprains), and contusions are the most common injury type in adolescent soccer (Emery, Roy, Whittaker, Nettel-Aguirre, & Van Mechelen, 2015; Faude & Rössler, 2015; Faude et al., 2013; Rosenbaum, Silvis, Williams, & Davis, 2009).

2.3.2. Illness in ball game sports

Engebretsen et al. (2013) studied injuries and illnesses in the London summer Olympic Games 2012, including some ball game sports. Athletes in soccer suffered from 76 illnesses, corresponding to 8.4% of all illnesses in the Olympic games, athletes in handball suffered from 20 illnesses, corresponding to 2.2% of all illnesses. In soccer the respiratory system was the most frequently affected system with 32 illnesses followed by the gastrointestinal system with 21 illnesses. In handball the respiratory system was the most affected with seven illnesses, as well as other non-specified systems with five illnesses. In both sports infection was the most common cause of illness, and other non-specified causes as second most common (Engebretsen et al., 2013). Gabbett et al. (2014) refer to other studies investigating illness risk on adolescent soccer players when they claim that physical training load and psychological stress both was related to illness with an odds ratio (OR) of 1.12 and 2.27 respectively, however the risk of illness was reduced when players perceived they were in better shape (OR 0.56) and even further reduced with greater social (0.66) and physical (0.62) recovery (Brink, Visscher, Coutts, & Lemmink, 2012; Gabbett et al., 2014).

2.4. Relative Energy Deficiency in Sport

Relative Energy Deficiency in Sport (RED-S) is a clinical phenomenon that refers to an inadequacy of energy to support a range of different body functions in order to achieve optimal health and performance for athletes (Mountjoy et al., 2014). It is a syndrome resulting from relative energy deficiency that affects many aspects of psychological function including, but not limited to, metabolic rate, menstrual function, bone health, immunity, protein synthesis, cardiovascular and psychological health (Mountjoy et al., 2014). Historically, RED-S is an expanded concept of the Female Athlete Triade to acknowledge a wider range of outcomes and the application to male athletes. The female athlete triad refers to the three interrelated spectrums energy availability, menstrual function and bone mineral density (Nattiv et al., 2007). An athlete’s condition moves in one direction or the other along each spectrum at a different rate according to her diet and exercise habits (Nattiv et al., 2007). RED-S include not only menstrual function and bone health as variables, but also immunological factors, endocrine factors (hormonal biomarkers), metabolic factors, hematological factors, growth/development, physiological factors, cardiovascular factors and gastrointestinal factors (see figure 1) (Mountjoy et al., 2014). The RED-S syndrome is also associated with different negative aspects on performance variables (see figure 2) such as increased injury risk, decreased training response, decreased coordination, decreased concentration, irritability and depression among others (Mountjoy et al., 2014).

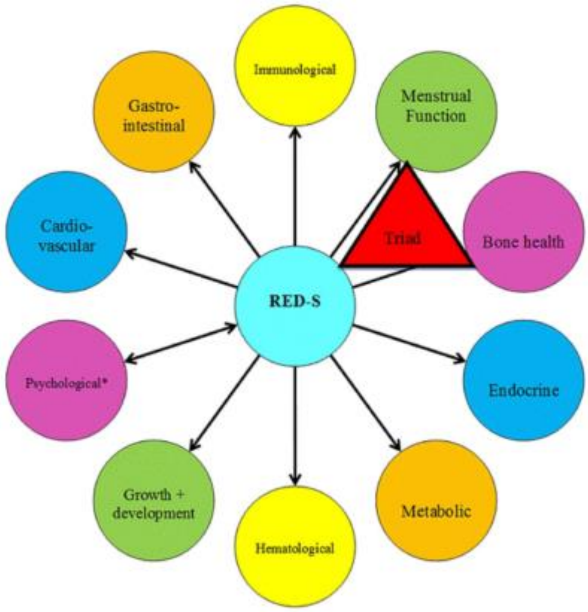

Figure 1: *Health consequences from Relative Energy Deficiency in Sports(RED-S), from Mountjoy et al. (2014) The red area is what is known as the Triad for female athletes*

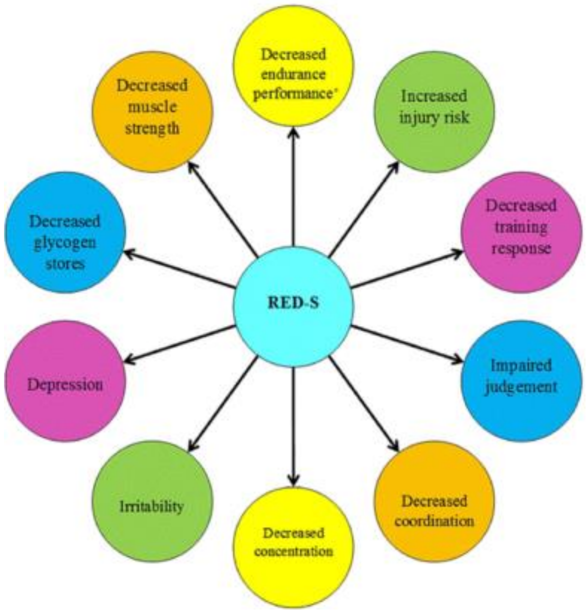

Figure 2*: Performance consequences from Relative energy Deficiency in Sports (RED-S) from Mountjoy et al. (2014)*

2.5. Risk factors for injuries and illnesses

2.5.1. Anthropometry

Anthropometry refers to the scientific study of the measurement and proportions of the human body, and its different parts (Kent, 2006). Optimization of body weight and composition may provide an elite athlete a competitive advantage in sports. In many sports low body weight and/or a low fat/muscle ratio (leanness) is important in the strive for top performance (Hagmar, Hirschberg, Berglund, & Berglund, 2008). However, the strive for leanness may also lead to negative health consequences, if chronic energy deficiency develops athletes are at risk of RED-S and the female athlete triad (Hagmar et al., 2008). As mentioned in section 2.4. athletes suffering from RED-S are associated with an increased susceptibility of injury (Mountjoy et al., 2014). Other studies examining sport injuries and risk factors have less supporting findings: Visnes and Bahr (2013) stated that body composition did not appear to be a risk factor for injury for young athletes, as no trend of increased body mass or higher skinfold were associated with injury risk. In the study by Kemper et al. (2015) they found that both increase (p=0.03) and decrease (p=0.06) in body mass index (BMI**)** value were associated with higher risk of injury, as well as low percentage of fat were associated with higher risk of injury (p=0.01) in elite youth soccer players. Furthermore Ezzat, Schneeberg, Koehoorn, and Emery (2016) revealed that overweight and obese youth did not have increased odds of sport injury.

2.5.2. Bone health

Participating in sports can have a positive effect on bone mass (Andreoli et al., 2001). According to Wolfes law bone will respond over time to the stress it is affected by (Scofield & Hecht, 2012). Weight-bearing activity stimulates osteoclasts and osteoblast in bone modelling and remodeling of existing bone during childhood and adolescence, in addition weight-bearing activity increases BMD (Ackerman et al., 2015; Scofield & Hecht, 2012). Consequences of poor bone health may be stress fractures and osteoporosis, stress fractures occur when the osteoclastic activity (bone resorption) outpaces osteoblastic activity due to normal remodeling is interrupted by an increased training load (Scofield & Hecht, 2012). BMD is one aspect of bone health, Nattiv et al. (2007) refer to BMD as classifications that shifts in a continuum from optimal bone health to low bone health (Z-score between -1.0 and -2.0) and to osteoporosis ($\leq$ -2.0) (Nattiv et al., 2007). Osteoporosis occur due to the lack of weight-bearing activity, often seen in swimming and cycling, athletes in these sports are at an increased susceptibility for low BMD (Scofield & Hecht, 2012).

2.5.3. Performance variables

Minimal research has been conducted on the relationship between aerobic fitness, defined as VO_{2max}, and injury risk, making the true relationship between aerobic fitness and injury risk less clear (Watson et al., 2017b). Criteria's for reaching VO_{2max} are that VO_2 reaches a plateau despite increases in workload. In the study of Watson et al. (2017b) on collegiate soccer players they reported preseason VO_{2max} as an independent predictor of in-season injury. Players who experienced an injury during the season had a significantly lower preseason VO_{2max} than players who were not injured during the season. With regard to illness similar findings were revealed, Andrew Watson et al. (2017a) reported preseason VO_{2max} in female youth athletes as a significant predictor for the number of illnesses during a season; an increase of VO_{2max} was associated with a decreased risk of illness. However, little research on the relationship between aerobic fitness and illness risk in athletes exists (Andrew Watson et al., 2017a). Regarding reaction time and injuries previous research have shown that injured players in soccer had a slower reaction time compared with uninjured players after a 12-minute soccer-specific run test (Dvorak et al., 2000). Despite this, little research exist on reaction time as a risk factor for injury.

2.5.4. Energy availability

Nattiv et al. (2007) refer to EA as a continuum from optimal EA to low EA with or without an eating disorder. EA is defined as dietary intake (EI) in kcal/day or kJ/day minus exercise energy expenditure (EEE) normalized to fat-free mass (FFM) and can mathematically be calculated as: EA=(EI-EEE)/FFM (Nattiv et al., 2007). EA can be understood as the amount of energy that remains for physiological processes after deducting the energy cost of exercise (Koehler et al., 2016). In the ACSM position stand on the female athlete triad they stated that low EA can have negative health consequences (Nattiv et al., 2007). Following up Mountjoy et al. (2014) stating that athlete's suffering from long-term low EA may develop nutrient deficiencies, chronic fatigue and increased risk of infections and illness. A previous study reported more specific that chronic energy deficiency in combination with intense physical exercise set athletes at a higher risk of upper-respiratory tract infections (Hagmar et al., 2008).

2.5.5. Sleeping time

Sleep is an essential part of recovery after being active in sports (Nédélec et al., 2013). Studies have reported sleep time as an important factor contributing to maintaining energy balance (Benedict et al., 2011; Penev, 2012; St-Onge, 2013), however, the role of sleep in energy expenditure (EE) and thereby EA, RED-S and ultimately increased risk of injury and illness are uncertain. In the study of von Rosen, Frohm, Kottorp, Fridén, et al. (2017) they found an increase in training load, training intensity and at the same time decreased volume of sleep significantly corresponding to an increased risk of injury compared to athletes with no change in these variables. von Rosen, Frohm, Kottorp, Friden, and Heijne (2017) added to the understanding that sleeping more than eight hours during weekdays and having a healthy diet could reduce the odds of sustaining new injuries among adolescent elite athletes.

3. Materials and methods

3.1. Design and recruitment

The study design in this master thesis is cross-sectional, designed to measure the prevalence of injuries and illnesses in youth sports as well as examination of selected risk factors for injury and illnesses. A total of 36 students were recruited from high schools as part of an on-going PhD project at the University of Agder during the autumn 2017 (see Figure 3).

3.2. Subjects

The subjects in this study were recruited from high schools in the south of Norway with a study program of sport within three hours' drive to the laboratory, primarily Sirdal high school (n=10), Setesdal high school, department Hovden (n=8), Akademiet (n=3) and Kristiansand

Katedralskole Gimle (KKG) (n=15). The subjects were divided in two groups, endurance sports (n=24) and ball game sports (n=12). The endurance group consisted of athletes in cross country skiing (n=12), biathlon (n=8), orienteering (n=3) and triathlon (n=1). The group consisting of ball game sports includes athletes in soccer (n=9) and handball (n=3).

3.2.1. Criteria for inclusion/exclusion of subjects

The inclusion criteria were:

- Student at first year on high school with sport education line
- Regularly competing in an endurance or ball game sport at regional and/or national level
- Absence of illnesses or injuries that prevent participation in the project

No subjects were excluded due to illnesses or injuries before data collection started. Two subjects were excluded from the analysis due to not completing the Oslo Sports Trauma Research Center questionnaire on Health problems (OSTRC-H) questionnaire. Four subjects were excluded from the logistic regression analysis due to missing data (see figure 3).

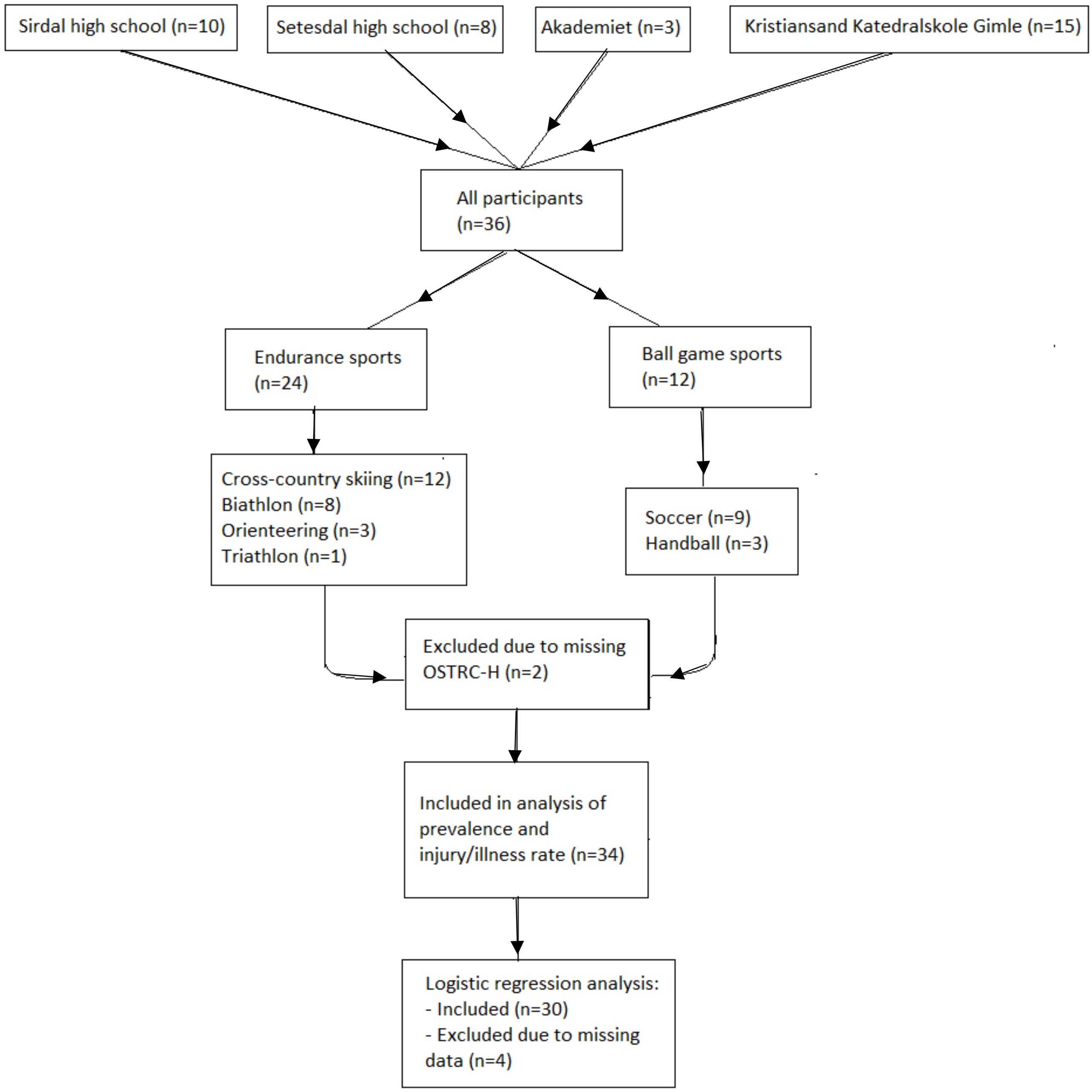

***Figure 3**: Flowchart of recruitment and inclusion. Two subjects were excluded due to not fulfilling OSTRC-H and Four subjects were excluded from logistic regression analysis due to missing data. A total of 34 subjects were included in analysis of prevalence of injury*

3.3. Data collection procedure and measurements

All testing was performed at the University campus, subjects studying at KKG and Akademiet were tested on two non-consecutive days while subjects studying at the high schools of Sirdal and Setesdal completed all testing on one day. Due to travel, the subjects from Sirdal and Setesdal arrived at campus the day before testing and stayed at campus overnight. Training was further restricted to a maximum of 60 minutes of low intensity the day before. The following morning a researcher wakened the subjects in a specific order to test resting metabolic rate

(RMR). The test were performed in a fasting state and were estimated to last approximately 40 minutes according to protocol of Compher, Frankenfield, Keim, Roth-Yousey, and Group (2006). After initial testing (se figure 4 for test procedure) the subjects were interviewed about their diet habits the past seven days and asked to fulfill the questionnaires that was handed to them. Subjects were instructed to eat and drink in order to get ready for testing maximal oxygen uptake (VO_{2max}), the test were performed at minimum three hours after they were allowed to eat and drink. After testing VO_{2max} the subjects from Sirdal and Setesdal had finished full test procedure. The subjects from KKG and Akademiet had been handed over questionnaires, as well as a heart rate monitor and sensor from Polar (M400) and an activity tracker from Sensewear (BodyMedia, Inc., Pittsburgh, PA, 175 USA) at least seven days before testing physical characteristics. They were told to use the activity tracker continues from 00.00 a.m. on the first day to 00.00 p.m. on the last day in order to record activities such as sleeping, sitting and walking. Further they were instructed to take off the activity tracker during training sessions and to only wear the polar equipment. Subjects from KKG and Akademiet met at the University campus at an arranged time for testing physical characteristics (day 1 in test procedure, se figure 5), they were instructed to travel to the lab using only motorized transportation, and under no circumstances were allowed to walk or ride a bicycle. Subjects arrived the laboratory in a fasting state according to protocol of RMR between 6 and 8 a.m. (Compher et al., 2006). After testing physical characteristics, the subjects were interviewed about their diet habits the past seven days and handed in the activity tracker, the polar equipment and the fulfilled questionnaires. They met to test VO_{2max} later that day or one of the following 2-3 days.

Test procedure

Start App. 06:00 a.m.	Measurement of height and weight, and 30 min. RMR-test	DXA scan	Blood pressure	Work Efficiency	Reaction time	Maximum strength/ Power	Diet- intervie questio

➡	VO_{2max}	Maximum strength/ power

***Figure 4**: Test procedure for Sirdal and Setesdal high school in the phd-project. Only tests highlighted in blue were used in this master thesis*

Day 1: 06:00 a.m. – 12:00 a.m. (2,5 hours per participant)

➡	Measurement of height and weight, and 30 min. RMR-test	DXA scan	Blood pressure	Work Efficiency	Reaction time	Maximum strength/ Power	Die and que

Day 2: 12:00 a.m. – 05:00 p.m. (0,5 hours per participant)

Height and weight measurement	VO_{2max}	Maximum strength/ power

Figure 5*: Test procedure for KKG and Akademiet in the phd-project. Only tests highlighted in blue were used in this master thesis.*

3.4. Anthropometry and body composition

Body weight was measured in light clothing to the nearest 0.1 kg using a Seca weight scale (Seca 1; model 861, Germany). Height was measured to the nearest 0.1 cm using a wall-affixed centimeter scale (Seca Optimera, Seca, UK), and was done without shoes. BMI, i.e. weight in kilos divided by height squared in m^2 (kg/m^2). Body composition and bone mineral density (BMD) were measured using dual-energy X-ray absorptiometry (DXA; GE-Lunar Prodigy, Madison, WI, USA) at the University lab by a trained technician.

The test was performed immediately after the RMR test. During the DXA test no jewelry or other ornaments were allowed to be worn, and the standardized protocol of Nana, Slater, Hopkins, and Burke (2012b) were used; subjects were instructed to lie in a supine position centrally aligned in the scanning area, their feet and legs were placed in a natural position and kept straight. Similarly, subjects' hands were placed in a natural position alongside, slightly away from the body with palms kept in a midprone position with thumbs pointing upwards. The DXA scanned the subjects from head to toe. DXA determines bone mineral content (BMC), Fat-Free Mass (FFM) and BMD at femur neck, total hip, lumbar spine (L1-L4), and total body. To compare BMD values BMD was examined as BMD Z-scores, which express BMD values relative to a reference population matched for age, height, weight and ethnicity (Nichols & Rauh, 2011). BMD was classified in the subjects as recommended in previous statements of athletes (Mountjoy et al., 2014; Nattiv et al., 2007), as:

- Normal BMD: Z-score of higher than -1 in the measured area.
- Low BMD: Z-score between -1 to -2 in at least one area measured.
- Osteoporosis: Z-score of -2 or lower in at least one area measured.

3.5. Questionnaire and diet interview

OSTRC-H

The Oslo Sports Trauma Research Center questionnaire on Health problems (OSTRC-H) is a validated method for registering injury and illnesses among Norwegian athletes participating in 2012 Olympic and Paralympic games (Benjamin Clarsen et al., 2014), while the translated version used in this thesis is not validated. Nevertheless, attempts were made to ensure the reliability and validity of the translation in a pilot study, the questionnaire were sent to four same aged peers. The peers were instructed to fulfill the questionnaire, register the time they used to complete the questionnaire and to give feedback whether they had any questions regarding the questionnaire (se section 4.3 for further information). In addition to the questions in OSTRC-H, questions about illness- and injury registration, i.e. which type of illness they had experienced and in which body part the injury they had experienced occurred were added. The subjects should also register days of absence due to injury or illness. After injury- and illness registration the questionnaire asked if the subjects had done preventive measures to prevent new injury in the same body part or to prevent similar disease (see Appendix 1).

Diet interview

The test personnel were trained and instructed in how to perform diet interviews in an ethical and safe manner. To secure reliable and valid results it was important to get the interviews standardized and to be objective during the interview, including ensuring that there was no right or wrong answers. The test personnel should strive to create a safe environment for the subjects, the interview took place in a closed room with only the interviewer and the subject present. The interviewer followed an interview protocol (see Appendix 2) trying to get the subject to recall the intake of food and beverages during the last seven days. To calculate the amount of food and beverages, the test personnel had prepared meals and taken three pictures with three specific weight classes, i.e. small, medium, big, before the interview. All food and beverages were weighed on the same type and model of kitchen scale and placed on a neutral plate of the same size. The size of the portions used in this project were according to the recommendations of Ygil (2013). The subjects were not aware of the weight of the food on the plate and could choose unaffected between the three pictures. The same protocol was used for beverages. After the interview the researcher logged the food and beverage intake with the food registration software Dietist Net (Dietist Net, Kost och Näringsdata, Bromma, Sweden). Dietist Net has access to the Norwegian food table (Matvaretabellen 2014), an open Norwegian nutritional information database (MILLUM PDB) and the U.S national nutrient database (US department of Agriculture).

3.6. Energy availability and exercise energy expenditure

EA was calculated as EA=(EI-EEE)/FFM as outlined in section 2.5.4. EI was calculated from retrospective food records described in section 3.5; Diet interview. EEE for each individual training session was estimated by using exercise training logs and heart rate (HR) sensor combined with HR monitor. HR was classified to specific HR zone described by Seiler and Tonnessen (2009) as the sum of the time spent in each HR zone. EA was calculated using the EI and EEE determined within the same 7-day period and FFM was determined by DXA.

Subjects activity level was monitored using Sensewear multi-sensor (BodyMedia, Inc., Pittsburgh, PA, 175 USA.) which includes accelerometer, the monitor was worn on the right arm according to protocol of Berntsen et al. (2008). Data from the Sensewear monitor were downloaded to a computer with software; Bodymedia 8.2 (BodyMedia, Inc., Pittsburgh, PA, 175 USA) developed by the manufacturer.

3.7. Performance variables

3.7.1. Reaction time

Reaction time was measured using a portable computer with the Musclelab (version 8.31)-program installed. Musclelab measures the subjects reaction time, by measuring the time the subjects use to press keyboard SPACE bar when visual stimulus changes on the computer screen. Before the test, subjects had to register dominant side and could choose which side to test (which hand to use), they could also choose to use both hands. The subjects were instructed how to test and had one try on test protocol for familiarization. After instruction and one try on test protocol the test began, each subject performed three reaction trials. The shortest reaction time of the three trials was used in the statistical analysis.

3.7.2. Maximal oxygen uptake

Subjects from Akademiet and KKG met at the arranged time on day 2 for their VO_{2max}-test while subjects from Sirdal high school and Setesdal high school tested VO_{2max} at the end of day 1. Before the test, the subjects warmed up on the treadmill and was informed about the test procedure. The test was performed on a Lode Katana Sport treadmill (Lode B.V., Groningen, The Netherlands). In the protocol used, the subjects started at 9 km/h with a constant positive incline of 6 degrees (corresponding to 10,5% incline). The speed was increased by 1km/h/min until voluntary exhaustion.

VO_{2max} was measured using Metamax (Metamax 3B, CORTEX Biophysik GmbH, Walter-Köhn-Str. 2d, 04356 Leipzig, Germany)). The Metamax is a portable metabolic measurement system and provides respiratory values breath by breath. During the entire test, the subjects breathed through a Hans Rudolph breathing mask (Hans Rudolph, Kansas, MO, USA) that was carefully placed over the mouth and nose, and held in place with a head cap. Before the test, the breathing mask was checked for leakage by inhaling and exhaling against resistance. The Metamax ventilation- and gas analyzer was calibrated every second subject tested, and both turbine flow meter and gas sensor was changed at the same time. I addition to the standardized calibration every second object the Metamax was calibrated if ambient conditions changed in the laboratory. The Metamax ventilation meter was calibrated using a three-litre mechanical pump (Cortex Biophysik GmbH, Model: M9474-C, Medikro OY, Kellolahdentie 27, Kuopio, Finland), and gas-calibration was performed with ambient air and known gas mixture (Co_2; 4% O_2; 16%). HR was measured using Polar H10 (Polar Elektro Oy, Kempele, Finland). Capillary blood samples were taken after 30 seconds, but before 1 minute after the test was finished and analyzed for whole blood using a stationary lactate analyzer (EKF BIOSEN, EKF diagnostic, Cardiff, UK). VO_{2max} was calculated as the average of the two highest 30-sec consecutive VO_2 measurements. Plateau of VO_2 curve and/or HR $\geq$95% of known HRmax, RER $\geq$1.10 and [la-] $\geq$8.0 $mMol.L^{-1}$ were used as a criteria for the attainment of VO_{2max}. If the subjects did not reach a Vo_2 plateau, the test was classified as a VO_{2peak}-test, showing the highest possibly VO_2 the subject could attain on that day, and not the true maximal VO_2 level.

3.8.Ethical considerations

This project was performed with participants written informed consent (see appendix 3). Before inclusion, all participants were informed orally and in writing of all study procedures explaining that the study involved fasting before testing, measurement of body composition, and testing to exhaustion, all of which could cause some discomfort. Permission to undertake this study was provided by the ethics committee at the faculty of health and sports science at the university in Agder (21.08.2017). All information about the participants were anonymized and stored in a safe-deposit box. After testing ended and data was analyzed subjects received information about their result on variables tested, information was provided in a thoughtful and gentle form. If some of the findings were either higher or lower than population-based reference values, the subjects were advised to contact medical personal for a follow up.

3.9.Statistical analysis

All data were statistically analyzed using SPSS (SPSS for Windows, v. 24; SPSS Inc, Chicago, USA) and graphs designed using GraphPad Prism 7 for Windows version 7.04 (GraphPad Software, Inc., LA Jolla California USA). The dataset was checked for missing data and non-normality before statistical tests were performed. Normal distributed data are presented as mean and standard deviation. Non-normal distributed data are presented as median and interquartile range (25-75). The participants were divided by type of sports, endurance sports group and ball game sports group. When comparison differences between these two groups, an independent sample t-test was used for comparison of means in normally disturbed data, and Mann Whitney U-test was used for comparison of medians of data not normal distributed. *P*-value was assessed when checking for correlation between variables in each group. *P*-value of $p<0.05$ was considered significant when checking for correlation. When exploring injury and illness rate 95% CI for mean was calculated, i.e. total amount of injuries and illnesses divided by participants. To identify possible associations between injury and selected risk factors a logistic regression analysis were used, the same analysis were used when analyzing associations between illness and selected risk factors. The regression analysis was performed in all cases and not differentiated on type of sports due to the group sizes and the low participation in general. Hours of training were removed from the analysis due to missing data and the ability to perform valid analysis. *P*-value were used to assess whether there was an association between injury or illness and the risk factors tested. A significance level of $p \leq 0.01$ was used in the logistic regression analysis in order to not draw false conclusions based on false significant levels.

4. Method discussion

4.1. Design

This study uses a cross-sectional design, a design that is often used in retrospective studies and is appropriate for describing phenomenon at a fixed point. In cross-sectional studies data is collected at one point in time, or multiple times in a short time period (Levin, 2006; Polit & Beck, 2014). Cross-sectional studies are usually conducted to estimate the prevalence of the outcome of interest for a given population, often for the purposes of public health planning (Levin, 2006). In addition to this, data can also be collected on individual characteristics, including exposure to risk factors, alongside information about the outcome. Thereby, cross-sectional studies gives a “summary of status” on outcome and characteristics associated with it, at a specific point in time (Levin, 2006). Accordingly, due to the aim of this thesis this type of study design seemed to be a suitable method for investigating the research questions. Cross-sectional design is limited in that it only measures outcome and exposure at the given time of the study. The situation may provide differing results if another timeframe had been chosen. As a result, it is not possible to identify whether anthropometry, bone health, performance, energy availability or sleeping time is responsible for the observed effects.

4.2.Study sample

Study sample consisted of first year students at high schools in the southern Norway with a study program of sports. Altogether 36 students belonging to a various set of sports categorized into two categories, endurance sports and ball game sports, were included in the study (see figure 3). Two participants were excluded from the analysis due to not completing the OSTRC-H questionnaire. The low number of participants and the different numbers of participants in each group (endurance, n=24 and ball, n=10), made it difficult to gain statistical power and detect true differences (Thomas & Nelson, 1996). Although the study sample was appropriate to investigate the aim of this study, it was far too low number of participants to conduct a study with statistical power. The low number and different number of participants in each sub-group in this study make it difficult to generalize the findings, the findings can only be considered as tendencies. More studies are needed, and a higher number of participants is probably required to find true statistical significance.

4.3. Measurement

4.3.1. Anthropometry and body composition

The same weight and height scale were used to measure height and bodyweight for all subjects, and the same researcher assessed all cases to ensure similar measurement and procedure for testing. DXA were used to assess body composition and bone health, DXA is an objective method that is painless, very accurate and widely used for assessing BMD and risk of osteoporosis (Nana, Slater, Stewart, & Burke, 2015). It is considered the “gold standard” for measuring bone mass (Kleerekoper, 1998). The DXA delivers a two-dimensional picture (g/cm^2) of the site scanned, rather than volumetric density (g/cm^3), and therefore DXA determines bone mineral content (BMC) of the scanned area and divides this by area. An experienced technician performed all scans and analysis to minimize the possibility of error, however hydration status was not accounted for and this may affect body composition and analysis (Horber, Thomi, Casez, Fonteille, & Jaeger, 1992; Nana, Slater, Hopkins, & Burke, 2012a; Nana et al., 2015).

4.3.2. Questionnaire and diet interview

In this thesis a translated version of the OSTRC-H with an added part of questions aiming to identify illness type and/or location of injury were used. Although OSTRC-H is a validated questionnaire there are several methodological weaknesses related to using the questionnaire in this thesis. It should also be noted that the English version of OSTRC-H is only validated in adult elite athletes (Benjamin Clarsen et al., 2014). In general, using self-reported methods depend on the participants compliance with the method, the accuracy in validating and diagnosing the injury and illness, and the definition of injury/illness. Contrary, the strength of using self-reported methods is that the participants do not need to depend on medical staff to record an injury, it is both time and cost-saving. Even minor injuries are likely to be reported (von Rosen et al., 2016).

Methodological weaknesses specific to this thesis are the use of a non-validated translated version of OSTRC-H, as well as the non-validation in adolescent elite athletes. When noticeable changes to an established method are made it is important to validate the new method in order to have confidence in the data produced (Tanner & Gore, 2012). A thorough pilot study to validate the translated version or use of another questionnaire could be appropriate in this case. Especially when considering that the researcher added a part of questions to identify injury and/or illness, a thorough pilot study should have been made. Due to little time to go through with a thorough pilot study this was not done, however an attempt to ensure the reliability and validity of the questionnaire was made. The questionnaire was sent to four same aged peers. The peers used from four to ten minutes to fulfill the questionnaire. The feedback from the peers in the pilot study was that the questionnaire was easy to understand, however in two of the cases the answers in question 1 and 4 were inconsistent. In question 1 they answered alternative 3 "*Reduced participation due to injury/illness*", and in question 4 they answered alternative 1 "*No symptoms/health complaints*". To avoid this problem the main focus of question 4 was underlined; *To what extent <u>have you experienced</u> symptoms/health complaints during the past 6 months*. In addition, examples of symptoms on both injury and illnesses were added. If the subjects answered one of the alternatives with injury/illness in question 1 and/or one of the alternatives with symptoms/health complaints in question 4 they were asked to continue the registration on the next pages. The next pages in the questionnaire continued by asking them about illness- and injury registration, i.e. which type of illness they had experienced and in which body part the injury they had experienced occurred. The subjects should also register days of absence due to injury or illness. After injury- and illness registration the questionnaire asked if the subjects had done preventive measures to prevent new injury in the same body part or to prevent similar disease (see Appendix 1). The pilot study resulted in a minor change to the questionnaire before it was sent to the participants. Ideally, a new pilot study should have been made before starting data collection.

Diet interview

The aim of the semi-structured dietary interview was to assess habitual dietary pattern and to estimate energy intake. A seven-days recall interview was chosen over daily food and beverage logging, were the subjects would have had to weigh and log their daily intake, as a compromise between the high schools for them to provide the project with subjects. Daily logging of food and beverages were preferred, but due to concern from the high schools based on past experiences with this method it was decided to interview the subjects. Although individual logging is associated with less bias than recall interview, ethical aspects as the stressful situation regarding food weighing and intake, performance, and the strive for the ideal body image, made recall interview preferred in this case. For many people talking about their dietary habits as well can be very intimidating, especially when they are faced by health professionals. It is important that the interviewer manage to create a comfortable environment where the subject feels important and that he/she can be 100% honest. Another limitation with this method is if the subject has difficulties in remembering. According to the interview guide the subjects should be given some time to think back, but we have no guarantee that this will provide valid data. The amount of food registered for each individual athlete can differ from the reality. Pictures with prepared meals may be an appropriate instrument in the registration, but the possibility of covering all types of meal or the correct kilogram for one portion in every case is limited. In the cases of interviewing subjects from the high schools of Sirdal and Setesdal, the researchers had received dinner menus from dorm room chef in order to minimize recall bias.

4.3.3. Energy availability and exercise energy expenditure

The Sensewear armband provided data of energy expenditure through the seven days of registration, when calculating EA the formula EA=(EI-EEE)/FFM was used. Although this is a recognized formula for calculating EA the research of Melin (2015) provides a more precise estimate of the true EEE by subtracting both RMR and non-exercise activity thermogenesis (NEAT) from the EEE. The formula used by Melin (2015) is as follows: EA=(EI – (EEE – (DEE – EEE))/FFM), where DEE is daily energy expenditure. This formula in calculating EA could lower the risk of over-reporting reduced EA in this thesis, however the significance of this uncertainty in calculation is unknown. Another possible bias in calculating the true EA is the amount of EI reported in the diet interview, se section 4.3.2. for further discussion.

4.3.4. Performance variables

Performance variables in this thesis was reaction time and VO_{2max}, both tests are considered being objective and used in previous research among athletes (Tornberg et al., 2017; Vikmoen, Ronnestad, Ellefsen, & Raastad, 2017). The shortest reaction time of three trials was used in the analysis, it is unknown if the shortest reaction time is representative for the subjects and it can be argued that an average of the three trials would provide a more valid result. Testing of VO_{2max} followed a standard test protocol (se section 3.8.2.) to minimize risk of risk of error and to secure similar test conditions for each subject. The Metamax measured ventilated volume (VE) and volume percentage oxygen in expressed air ($O_{2\%}$). Studies have shown the Metamax to slightly overestimate VO_2, particularly at maximal exercise (Overstreet, Bassett, Crouter, Rider, & Parr, 2017) which leads to uncertainty of the subjects real VO_{2max}.

4.4. Strength and limitations

This thesis is a cross-sectional study aiming to find significant factors associated with increased risk of athletes' injury and illness. The main strength of this study was the use of well-established and objective measuring methods; DXA, Sensewear and VO_{2max} are acknowledge methods widely used in both research and elite sports, e.g. Koehler et al. (2016), Vikmoen et al. (2017), Nana, Slater, Hopkins, and Burke (2013), Barrack et al. (2014), Ackerman et al. (2015), Reeve, Pumpa, and Ball (2014) and Berntsen et al. (2008) to mention some studies. Furthermore, was the strength increased by using the same research team with assigned responsibility for testing, the same equipment, the same test leader and technician during the whole registration period.

There are several limitations in this study. The main limitation is probably the small sample size used to investigate the research questions. Correlation studies are usually recommended to have participant numbers in the hundreds (Knudson & Lindsey, 2014; Pyne & Hopkins, 2012), in this study results from only a total of 30 participants took part in the logistic regression analysis and thereby providing weak statistical power to detect real differences. Even if the 10-participants rule of Maxwell (2004), which suggests $N=10$ for each predictor or variable tested, is applied in this study, it would take at least 100 participants due to all the risk factors tested to increase the statistical power (Knudson & Lindsey, 2014). Due to the small sample size and all variables tested an *p*-level of 0.01 was set to avoid making a type I error. Type I error is to reject the null-hypothesis even if it is true, and thereby stating a false negative, however this could further lead to an increased risk of making a type II error (Knudson & Lindsey, 2014). Type II error occur when a non-significant correlation is rejected even if it is significant in the population (Knudson & Lindsey, 2014).

Other major limitations in this study were the cross-sectional design and no control group included. Cross-sectional design measures the outcome and exposure at the given time, the situation may provide differing result if another timeframe had been chosen and therefore making it impossible to infer causality (Levin, 2006). Nevertheless, cross-sectional designs may provide indications of association between risk factor and injury or illness and are therefore useful in generating hypothesis for future research. If two or more registration periods with the same sample had been carried out, as a longitudinal study, the situation of prevalence and risk factors is monitored over time, and this information could be used in development of new preventive measures. If only a control group had been added to the study this would mean a stronger indication, but in the reality no more causality. To make causal inferences a randomized control trial (RCT) with injury and illness registration, as well as monitoring risk factors over a time period should have to be done (Levin, 2007). Lastly, a limitation in this study was that other variables such as training hours, muscle strength, training versus competition, acute injury versus overuse injury, injury severity, opponent, clothing, warm-up program were not analyzed. These variables were not included due to the method used in this study combined with missing data and limited time to data collection, and analysis as well as write the thesis.

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Part II:

Paper

Prevalence and associations of injury and illness among high school elite sport-students in the south of Norway

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Prevalence and associations of injury and illness among high school elite sport-students in the south of Norway

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Running head: Injury and illness among high school elite sport-students

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Abstract

Youth participating in sports are often associated with a healthy lifestyle, however illness and injuries are frequently reported in sports. The aims for this study was; (1) to examine the prevalence of sport injuries and illnesses among elite sport students at high school with regard to sports group and (2) to examine anthropometry, bone health, performance variables, energy availability and sleep time with associations to sport injuries and illness prevalence in the same sample.

Thirty-six high school elite sport students, endurance athletes (n=24) and ball game athletes (n=12) [age: 16.3±0.2 years presented as mean and standard deviation if normal distributed; Body mass index (BMI): 20.8±1.8 kg/m^2; body fat: 15.8% (10.7-24.7%) presented as median and interquartile rage if non-normal distributed; Fat-free mass (FFM): 15.41 kg (47.7-60.6 kg)] were recruited. Test protocol included assessment of anthropometry, body composition, performance variables, energy availability, restitution, injuries and illnesses retrospective registration for the past six months. A total of 34 subjects were included in the analysis.

Sixteen subjects experienced a total of 30 injuries (injury rate 0.88, 95% confidence interval (CI) 0.47–1.29). Twenty-eight subjects were exposed to a total of 78 illnesses (illness rate 2.29, 95% CI 1.66 to 2.93). No risk factors associated significantly with injury or illness.

Prevalence of injury were higher in ball game sports versus endurance sports, while endurance sports had highest prevalence of illness. Neither anthropometry, bone health, performance variables, energy availability or sleep time were found associated with prevalence of injury or illness in this sample of participants.

Keywords

Adolescent, athlete health, bone health, energy deficiency, VO_{2max}*, reaction time, sleep*

Introduction

Illness and injuries occasionally occur in sport; the nature of sports probably never allows to completely deal with sport injuries. Studies have shown incidence of injuries to increase suddenly from 14 years of age to the age of 16, and youth in sports are at a high risk for overuse injuries, because of a high volume of training, intensity, and the adolescent growth spurt (1, 2).

In Norway, high school students choose a study program according to their area of interest, e.g., sport. Students who choose sports programs participate in more training hours and competition and may thereby be at a higher risk of sport injuries and illnesses than their peers. Illness and injuries may be a limiting factor in development of young athletes, in worst cases could an injury be the cause of an athletes' possibility to be physically active for the rest of one's life, due to the injury severity (3). Early specialization, increased training intensity, increased training load, competence-based self-esteem, decreased sleeping volume, psychological stress and age are some risk factors for sport injuries and illnesses found in the literature (4, 5).

Furthermore, Mountjoy, Sundgot-Borgen (6) also add RED-S (Relative Energy Deficiency in Sport) as a potential factor for injury and illnesses (7). RED-S is a clinical phenomenon that refers to an inadequacy of energy to support a range of different physiological body functions in order to achieve optimal health and performance for athletes (6). RED-S is an expanded concept of the Female Athlete Triade to acknowledge a wider range of outcomes and the application to male athletes (6). Energy deficiency, disordered eating and exercise addiction are factors that possibly can contribute to athletes developing RED-S. Energy deficiency or low energy availability (EA) refer to the balance between dietary intake and energy expenditure required for health and activities for daily living, growth and sporting activities (6). Although RED-S is a syndrome thought to be a predictor for sport injuries and illnesses (7), further research is needed on the prevalence of RED-S and the association with sport injuries and illnesses among young high school students (7).

Low EA appears to occur in weight sensitive sports due to the importance of leanness and/or weight in their role of performance (6). Kemper, van der Sluis (8) showed low percentage of fat in youth elite soccer players to associate with increased risk of injury. Despite the supposed relationship between anthropometry and risk of injury is apparent, research is both divergent and lacking (8). Low EA is also recognized as an independent factor of poor bone health (6). Poor bone health as well, is associated with increased risk of stress fractures and osteoporosis.

This association however, is less investigated in youth sports and the relationship is to some degree uncertain (6, 9).

The competitive demands for youth in elite-sports are typically higher due to the specialization and given pressure for successful performance during games, matches, meets or tournaments (10). Although studies have found significant associations to injury and illness with the performance variables maximal oxygen uptake (VO_{2max}) and reaction time, little research has been conducted on the relationship between these variables and injuries and illnesses in youth elite sports (11-13). Studies have also reported decreased sleep time as a factor contributing to a higher risk of injury and illness, as well as an important factor in maintaining energy balance (4, 5, 14). Therefore, it is important to investigate the contribution of sleep time as a risk factor for injury and illness by itself and as a part of EA.

The aim of this study was therefore twofold; 1. to examine the prevalence of sport injuries and illnesses among elite sport students at high school with regard to sport group and 2. to examine anthropometry, bone health, performance variables, energy availability and sleep time with associations to sport injuries and illness prevalence in the same sample.

Materials and methods

Subjects

Thirty-six subjects were recruited from high schools in the south of Norway with a study program of sport, primarily Sirdal high school (n=10), Setesdal high school, department Hovden (n=8), Akademiet (n=3) and Kristiansand Katedralskole Gimle (KKG) (n=15). The subjects were divided in two groups, endurance sports (n=24) and ball game sports (n=12). The endurance group consisted of athletes in cross country skiing (n=12), biathlon (n=8), orienteering (n=3) and triathlon (n=1). The group consisting of ball game sports includes athletes in soccer (n=9) and handball (n=3). Inclusion criteria were: student at first year on high school with sport education line, regularly competing in an endurance or ball game sport at regional and/or national level, absence of illnesses or injuries that prevent participation in the project. No subjects were excluded due to illnesses or injuries before data sampling, for exclusion and drop-outs see Figure 1. A total of 34 subjects were included in the examination of prevalence of sport injuries and illnesses, and a total of 30 subjects were included in the final analysis in this study. The study was approved by the University Faculty Ethics Committee

(FEK) at the University in Agder. All subjects signed a written informed consent before study participation.

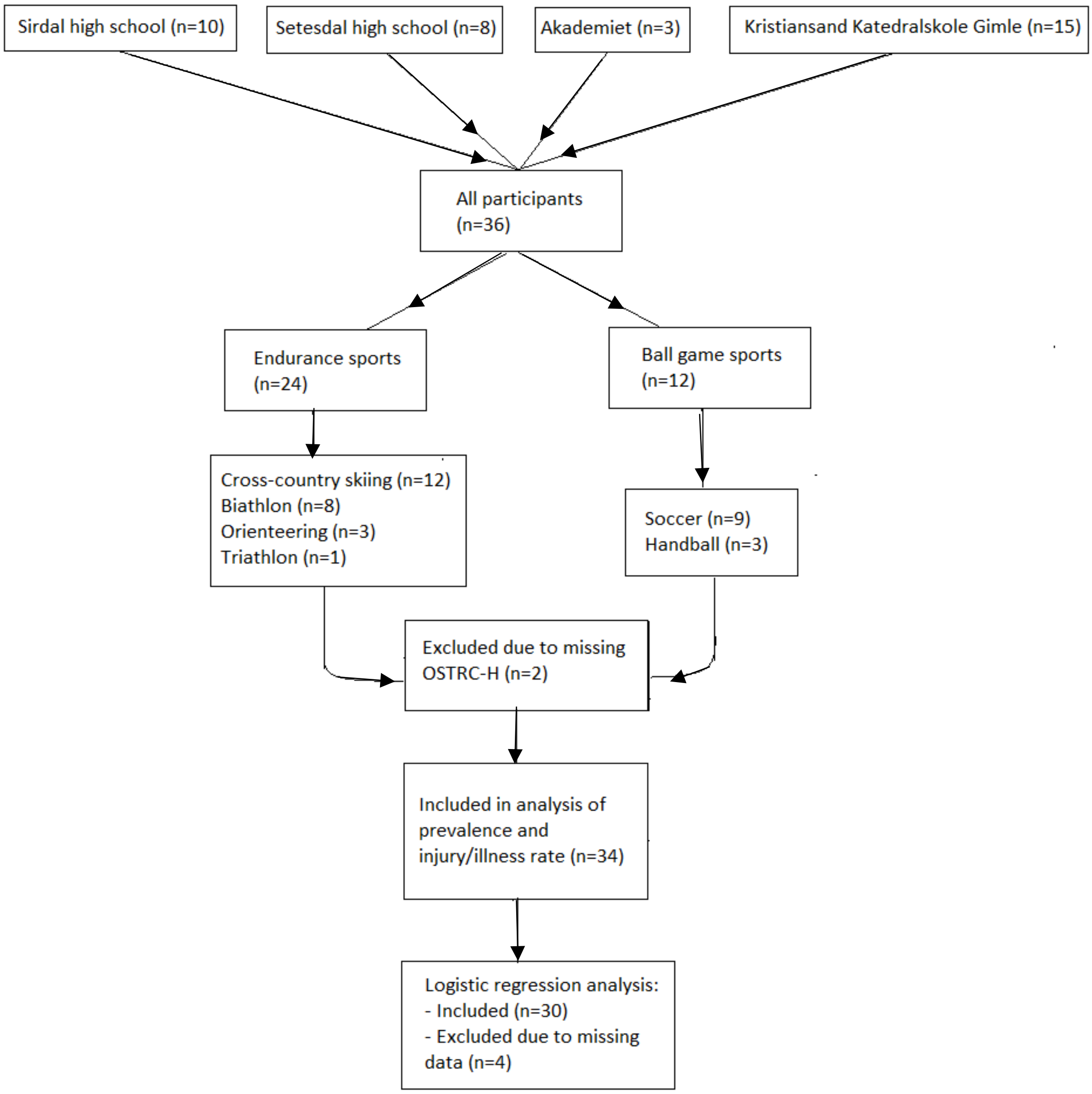

***Figure 6**: Flowchart of recruitment and inclusion. Two subjects were excluded due to not fulfilling OSTRC-H and 4 subjects were excluded from logistic regression analysis due to missing data. A total of 34 subjects were included in analysis of prevalence of injury*

Methods

The subjects studying at KKG and Akademiet were tested on two non-consecutive days while subjects studying at the high schools of Sirdal and Setesdal completed all testing on one day (see Figure 2 and 3).

Test procedure

Start

App. 06:00 a.m.

Measurement of height and weight, and 30 min. RMR-test	DXA scan	Blood pressure	Work Efficiency	Reaction time	Maximum strength/ Power	Diet- intervie question

VO_{2max}	Maximum strength/ power

Figure 7: Test procedure for Sirdal and Setesdal high school in the phd-project. Only tests highlighted in blue were used in this study.

Day 1: 06:00 a.m. – 12:00 a.m. (2,5 hours per participant)

Measurement of height and weight, and 30 min. RMR-test	DXA scan	Blood pressure	Work Efficiency	Reaction time	Maximum strength/ Power	Die and que

Day 2: 12:00 a.m. – 05:00 p.m. (0,5 hours per participant)

Height and weight measurement	VO_{2max}	Maximum strength/ power

Figure 8: Test procedure for KKG and Akademiet in the phd-project. Only tests highlighted in blue were used in this study.

Anthropometry and body composition

Body weight of the subjects was measured to the nearest 0.1 kg using a Seca weight scale (Seca 1; model 861, Germany), and was performed without shoes and in light clothing. The subjects height was measured to the nearest 0.1 cm using a wall-affixed centimeter scale (Seca Optimera, Seca, UK), and was done without shoes. Body mass index (BMI), i.e. weight in kilos divided by height squared in m² (kg/m^2). Body composition and bone mineral density (BMD) were measured using dual-energy X-ray absorptiometry (DXA; GE-Lunar Prodigy, Madison, WI, USA).

Questionnaire and diet interview

In this study the Oslo Sports Trauma Research Center questionnaire on Health problems (OSTRC-H) with some added questions regarding injuries and illnesses were used. The added questions of OSTRC-H investigated which type of illness they had experienced and in which body part the injury they had experienced occurred were added. The subjects should also register days of absence due to injury or illness. After injury- and illness registration the questionnaire asked if the subjects had done preventive measures to prevent new injury in the same body part or to prevent similar disease. Seven-days recall interview were conducted to assess the subjects food and beverage intake, intake was logged and analyzed to assess energy intake with the food registration software Dietist Net (Dietist Net, Kost och Näringsdata, Bromma, Sweden). Dietist Net has access to the Norwegian food table (Matvaretabellen 2014), an open Norwegian nutritional information database (MILLUM PDB) and the U.S national nutrient database (US department of Agriculture).

Energy availability and exercise energy expenditure

Energy availability (EA) was calculated as dietary intake (EI) in kcal/day or kJ/day minus exercise energy expenditure (EEE) normalized to fat-free mass (FFM) and can mathematically be calculated as: EA=(EI-EEE)/FFM (15). EI was calculated from retrospective food records described in the section above. EEE for each individual training session was estimated by using exercise training logs and heart rate (HR) sensor combined with HR monitor. HR was classified to specific HR zone described by Seiler and Tonnessen (16) as the sum of the time spent in each HR zone. EA was calculated using the EI and EEE determined within the same 7-day period and FFM was determined by DXA.

Subjects activity level was monitored using Sensewear multi-sensor (BodyMedia, Inc., Pittsburgh, PA, 175 USA.) which includes accelerometer, the monitor was worn on the right arm according to protocol of Berntsen, Hageberg (17). Data from the Sensewear monitor were downloaded to a computer with software; Bodymedia 8.2 (BodyMedia, Inc., Pittsburgh, PA, 175 USA) developed by the manufacturer.

Reaction time

Reaction time was determined using a portable computer with the Musclelab (version 8.31)-program installed. The subjects were instructed how to test and had one try on test protocol for familiarization. Test protocol were to press keyboard SPACE bar when visual stimulus changed on the computer screen as fast as they could, each subject performed three reaction trials. The shortest reaction time of the three trials was used in the statistical analysis.

Maximal oxygen uptake

VO_{2max} was determined performing an incremental run test to exhaustion on a Lode Katana Sport treadmill (Lode B.V., Groningen, The Netherlands). The subjects started at 9 km/h with a constant positive incline of 6 degrees (corresponding to 10,5% incline). The speed was increased by 1km/h/min until voluntary exhaustion. VO_{2max} was measured using MetaMax (MetaMax 3B, CORTEX Biophysik GmbH, Walter-Köhn-Str. 2d, 04356 Leipzig, Germany). The Metamax is a portable metabolic measurement system and provides respiratory values breath by breath using a Hans Rudolph breathing mask (Hans Rudolph, Kansas, MO, USA). All systems was calibrated according to standards.

Statistics

All data were statistically analyzed using SPSS (SPSS for Windows, v. 24; SPSS Inc, Chicago, USA) and graphs designed using GraphPad Prism 7 for Windows version 7.04 (GraphPad Software, Inc., LA Jolla California USA). The dataset was checked for missing data and non-normality before statistical tests were performed. Normal distributed data are presented as mean and standard deviation. Non-normal distributed data are presented as median and interquartile range (25-75). The participants were divided by type of sports, endurance sports group and ball game sports group. When comparison differences between these two groups, an independent sample t-test was used for comparison of means in normally disturbed data, and Mann Whitney U-test was used for comparison of medians of data not normal distributed. *P*-value was assessed when checking for correlation between variables in each group. *P*-value of $p<0.05$ was considered significant when checking for correlation. When exploring injury and illness rate 95% confidence interval (95% CI) for mean was calculated, i.e. total amount of injuries and illnesses divided by participants. To identify possible associations between injury and selected risk factors a logistic regression analysis was used to determine odds ratios (OR) and 95% CI, the same analysis were used when analyzing associations between illness and selected risk factors. The regression analysis was performed in all cases and not differentiated on type of sports due to the group sizes and the low participation in general. Hours of training were removed from the analysis due to missing data and the ability to perform valid analysis. *P*-value were used to assess whether there was an association between injury or illness and the risk factors tested. A significance level of $p \leq 0.01$ was used in the logistic regression analysis in order to not draw false conclusions based on false significant levels.

Results

Data from a total of 34 participants were included in the analysis. Mean age of the participants was 16.3±0.2 years with an median VO_{2peak} ($mL \cdot kg^{-1} \cdot min^{-1}$) of 59.0 (52.0-66.0). The participants were divided into two groups, endurance sports (n=24) and a group of ball game sports (n=10). Endurance athletes had lower BMI ($p<0.05$) and body weight ($p<0.05$) compared to ball game sport athletes (table 1). Otherwise, no differences between the two groups were observed (table 1).

Table 1: *Characteristics of participants categorized according to type of sport*

Variables	**Total (n=34)**	**Endurance sports (n=24)**	**Ball game sports (n=10)**
Age (y)	16.3±0.2	16.4±0.2	16.5±0.2
Height (cm)	175.0 (172.8-182.8)	174.0 (172.9-181.2)	180.5 (172.4-185.5)
Body weight (kg)	65.7±8.3	63.3±7.4*	71.5±7.6
BMI (kg/m²)	20.8±1.8	20.3±1.7**	22.0±1.5
Body fat (kg)	10.2 (7.3-15.7)	9.706 (6.1-13.6)	12.2 (8.0-18.3)
Body fat (%)	15.8 (10.7-24.7)	15.8 (10.2-23.6)	16.1 (12.4-28.2)
FFM (kg)	54.1 (47.7-60.6)	51.575 (46.8-60.8)	59.1 (50.2-62.7)
VO_{2peak} ($mL \cdot kg^{-1} \cdot min^{-1}$)	59.0 (52.0-66.0)	59.5 (54.5-67.0)	58.0 (49.5-66.0)
EA (kcal/kgFFM/day)	46.8±14.6	46.9±14.7	46.4±15.0
Sleep SW (h)	7.3±0.4	7.34±0.5	7.33±0.4
Reaction time (s)	0.252±0.025	0.251±0.026	0.253±0.025

Data that are normal distributed are presented as mean and standard deviation.

Data that are not normal distributed are presented as median and interquartile range (25-75).

BMI, body mass index; FFM, fat free mass; $VO_{2peak,}$ peak oxygen uptak ($mL \cdot kg^{-1} \cdot min^{-1}$); EA, energy availability; Sl SW, hours of sleep registered with sensewear; Sleep SR, hours of sleep self-reported

*$p<0.05$ **$p<0.01$

Injury prevalence

The total number of injuries experienced by the subjects were 30, resulting in an injury rate of 0.88 (95% CI 0.47 - 1.29) during the six months of registration. The subjects participating in ball game sports experienced 13.3% mores injuries than subjects participating in endurance sports (56.6% vs. 43.3% $p<0.01$). The prevalence of injuries was higher in ball game sports (17 injuries) than in endurance sports (13 injuries) ($p<0.01$). In the sport groups all together, the body part with the highest prevalence of injury was the ankle (20.0%), with lower back (16.6%) following as number two. There were three and four subjects with two and three injuries each, respectively. See figure 4 and 5 (supporting information) for more details regarding injuries.

Risk factors for injury

Table 2 presents results of a logistic regression analysis assessing the relationship between risk factors and injuries during the registration period. Although there was no significant association between the variables and the prevalence of sport injuries, a higher percentage of fat showed a tendency to associate with lower risk of injury ($p = 0.047$), and higher BMD z-score in L1-L4 showed a tendency to associate with lower risk of injury ($p = 0.031$). Subjects reporting higher percentage of body fat had some lower risk of sustaining injuries (OR, 0.124; 95% CI, 0.016 – 0.971). In addition subjects with better z-score in L1-L4 had lower risk of sustaining injuries (OR, 24.9; 95% CI, 1.351 – 459.4) (table 2).

Table 2: *Adjusted odds ratio (ORs) for the prevalence of injuries*

Variables	**B**	**All participants** (n=30)	
		OR (95% CI)	***p* value**
Sex	-8.0	0.000 (0.000 – 4.742)	0.101
Height (cm)	-0.2	1.234 (0.928 – 1.641)	0.148
Weight (kg)	2.2	9.249(0.919 – 93.088)	0.059
Fat (%)	-2.0	0.124 (0.016 – 0.971)	0.047
FFM (kg)	-0.0	0.997 (0.995 – 1.000)	0.054
VO_{2peak} ($mL\cdot kg^{-1}\cdot min^{-1}$)	0.0	1.060 (0.759 – 1.480)	0.734
EA (kcal/kgFFM/day)	0.0	1.040 (0.944 – 1.145)	0.431
Sleep SW (h)	1.9	7,252 (0.519 – 101.264)	0.141
L1-L4 Z-score (g/cm^2)	3.2	24.913 (1.351 – 459.486)	0.031
Reaction time (s)	-33.2	0.000 (0.000 – 261619271.6)	0.216

Fat (%), body fat in percent; FFM, fat free mass; VO_{2peak}, peak oxygen uptake ($mL\cdot kg^{-1}\cdot min^{-1}$); EA, energy availability; Sleep SW, hours of sleep registered with sense wear; L1-L4 Z-score, bone mineral density in L1-L4 Z-score.

Illness prevalence

A total of 28 subjects (82%) had experienced 78 cases of illness the last six months, resulting in an illness rate of 2.29 (95% CI 1.66 to 2.93) during the six months of registration. Athletes participating in endurance sports reported 59 cases of illness, while athletes in ball game sports reported 19 cases of illness (59 vs. 19, p = 0.270). Mild cold was the illness most commonly reported with occurrence of 50,0% (n=39) of all illnesses (figure 6-8). Endurance athletes reported 29 cases of mild cold while athletes in the ball game sports group had experienced 10 cases (29 vs. 10, p = 0.342). In all types of illnesses reported, except bronchitis (n=1)(figure 6, supporting information), endurance athletes reported more cases of illness than athletes from ball sports, see figure 6-8 (supporting information).

Risk factors for illness

Despite the high amount of illnesses, none of the variables selected associated significantly with risk of illness.

***Table 3**: Adjusted odds ratio (ORs) for the prevalence of illness*

Variables	**B**	**All participants** (n=30)	
		OR (95% CI)	***p* value**
Sex	4.9	1.543 (0.000 – 4889.794)	0.916
Height (cm)	-0.1	0.868 (0.620 – 1.214)	0.407
Weight (kg)	-1.5	1.246 (0.122 – 12.686)	0.853
Fat (%)	1.5	0.581 (0.080 – 4.198)	0.590
FFM (kg)	0.0	1.000 (0.997 – 1.003)	0.945
VO_{2peak} (mL·kg^{-1} ·min^{-1})	-.03	0.604 (0.340 – 1.071)	0.084
EA(kcal/kgFFM/day)	0.0	0.942 (0.825 – 1.075)	0.375
Sleep SW (h)	-0.0	2.739 (0.128 – 58.685)	0.519
L1-L4 Z-score (g/cm^2)	-1.5	0.208 (0.018 – 2.465)	0.213
Reaction time (s)	20.2	1.623E+22 (0.000 – 2.801E+49)	0.110

Fat (%), body fat in percent; FFM, fat free mass; VO_{2peak}, peak oxygen uptake (mL·kg^{-1} ·min^{-1}); EA, energy availability; Sleep SW, hours of sleep registered with sense wear; L1-L4 Z-score, bone mineral density in L1-L4 Z-score.

Table 5 here

Discussion

The aim of this study was to investigate the prevalence of sport injuries and illnesses as well as possible risk factors associated with injury or illness among elite sport-students at high school. The main findings of this retrospective cross-sectional study were that the subjects experienced 30 injuries, with a injury rate of 0.88 during the six months of registration, and 78 cases of illness, corresponding to a illness rate of 2.29 in the same period.

Injury and illness rate

Previous research investigating frequencies of injuries often express rates of injury as incidence rates calculated as the numbers of injuries per 1000 participating hours (18), in this study both injury and illness rates are expressed as prevalence with 95% CI. This inconsistency with previous research make it difficult to compare results in this study with other studies, nevertheless to express injury and illness rate as prevalence with 95% CI was found necessary due to limited data. Limitation of data regards incomplete questionnaires examining monthly amount of training, too few subjects registered their mean amount of training hours.

The participants in this study experienced a total of 30 injuries during the past six months, the ball game sports group accounted for significantly more injuries than the endurance sports group (17 injuries vs. 13 injuries). Data analysis revealed an injury rate of 0.88 for all participants, divided by sport groups; 1.70 in ball game sports versus 0.54 in endurance sports. During the six months of registration the participants were exposed for 78 cases of illness, endurance athletes accounted for 59 illnesses versus ball game sports 19 illnesses respectively. Corresponding to an illness rate of 2.29 for all participants, divided by sport groups; 1.90 in ball game sports versus 2.46 in endurance sports. Both injury- and illness rates in this study appears to be lower than rates reported by previous research (1, 13, 19-22). However, first of all this might be explained by different expression of injury and illness rate, second, it might be because of registration off-season for the endurance group versus other studies investigating injuries during season, competition/training or during tournaments (23, 24). Especially rates of injury are prone to this, according to Murphy, Connolly (25) there is a general agreement among researchers that injury incidence is greater in competition than in training sessions, both previous research and research up to date confirms this agreement (26-29). Some studies however have found incidence of injury during competition and training similar (21). Whether incidence of illness increases during tournament versus season and off-season is less clear and less reported, however the design of tournaments, with a high amount of competition and training in a short period makes it highly probable (20). Thirdly, the self-reporting scheme with six months of recall may be a limiting factor in injury and illness registration (30). The self-reporting issue is associated with a financial advantage due to a low cost, nevertheless athletes threshold to report injury or illness may be different as well as the definition of injury and illness may be unclear amongst the participants. Another issue regarding retrospective self-reporting is the recall bias, an athlete's ability to remember all injuries and illnesses might be limited. Studies have concluded that retrospective injury registration is limited versus prospective registration due to recall bias (31). Clarsen, Myklebust (32) recommend, regardless of sampling frequency, that retrospective studies that register health problems not extend seven days of recall, in order to minimize the risk of bias.

Risk factors for injury

The logistic regression analysis revealed that none of the tested variables were significantly associated with injury. Previous research have stated inadequacy of energy as the underlying problem of RED-S, which further is associated with negative health issues and increased risk of injury (6). EA in this study did not reach any significant values regarding association of injury, however this might be due to, but not limited to, poor quality of data or small sample size. EI is an essential part when calculating EA. Food and beverages intake were logged using a seven-days recall interview were the subjects should try to recall all their intake of energy the past seven days. This method of logging energy intake might be most appropriate when assessing food and beverage intake in young athletes, however it has some limitations in providing valid data (33). First of all, for many people talking about their dietary habits might be intimidating, one can never be 100% certain that the participants is completely honest. Secondly, recall bias may be apparent. The participants were asked to recall seven days of EI, this includes all breakfast, lunch, dinner, supper and meals in between. It is likely that at least some of the participants forgot to report a meal due to the retrospective design. This possible bias in calculation of EA makes the prevalence of low EA unreliable to some degree, as well as the association between EA and injury and illness are uncertain.

Another variable tested to assess risk factor is anthropometry, hence height, body weight, body fat percentage, and FFM. Previous research has shown some different findings regarding body composition and injury incidence, however a lower amount of fat percentage seems to be associated with increased risk of injury (8). Results in this study did not show any significant variables associated with risk of injury, however a lower amount of fat percentage showed a tendency to associate with higher risk of injury (p=0.047). In many studies this p-value would be found significant, however due to the chosen p-level (p=0.01) in this study it was not considered significant. The selected *p*-level was chosen due to the small sample size and the amount of variables tested, a larger sample size could have decreased the *p*-level to significant level or provided enough participants to maintain a *p*-level of $p=0.05$.

Bone health is a second variable revoked for significance due to the chosen *p*-level, the association of L1-L4 Z-score with injury provided a *p*-value of $p=0.031$. In this case, a higher value of Z-score in L1-L4 was associated with decreased risk of injury, this is indirect consistent with earlier studies claiming reduced bone health increased risk of stress fractures and risk for fragility fractures later in life (9).

For athletes in elite sports and elite youth sports the goal is to optimize performance, performance variables in this study were VO_{2peak} and reaction time. Pre-season VO_{2max} in soccer players have been reported in the study of Watson, Brindle (11) as an independent predictor of in-season injury. Players who experienced an injury during the season had a significantly lower pre-season VO_{2max} than players who were not injured during the season. Contrary to the published literature, no significant association between VO_{2peak} and risk of injury were found in this study. The differing results might come of the different numbers of participants in each sport groups (endurance sports group, n=24 vs. ball game sports group, n=10), also with regard to post- and pre-season for the different sports group. Injury registration in this study had a duration for the past six months. As the registration period were late October and early November only the ball game sports group registered injuries that occurred during the season. If the registration had been conducted in post-season for the endurance group a different result might have been expected. The other performance variable investigated; reaction time was not associated with risk of injury. In the study of Dvorak, Junge (12) injured athletes had a slower reaction time after at 12-minute run compared with uninjured athletes, in the present study the subjects did not perform the reaction test after an exhausting test, the reaction time test were performed after a non-exhausting work-efficiency test. It should be noted that there were no significant differences between injured and uninjured athletes in the study of Dvorak, Junge (12) without the influence of physical exercise either, pointing out that methodological differences may account for the different findings.

Dupont, Nedelec (34) suggest that inadequate recovery leads to fatigue and increases risk of overuse injury. Sleep is the only recovery variable investigated in this study and results showed no significant association with increased risk of injury. Previous studies have investigated the role of sleep in recovery and the association between hours of sleep and risk of injury. Nédélec, McCall (35) stated that sleep is an essential part of recovery, furthermore the results in the study of Benedict, Hallschmid (14) show that sleep play an immediate regulatory role for energy expenditures. von Rosen, Frohm (4) found decreased sleeping volume alongside with other variables, to associate with increased risk of injury (hazard ratios 2.37). Similar findings were revealed in another study of von Rosen, Frohm (36) where sleeping more than eight hours during weekdays and having a healthy diet could reduce the odds of sustaining new injuries. It is likely that the small sample size in the present study must account for the non-significant findings and differing results from previous studies, as well as the cross-sectional design and measurement methods sets the athlete prone for the "Hawthorne effect". The Hawthorne effect suggest that subjects modifies their behavior from what it would be without the knowledge of them being studied (37).

Risk factors for illness

With regards of illness and variables investigated, data analysis showed no significant associations. Several studies investigate rate of illness (1, 21, 22), however to this authors knowledge there is a lack of studies investigating risk factors of illness. A study investigating anthropometry in Olympic athletes shown chronic energy deficiency, or in this case, low EA in combination with intense physical exercise to increase risk of upper-tract infections (38). In this study variables regarding anthropometry; height, body weight, fat in percent and FFM as well as EA did not associate significantly with illness. Additionally Hagmar, Hirschberg (38) found a higher frequency of illness among Olympic athletes participating in leanness-emphasizing disciplines than in non-lean disciplines, however only significant among men (38). Although this do not provide evidence for association to variables investigated in this study, athletes participating in leanness sports were shown to exhibit a lower BMI and more pronounced variations in weight (38). Thereby indicating an association between anthropometry and illness for future studies to investigate. In this study, the endurance sports group is considered emphasizing leanness, while sports in the ball game sport group are not considered emphasizing leanness. Sundgot-Borgen and Torstveit (39) provided evidence indicating the prevalence of eating disorders are higher among elite athletes both in sports emphasizing leanness and sport that do not emphasize leanness compared with control group. This can indicate that athletes participating in both sport groups are at risk of eating disorders, and possible low values regarding anthropometry.

Low energy availability is one of few variables studied regarding association to illness risk. Mountjoy, Sundgot-Borgen (6) point out low energy availability as the main cause of RED-S. RED-S can have serious implications for many body systems, affecting both performance and health, athletes suffering from long-term low EA could be at increased risk of infections and illness due to nutrient deficiencies. However, in this study EA did not correlate with increased risk of illness, the non-significant values in this study may be caused by methodological limitations already discussed in the previous section regarding EA as a risk factor to injury.

The performance variable VO_{2peak} has previously been reported as a significant factor regarding illness prevalence, in the study of Watson, Brickson (13) an increase of pre-season VO_{2max} were a significant factor for a decreased risk of illness during the season. In this study VO_{2peak} did not correlate significantly with an increased risk of injury, however this may be to methodological limitations already discussed in the previous section regarding performance variables associated with risk of injury.

Little is known about hours of sleep and immune function as well as infection incidence (40). However, as sleep time is a major determinant in maintaining energy balance and recovery after being active in sports (14, 35), it could therefore be expected to correlate with risk of illness. In the study of Walsh, Gleeson (40) they claim that poor sleeping quantity and/or quality increased symptoms of common cold, as well as adults who slept less than seven hours per night were nearby 3 times more likely to develop symptoms of common cold than adults who slept more than eight hours per night. In the present study analysis revealed no significant correlation between hours of sleep and risk of illness. The non-significant findings in this study may be due to methodological limitations discussed in the previous section about hours of sleep associated with risk of injury.

In conclusion the prevalence of injury were at a rate of 0.88 per participant during the six months of registration. Injuries divided by sport groups; injury rate of 1.70 in ball game sports versus 0.54 in endurance sports per participant. Anthropometry, bone health, performance variables, energy availability and sleeping time did not associate significantly with risk of injury. The prevalence of illness were at a rate of 2.29 illnesses per participant during the registration period. Illness divided by sport groups; illness rate 1.90 in ball game sports versus 2.46 in endurance sports per participant. Anthropometry, bone health, performance variables, energy availability and sleeping time did not associate significantly with risk of illness.

Other studies have found some of these factors to associate with risk of both injury and illness, the non-significant associations in this study could possibly be explained by the small sample size as well as the endurance athletes registering injuries and illnesses off-season. Future studies should strive to be prospective cohort studies analyzing prevalence and risk factors for injuries and illness over time, they should be at least 10 participants for each predictor or variable tested. Variables such as hours of training, acute versus overuse injuries, injury- and illness severity should also be included in future analysis, due to consistency of existing research and the role of risk factors in type of injury and severity.

Strength and limitations

This study is a cross-sectional study aiming to find significant factors contributing to increased risk of athletes' injury and illness. The main strengths of this study were the use of well-established and objective measuring methods; DXA, Sensewear and VO_{2peak} are acknowledge methods widely used in both research and elite sports. Furthermore, was the strength increased by using the same research team with assigned responsibility for testing, the same equipment, the same test leader and technician during the whole registration period. There are however several limitations in this study. The main limitation is perhaps the small sample size used to investigate associations, and thereby weak statistical power. Due to the small sample size and all variables tested, a significance level at 0.01 was set to avoid making a type I error, however this increases the risk of making type II errors. A type II error probably occurred when assessing fat in percent and L1-L4 Z-score and the correlation to injury, as the factors have been proven significant in previous research. Another major limitation in this study were the cross-sectional retrospective design, which only measures the outcome and exposure at the given time, the situation may provide differing result if another timeframe had been chosen and therefore making it impossible to infer causality. Additionally, the retrospective design is prone to recall bias, previous studies have concluded that retrospective injury and illness registration is limited to prospective registration. Injury and illness was registered with a translated version of the OSTRC-H questionnaire. Questions aiming to identify illness type and/or location of injury was added to the questionnaire. Although OSTRC-H is a validated questionnaire there are several methodological weaknesses related to using the questionnaire in this study, e.g. the translated version of OSTRC-H is not validated, as well as the questionnaire is not validated in adolescent elite athletes. Additionally, an added part of questions regarding injury and illness registration were not validated. Lastly, a limitation in this study was that other variables such as training hours, muscle strength, training versus competition, opponent, clothing, warm-up program were not analyzed due to the method used in this study combined with missing data.

Perspectives

This study is the continuation of many studies investigating sport injuries among high school elite sport-students, however fewer studies have investigate risk factors of illness. Illness rate in this study indicate that high school elite sport students are at risk of sustaining illness, future studies should investigate risk factors for illness as well as risk factors for injury in adolescent sports. A longitudinal cohort study with a large sample size executed as prospective could be appropriate because of more accurate and complete data, and to exceed chances of inferring causality. For example, following first grade students through high school and registering injuries and illnesses, as well as monitoring risk factors, such as hours of participating in sport, training versus competition, injury severity, BMI and sex could provide knowledge in development of preventive measure in youth sport.

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Supplementary files for review

Figure 9: *Number of injury cases experienced by the participants in upper extremities.*

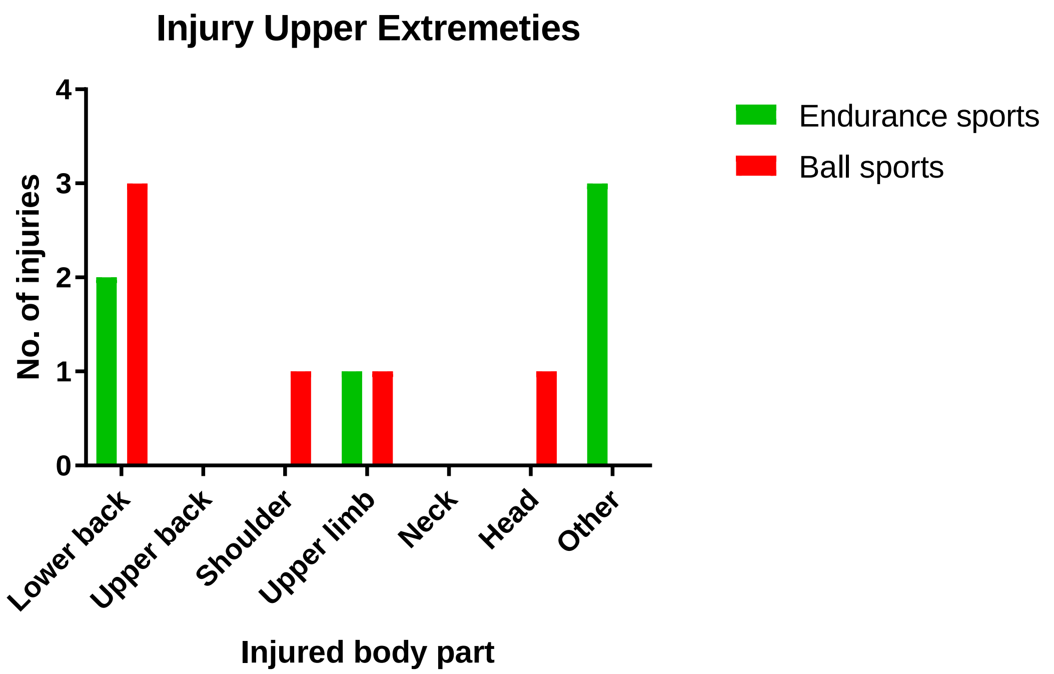
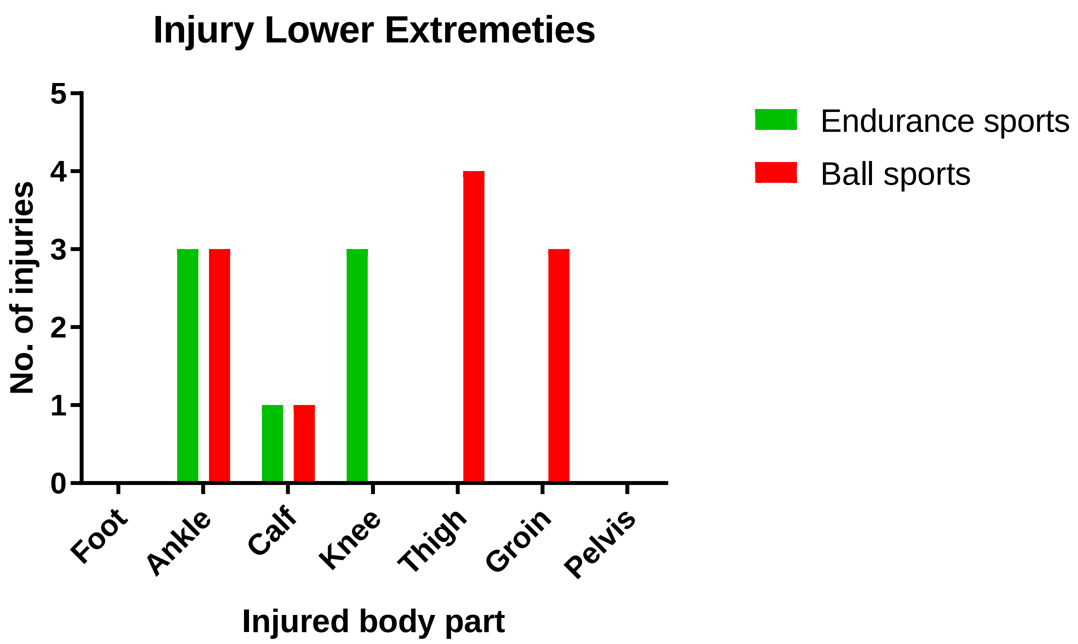
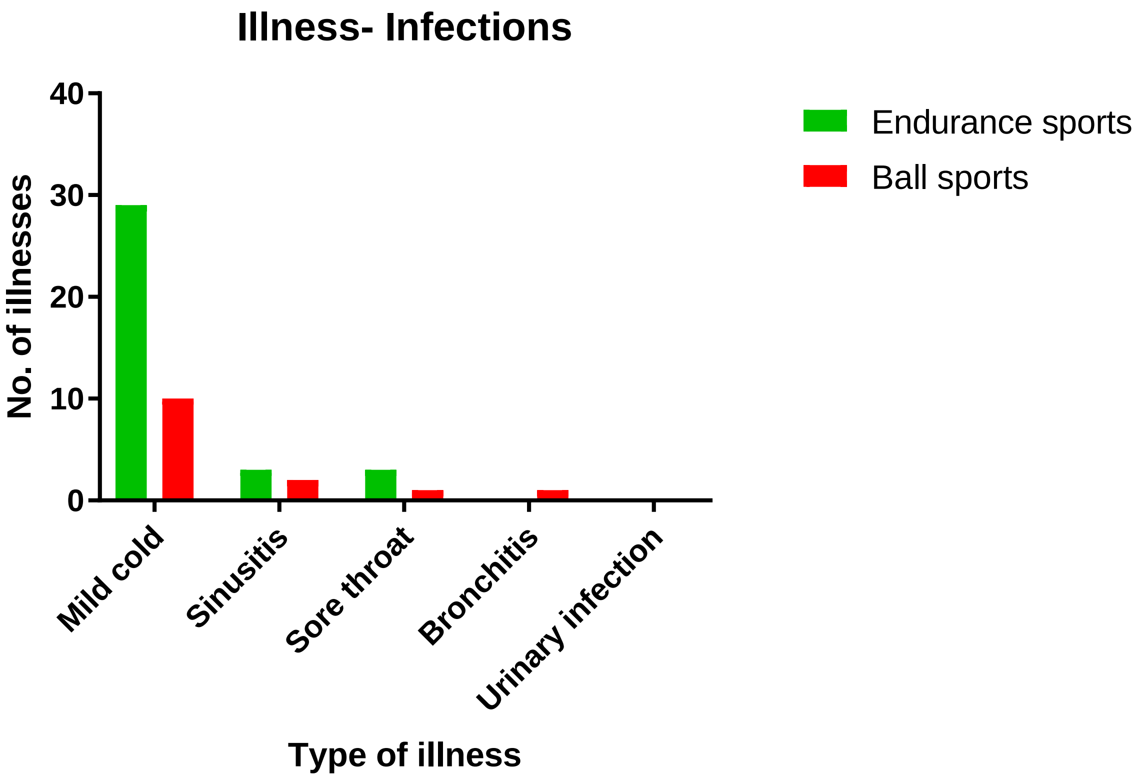

Injury Upper Extremeties
No. of injuries
0
1
2
3
4
Lower back
Upper back
Shoulder
Upper limb
Neck
Head
Other
Injured body part
Endurance sports
Ball sports

Figure 10*: Number of injury cases experienced by the participants in lower extremities.*



Injury Lower Extremeties
No. of injuries
0
1
2
3
4
5
Foot
Ankle
Calf
Knee
Thigh
Groin
Pelvis
Injured body part
Endurance sports
Ball sports

Figure 11*: Number of infection illnesses(cases) experienced by the participants.*



Illness- Infections
No. of illnesses
40
30
20
10
0
Mild cold
Sinusitis
Sore throat
Bronchitis
Urinary infection
Type of illness
Endurance sports
Ball sports

Figure 12*: Number of allergy illnesses (cases) experienced by the participants*

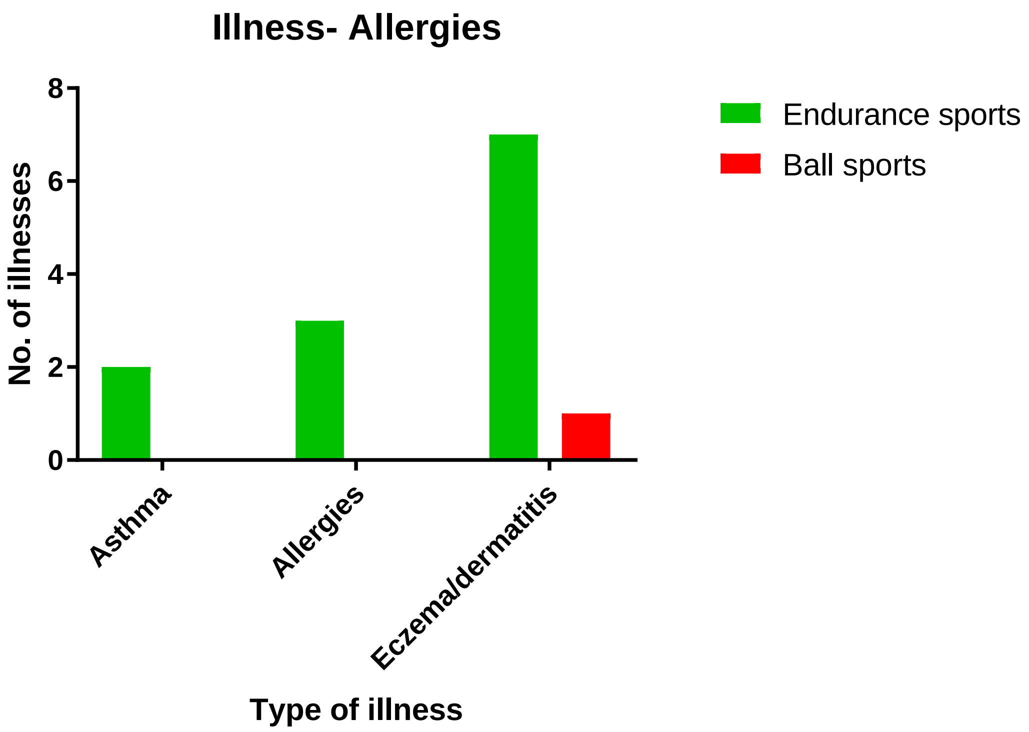

Illness- Allergies
No. of illnesses
8
6
4
2
0
Asthma
Allergies
Eczema/dermatitis
Type of illness
Endurance sports
Ball sports

Figure 13*: Number of multiple-disease illnesses (cases) experienced by the participants*

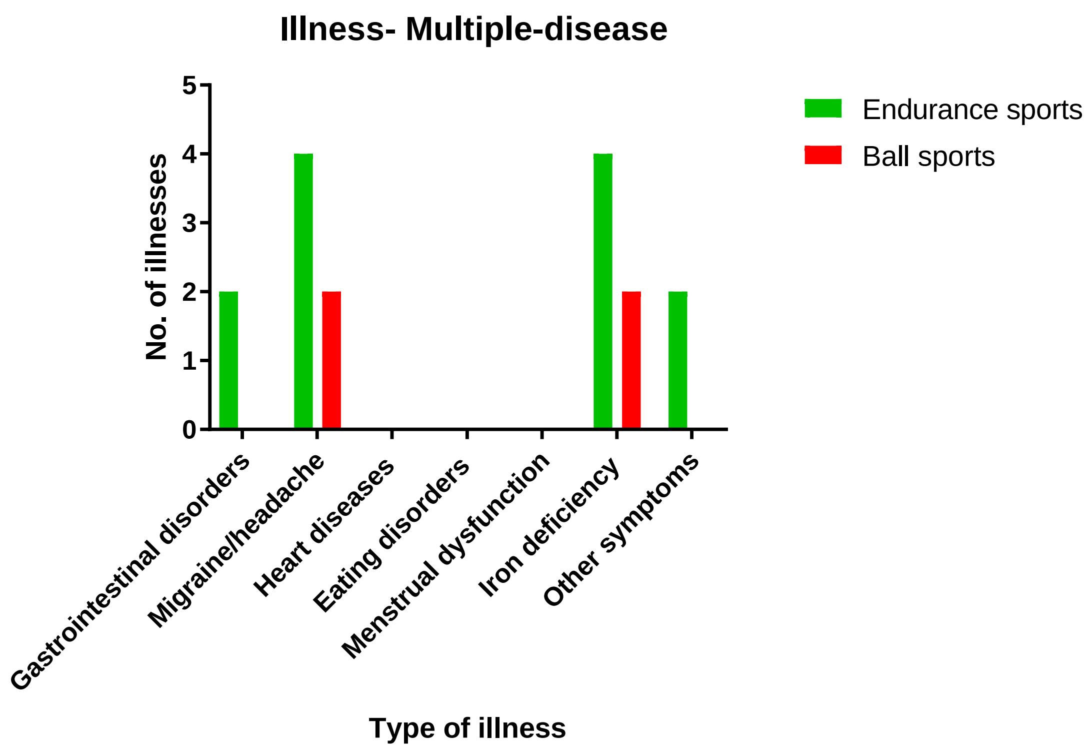

Illness- Multiple-disease
No. of illnesses
0
1
2
3
4
5
Gastrointestinal disorders
Migraine/headache
Heart diseases
Eating disorders
Menstrual dysfunction
Iron deficiency
Other symptoms
Type of illness
Endurance sports
Ball sports

Table 4*: Number of injuries and injury rate for athletes in endurance sport and ball game sports by categories of injury.*

Injury type Sport group	**Number of injuries**	**Injury rate**	**95% confidence interval**
All injuries	**30**	**0.88**	**0.47 – 1.29**
Endurance sport	13	0.54	0.09 – 0.99
Ball game sport	17	1.70	0.94 – 2.46
Lower back	**5**	**0.15**	**0.02 – 0.28**
Endurance sport	2	0.09	-0.04 – 0.21
Ball game sport	3	0.30	-0.05 – 0.65
Upper back	**0**		
Endurance sport	0		
Ball game sport	0		
Shoulder	**1**	**0.03**	**-0.03 – 0.09**
Endurance sport	0		
Ball game sport	1	0.10	-0.13 – 0.33
Upper limb	**2**	**0.03**	**-0.03 – 0.09**
Endurance sport	1	0.04	-0.04 – 0.13
Ball game sport	1	0.10	-0.13 – 0.33
Neck	**0**		
Endurance sport	0		
Ball game sport	0		
Head	**1**	**0.03**	**-0.03 – 0.09**
Endurance sport	0		
Ball game sport	1	0.10	-0.13 – 0.33
Foot	**0**		
Endurance sport	0		
Ball game sport	0		
Ankle	**6**	**0.18**	**-0.03 – 0.39**
Endurance sport	3	0.13	-0.14 – 0.40
Ball game sport	3	0.30	-0.05 – 0.65
Calf	**2**	**0.06**	**-0.03 – 0.15**
Endurance sport	1	0.04	-0.05 – 0.13
Ball game sport	1	0.10	-0.13 – 0.33
Knee	**3**	**0.06**	**-0-03 – 0.15**

Endurance sport	3	0.09	-0.04 – 0.21
Ball game sport	0		
Thigh	**4**	**0.12**	**-0.03 – 0.27**
Endurance sport	0		
Ball game sport	4	0.40	-0.10 – 0.90
Groin	**3**	**0.09**	**-0.01 – 0.19**
Endurance sport	0		
Ball game sport	3	0.30	-0.05 – 0.65
Pelvis	**0**		
Endurance sport	0		
Ball game sport	0		
Other	**3**	**0.06**	**-0.03 – 0.15**
Endurance sport	3	0.09	-0.04 – 0.21
Ball game sport	0		

Table 5: *Number of illnesses and illness rate for athletes in endurance sport and ball game sports by categories of illness.*

Illness type Sport group	**Number of illnesses**	**Illness rate**	**95% confidence interval**
All illnesses	**78**	**2.29**	**1.66 – 2.93**
Endurance sport	59	2.46	1.74 – 3.17
Ball game sport	19	1.90	0.39 – 2.27
Mild cold	**39**	**1.06**	**0.74 – 1.38**
Endurance sport	29	1.21	0.80 – 1.62
Ball game sport	10	0.67	0.28 – 1.05
Sinusitis	**5**	**0.09**	**-0.01 – 0.19**
Endurance sport	3	0.13	-0.02 – 0.27
Ball game sport	2	0.10	-0.13 – 0.33
Sore throat	**4**	**0.12**	**0.00 – 0.24**
Endurance sport	3	0.13	-0.02 – 0.27
Ball game sport	1	0.11	-0.15 – 0.37
Bronchitis	**1**	**0.03**	**-0.03 – 0.09**
Endurance sport	0		
Ball game sport	1	0.11	-0.15 – 0.37
Asthma	**2**	**0.06**	**-0.03 – 0.15**
Endurance sport	2	0.08	-0.04 – 0.20
Ball game sport	0		
Gastrointestinal	**2**	**0.06**	**-0.03 – 0.15**
Endurance sport	2	0.08	-0.04 – 0.20
Ball game sport disorders	0		
Allergies	**3**	**0.09**	**-0.01 – 0.19**
Endurance sport	3	0.13	-0.02 – 0.27
Ball game sport	0		
Migraine/headache	**6**	**0.18**	**0.02 – 0.35**
Endurance sport	4	0.17	-0.04 – 0.37
Ball game sport	2	0.22	-0.12 – 0.56
Eczema/dermatitis	**8**	**0.24**	**.0.13 – 0.62**
Endurance sport	7	0.29	-0.23 – 0.81
Ball game sport	1	0.11	-0.15 – 0.37
Urinary infection	0		

Endurance sport	0		
Ball game sport	0		
Heart diseases	0		
Endurance sport	0		
Ball game sport	0		
Eating disorders	0		
Endurance sport	0		
Ball game sport	0		
Menstrual dysfunction	0		
Endurance sport	0		
Ball game sport	0		
Iron deficiency	**6**	**0.15**	**0.02 – 0.28**
Endurance sport	4	0.17	0.01 – 0.33
Ball game sport	2	0.11	.0-15 – 0.37
Other symptoms	**2**	**0.06**	**-0.03 – 0.15**
Endurance sport	2	0.08	-0.04 – 0.20
Ball game sport	0		

Part III

Appendix

Contents:

Hroar Fintland

University of Agder

May 2018

Appendix 1

The OSTRC Questionnaire on Health Problems (OSTRC-H)

Vennligst svar på alle spørsmålene uavhengig om du har opplevd helseplager eller ikke i løpet av de siste 6 måneder. Velg alternativet som passer best for deg, og i tilfelle du er usikker, prøv å svare så godt du kan. Hvis du har hatt flere sykdoms- eller skadeproblemer, kan du referere til det som har vært ditt verste problem de siste 6 måneder. Du får muligheten til å registrere andre problemer ved slutten av spørreskjemaet.

Spørsmål 1

Har du hatt noen problemer med å delta i normal trening og konkurranse på grunn av skade, sykdom eller andre helseplager i løpet av de siste 6 måneder?

☐ Full deltakelse uten helseplager

☐ Full deltakelse, men med skade/sykdom

☐ Redusert deltakelse på grunn av skade/sykdom

☐ Kunne ikke delta på grunn av skade/sykdom

Spørsmål 2

I hvilken grad har du endret/modifisert trening eller konkurranse på grunn av skade, sykdom eller andre helseplager i løpet av de siste 6 måneder?

☐ Ingen endring~~reduction~~

☐ I mindre grad

☐ I moderat grad

☐ I stor grad

☐ Kunne ikke delta i det hele tatt

Spørsmål 3

I hvilken grad har skade, sykdom eller andre helseplager påvirket prestasjonen din i løpet av de siste 6 måneder?

☐ Ingen effekt

☐ I mindre grad

☐ I moderat grad

☐ I stor grad

☐ Kunne ikke delta i det hele tatt

Spørsmål 4

I hvilken grad har du opplevd symptomer på skade eller sykdom/helseplager i løpet av de siste 6 måneder?
Eks: 1) Vondt i kneet kan være symptomer på kneskade. 2) Rennende/tett nese kan være symptomer på forkjølelse

☐ Ingen symptomer/helseplager

☐ I liten grad

☐ I moderat grad

☐ I alvorlig grad

Dersom du krysset av for et av alternativene med skade/sykdom i spørsmål 1 og/eller for et av alternativene med symptomer/helseplager i spørsmål 4, vennligst fortsett registreringen på de neste sidene.

Registrering av sykdom fra de siste 6 måneder:

Har du hatt noen av disse sykdommene sist sesong?

		Varighet av sykdom					
	Antall episoder	1-3 dager	3-6 dager	1-2 uker	2-4 uker	>4 uker	Kommentarer:
Lett forkjølelse							
Bihulebetennelser							
Halsbetennelser							
Bronkitter							
Astmaplager							
Mage-tarm sykdommer							
Allergier							
Migrene/hodepine							
Eksem/hudsykdommer							
Urinveisinfeksjoner							
Hjerteproblemer							
Spiseproblemer							
Menstruasjonsforstyrrelser							
Jernmangel (anemi)							
Andre symptomer							

Registering av skader fra siste 6 måneder:
Har du hatt skader eller andre plager i noen av disse kroppsdelene sist sesong?

Ja: ______ Nei______

			Varighet på skade			
Region	Antall skader	Skadetype/diagnose	3-6 dager	1-2 uker	2-4 uker	>4 uker
Fot						
Ankel						
Legg						
Kne						
Lår						
Lyske						
Bekken						
Nedre del av rygg						
Øvre del av rygg						
Skulder						
Arm/hånd						
Nakke						
Hode						

Annet						

Dersom du har hatt skade(r) de siste 6 måneder

Hvilken behandling og skadeforebyggende tiltak har du gjort/gjør du for å hindre ny skade i samme kroppsdel?

Beskrivelse av behandling og skadeforebyggende tiltak:

☐ Har ikke gjort noen tiltak

Dersom du har hatt sykdom(er) de siste 6 måneder

Hvilke forebyggende tiltak har du gjort/gjør du for å hindre lignende sykdom?

Beskrivelse av forebyggende tiltak:

☐ Har ikke gjort noen tiltak

Appendix 2

UNIVERSITETET I AGDER

Manual for semistructured dietary interview

Energy availability and sports performance

Incidence and development of relative energy deficiency among young female and male athletes in Southern Norway

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n and aim

ıi-structured dietary interview is to assess habitual dietary pa y intake in adolescent athletes from three different high schools in Semistructured interviews allow for structure but are not so rigid that they limit the participant from sharing tangential and often relevant information.

For the purpose of this study, the interview aims to assess habitual meal patterns and dietary intake with specification of intake during the last seven days. There are several limitations compromising the validity of this method compared to the prospective weighed food record. Therefore, it is extremely important that the interviews are carried out as standardized as possible. The wording of the questions and how they are presented to the participants are crucial for the quality of the collected data. The language must be open-ended, unbiased, and nonjudgmental.

Be curious and get as much details about the respondent's meal pattern as possible. If he/she has difficulties in remembering, give him/her a little time to think back.
Make the respondent feel important. He/she has very important information we need in our research.

The interviewer must be completely objective. There are no "right" or "wrong" foods and it is important that the interview is reflected by this. Closed questions (where the answer can be "yes" or "no") should be avoided. Instead, questions often begin with "when" or "what". When you ask for details, it is okay to begin with "is this…", e.g. "is this a with or without sugar?"

For many people, talking about their dietary habits can be very intimidating, especially when they are face by health professionals. Maybe they are nervous when coming in to the interview. The interviewer must be natural in his questioning technique and when answers are received by the respondent. It is the interviewer's task to create a comfortable environment, where the respondent feels, he/she can be 100% honest. Nodding and smiling are simple and good ways to manage this. First step is to ask an ice-breaker question for instance: "Hi and welcome. I really appreciate that you want to participate in this study. What are your experiences so far?" or "what a nice weather today – how are you going to enjoy it later today?"

The interview guide serves the interviewer as a help to get the needed information but the order of the questions may depend on how the respondent answers and maybe you need to ask additional questions. Many sports are seasonal; therefor the interview is performed twice for each athlete.
Use the interview guide and write down the respondent's answers in the form.

2. Interview guide

Once again thank you for your participation in this study. Your participation is very valuable to us, and your participation help us with increased knowledge and to help you and other young athletes to optimize performance.

Now I will appriciate to know about you habitual eating habits. Our conversation will take about an hour. It is very important to me that you know, that there are not any "right" or "wrong" foods. Right foods are what you eat and it is important that you are honest. It is important that you tell me everything you eat and drink – also snacks and also if you eat or drink during the night. I will help you, if you are having trouble remembering and here beside me I have a little book with pictures of foods and portion sizes where you can identify which one is most equal to what you eat.

Do you have any questions before we begin?
So let us begin.

I will ask you to think back on what you have eaten during the last week.

1. From midnight; when is the first you eat or drink?
    a. What do you eat?
        i. Do you know the brand of this product?
        ii. Is this with sugar or a light version? (e.g. if the respondet answers youghurt)
        iii. Is this a full fat or a low fat version (e.g. if the respondet answers cheese, youghurt, or butter)
        iv. Is this a regular type or with whole grain? (e.g. if the respondet answers rice, pasta, or bread)
        v. How many slices/pieces do you eat? (e.g. if the respondet answers bread, crackers, or potatoes)
        vi. What size is this portion you eat? (e.g. if the respondet answers oat meal, pasta, rice, stew. Use the pictures)

        If e.g. the participant tells you he/she had 2 dl oat meal 5 times for breakfast during the week and 2 slices of knekkebrød with cheese the other 2 days:
        - *((40g/dl x 2) x 5)/7 =* ***57 g oat***
        - *((11g/slice x 2) x2/7 =* ***6.3 g Knekkebrød***
        - *((35g/slicex2) x2)/7 =* ***20 g cheese***

        What is written in bold should be entered in Dietist Net.

b. Thank you. And what else do you eat at this time a day? (repeat section a, until the respondent tells you he/she does not eat anything else at this meal)

c. What do you drink?
    i. Do you know the brand of this product?
    ii. Is this with sugar or a light version? (e.g. if the respondet answers drinkingyoughurt, chocolate milk, soda or lemonade. If the respondent tells you he/she drinks self-mixed sportsdrink, remember to ask about the concentration; how many scoops/grams per ½ liter?)
    iii. Is this a full fat or a low fat version (e.g. if the respondet answers milk or chocolate milk)
    iv. What size is this portion you drink? (small glass, large glass, a can, ½ liter?)

2. When do you eat next? (Repeat section a, b, and c)
    - Repeat untill midnight

3. You may need to add questions like «How often do you eat...?», «How often do you drink sports drink during training?», «How often do you eat after a training session?»

4. Thank you very much. Now I will read to you everything I have written of what you have told me so far.

5. Are there anything we have missed? (give the respondent time to think. In general people tend to forget snacks, alcohol and special foods they eat in the weekends. Athletes tend to forget what they drink/eat during training and supplements in general. Therefore, you may help the respondent by asking:

How about during training sessions – what do you drink/eat during this time?
Do you take any other supplements? For instance of vitamin/minerals?

After the interview: enter in Dietist Net and safe the filled-out form.
On page 5 you see examples of how to fill out the form. Page 6 contains the form, you need to print and fill out during the interview (you will probably need more than one).

Time	**Food/beverage item** (Preparation/cooking)	**Brand** (if known)	**Fat or fiber content** (if known)	**Amount (portion size/grams/slices/pieces)** Use pictures
6:30	*Oat meal*	*Solgryn*	*10% fiber*	*Medium portion*
6:30	*Milk*	*Arla*	*1,5% fat*	*1 big glass*
10:00	*Apple*	-	-	*Big size*
12:00	*White bread*	*Pågen Ätligen*	-	*2 slices*
12:00	*Butter*	*Tine*	*Full*	*Thinly coated*
18:30	*Pasta (boiled)*	-	*Whole-meal*	*Large portion*
19:00-20:00	*Sports drink*	*Powerade*	-	*500 ml*

Subject number:______________________				
Time	**Food/beverage item** (Preparation/cooking)	**Brand** (if known)	**Fat percentage or fiber content** (if known)	**Amount (portion size/grams/slices/pieces)** Use pictures

Appendix 3

Informasjon og forespørsel om deltakelse i et forskningsprosjekt ved Olympiatoppen Sør og Universitetet i Agder

«Energitilgjengelighet og idrettslig prestasjon»

Forekomst og utvikling av relativ energimangel og assosierte helse- og prestasjonsvariabler blant unge mannlige og kvinnelige idrettsutøvere i Sør-Norge

OLYMPIATOPPEN Sør

UNIVERSITETET I AGDER

Kjære unge idrettsutøver!

Vi søker talentfulle unge utøvere innen sykling, langrenn, skiskyting, langdistanseløping, fotball og håndball til å bli med på et forskningsprosjekt i forbindelse med en doktorgrad i idrettsvitenskap ved Universitetet i Agder (UIA) og i samarbeid med Olympiatoppen Sør.

Bakgrunn og hensikt

For utøvere i alle aldre kan det være vanskelig å finne den gode balansen mellom trening, kosthold og restitusjon. I dette forskningsprosjektet ønsker vi å kartlegge en rekke variabler som vi antar har en sammenheng med idrettslig prestasjon og helse. Vi har en del kunnskap om disse variablene blant voksne mannlige og kvinnelige utøvere på toppnivå, men vi vet mindre om tilsvarende variabler blant unge utøvere. Vi har spesielt lite kunnskap om hva som skjer i løpet av perioden hvor unge jenter og gutter går på idrettsgymnas. I denne perioden er det mange som opplever økte treningsmengder, mindre tid til restitusjon og utfordringer med å få i seg nok og riktig mat. I dette prosjektet ønsker vi derfor å måle variabler som treningsmengde, fysisk kapasitet (eks. utholdenhet, muskelstyrke og reaksjonstid), kostholdsvaner, kroppssammensetning og andre helsevariabler som blodtrykk, sykdom og skader. Vi ønsker å måle disse variablene to ganger i sesongen over den perioden man er elev ved idrettsgymnaset.

Dette ønskes gjort for å få et større innsyn i, og forståelse for, hvordan utøvere og trenere kan legge til rette for, og sikre grunnlaget for best mulig trening og prestasjon ikke bare på kort sikt, men også sikre at kroppen bygges opp for å tåle den økende treningsmengde som kreves over lang tid for å bli god i sin idrett.

Med bakgrunn i dette er det i kommende forskningsprosjekt ønskelig å kartlegge fysiologiske helse- og prestasjonsvariabler som trenings- og kostholdsvaner, kroppssammensetning, blodtrykk, hvilemetabolisme, fysiologisk kapasitet, sykdom og skader samt psykologiske variabler som motivasjon, velvære og trening to ganger i sesongen over tre år.

Vi håper at du har lyst til å hjelpe oss med å skaffe slik unik kunnskap og bidra til forskning innen idrettsvitenskap.

Forsøkspersoner

Vi ønsker å rekruttere utøvere som oppfyller følgende inklusjonskriterier:

(1) Elev ved VG1 på idrettsgymnas ved prosjektet begynnelse

(2) Konkurranseaktiv innen idretten sin på regionalt og/eller nasjonalt nivå

(3) Fravær fra sykdom og skader som hindre deltakelse i prosjektet.

Deltakelsen i prosjektet innebærer derfor for deg som deltaker, at du må være villig til å gjennomføre et testbatteri over to dager, samt svare på spørsmål om kosthold, trening og aktivitetsnivå, før og etter sesong (to ganger pr. år) i tre år (totalt seks ganger).

Hva innebærer deltakelse i prosjektet?
Dette er en kartleggingsstudie som vil inneholde to målepunkter fordelt over en sesong (før og etter sesong). Prosjektet vil gjennomføres over tre sesonger, hvilket innebærer seks måle- og registreringsperioder (se figur 1 for oversikt). Prosjektet er lagt opp slik at det ikke skal forstyrre treningsopplegget ditt hvis du ønsker å delta.

Testfasen:
Testfasen består av en testdag med spørsmål knyttet til kostholdet ditt (se eget ark). Du ankommer OLT Sør i Kristiansand kvelden før testen, med dertil overnatting i lokaler tett på OLT.

- Til testen skal du møte fastende i laboratoriet for måling av kroppssammensetning, beinhelse, hvilestoffskiftet, blodtrykk, reaksjonstest, styrketest samt en VO2maks test. I tillegg vil du bli spurt om å besvare noen spørreskjemaer om mat, kropp og helse. En gang i løpet av perioden vil du blive bedt om å svare på samme spørreskjema med to ukers mellomrom (se figur 1 i vedlegg). Du spiser frokost før VO2-maks testen.

***NB:** De siste 24 timer før testdagen må du ikke utføre intensiv eller utmattende trening/konkurranser eller drikke alkohol. Du har ikke tillatelse til å spise, snuse eller røyke de siste 9 timene før testene (disse gjennomføres tidlig på morgenen). De siste tre timer før testene må du ikke drikke te, kaffe eller annen koffeinholdig drikke. Som forsøksperson vil du bli godt ivaretatt av testledere.*

Månedlig spørreskjema:
Du vil hver måned få tilsendt en lenke på epost til et enkelt spørreskjema du bes utfylle elektronisk.

Mulige fordeler og ulemper:
Mulige fordeler:

- Bidra til å skaffe ytterligere kunnskap rundt energitilgjengelighet blant unge idrettsutøvere og ikke-konkurranseaktive ungdom
- Få mulighet til å teste fysisk kapasitet uten kostnad på UIA/OLT Sør
- Få kartlagt helsevariabler av betydning for idrettslig prestasjon uten kostnad på UIA/OLT Sør
- Få kartlagt energitilgjengelighet med muligheter for tilbakemelding på egne kostholdsvaner og utvalgte helsevariabler over tid
- Få målt hvilestoffskiftet og kroppssammensetning med gullstandard målemetoder og kunne følge disse over tid

Mulige ulemper:

- Må møte til fastende til testing hver 6. måned i 3 år. Slik testing kan ligge i skoletiden, da primært ved å erstatte andre treningsøkter, men forventes ikke å ha varighet på mer enn 1,5 time pr. test.
- Kan ikke trene intensive økter dagene før testing
- Må være opplagt til hver test og gjennomføre disse med god innsats
- Måling av hvilestoffskiftet kan oppleves ubehagelig for enkelte
- Risiko for overbelastning ved testing
- Må svare på spørsmål knyttet til kosthold og trening hver 6. måned i tre år (spørreskjema).

Hva skjer med informasjon om deg?

Data som blir registrert skal kun brukes slik som beskrevet i hensikten med prosjektet. Opplysningene vil bli behandlet uten navn og fødselsnummer, eller andre direkte gjenkjennende opplysninger. Som deltaker vil du få et ID nummer som representerer ditt navn. Tester som blir gjennomført og data som blir innhentet, vil knyttes til dette ID nummeret. Det er kun autorisert personell knyttet til prosjektet som har adgang til ID nummeret og nøkkelfilen vil oppbevares nedlåst hos prosjektansvarlig. Innsamlet data vil bli benyttet i masterprosjekt og doktorgradsprosjekt, men alltid anonymt. Dataene vil også kunne bli brukt til publisering i tidsskrift, undervisning og kongresser. Som deltaker har du rett til å få innsyn i data som er registrert på deg selv. Data vil oppbevares avidentifisert på prosjektlederes passordbelagte PC. Data vil bli oppbevart i opptil 10 år etter at prosjektet er avsluttet.

Rett til innsyn og sletting av opplysninger om deg
Hvis du sier ja til å delta i prosjektet, har du rett til å få innsyn i hvilke opplysninger som er registrert om deg. Du har videre rett til å få korrigert eventuelle feil i de opplysningene vi har registrert. Dersom du trekker deg fra prosjektet, kan du kreve å få slettet innsamlede prøver og opplysninger, med mindre opplysningene allerede er inngått i analyser eller brukt i vitenskapelige publikasjoner.

Frivillig deltakelse:
Det er frivillig å delta i prosjektet. Du kan når som helst og uten å oppgi noen grunn trekke ditt samtykke til å delta i prosjektet. Dersom du ønsker å delta, undertegner du samtykkeerklæringen på som medfølger. Om du nå sier ja til å delta, kan du senere trekke tilbake ditt samtykke uten at det påvirker din øvrige deltakelse. Dersom du senere ønsker å trekke deg eller har spørsmål til prosjektet, kan du kontakte prosjektleder/ kontaktperson (se under).
Ytterligere detaljert informasjon om prosjektet og de ulike testene kan utleveres ved å kontakte stipendiat Thomas Birkedal Stenqvist.

Annet:
Datainnsamling forventes avsluttet senest i uke 17, 2019. Datamateriale forventes oppbevart i 10 etter endt datainnsamling.

Hvordan bli med?
Dersom du ønsker å være en del av dette prosjektet kan du sende en mail eller SMS til thomas.b.stenqvist@uia.no / +47 45290621 der du beskriver følgende:

- Hvem du er
- Idrettsgren og nivå
- Skole og klasse
- Fødselsdato (**NB: IKKE FØDSELSNUMMER**)!!

Med vennlig hilsen
Thomas Birkedal Stenqvist
PhD stipendiat

Fakultet for helse- og idrettsvitenskap
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Universitetet i Agder
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Konsulent, Test- og laboratorietjenester
Olympiatoppen Sør

Prosjektansvarlig og veileder
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Førsteamanuensis

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Fagansvarlig Idrettsernæring og restitusjon,
Olympiatoppen Sør

VEDLEGG: Ytterligere informasjon om målemetodene

Detaljert beskrivelse av de ulike testene
Testdagen
Ved ankomst til laboratoriet ønsker vi først å måle hvilestoffskiftet ved hjelp av indirekte kaliometri.

Hvilestoffskiftet: Vi vet at det kan være store forskjeller i hvilestoffskiftet mellom individer og de aller færreste vet hvor mye energi de bruker i hvile da målemetodene sjelden er tilgjengelig. Som forsøksperson skal du ligge avslappet på en benk i ca. 30 minutter med en «hette» (som vist på bildet). Målingen medfører ingen smerte eller ubehag. Hvilepulsen vil bli registrert og vi vil se til at du ikke sovner underveis i målingen. Mens dere ligger på benken vil vi også måle **blodtrykket** liggende og deretter i stående posisjon.

Beinhelse og kroppssammensetning: DXA (dobbel røntgen absorpsjonsmetri) er gullstandard måling for vurdering av din kroppssammensetning og beinhelse. Dette måles ved hjelp av lav-dose røntgenstråling (stråledosen du blir utsatt for er svært liten og tilsvarer samme mengde du vanligvis får ved å fly fra Oslo til New York). Ved DXA måling vil du foruten å få målt muskelmasse og fettmasse også få målt din beinmineraltetthet (indikator på hvor sterkt skjelettet ditt er). Du vil få resultater både totalt for hele kroppen, men også i spesielt interessante områder som rygg og hofter. Selve målingen er helt smertefri og gjennomføres fullt påkledd ved å ligge på en benk/seng. Det vil kun ta ca. 15 minutter å gjennomføre målingen.

Arbeidsøkonomi: Vi ønsker å måle hvor effektive dere er til å utføre et stykke arbeide i fastende tilstand, og hvor mye det koster å doble arbeidsmengden. Arbeidet utføres på en stasjonær sykkel, hvor vi måler forbruket av oksygen og produksjonen av karbondioksid. Testen består av 3 blokker av 6 min hver. Belastningen er hhv. 0 watt, 50 watt og 100 watt. Belastningen er derfor meget lav og testen vil føles meget lett.

Reaksjonstest: Reaksjonstiden du bruker måles ved hjelp av en bærbar PC. Reaksjonstiden testes ved å måle tiden du bruker på å trykke mellomroms-tasten ned på tastaturet når PC-skjermen skifter farge.

Maksimal styrke: Her vil vi måle din maksimale muskelstyrke ved hjelp av dertil utvalgt styrkeprotokoll. Det vi ønsker å måle er hhv. Utholdenhet, maksimal styrke og power.

Måltid: Etter styrketesten er det tid for frokost. Dere spiser egen medbrakt mat, alternativ kjøper på Joker. De som testes tidlig MÅ medbringe egen frokost. Frokosten inntas 2 timer og 20 minutter før siste prestasjonstest.

VO_{2maks}: Under testen måles oksygenopptaket til utmattelse. Du vil bli bedt om å begynne arbeidet på en gitt belastning som vil økes hvert minutt inntil utmattelse inntrer og du ser deg nødsaget til å avslutte testen. De to høyeste målinger du oppnår danner grunnlag for dit maksimale oksygenopptak. Alle utenom syklister teste på tredemølle. Testen begynner på 6 km/t med en konstant stigning på 10,5%. Farten på tredemøllen økes med 1km/t pr. minutt inntil utmattelse inntreffer.

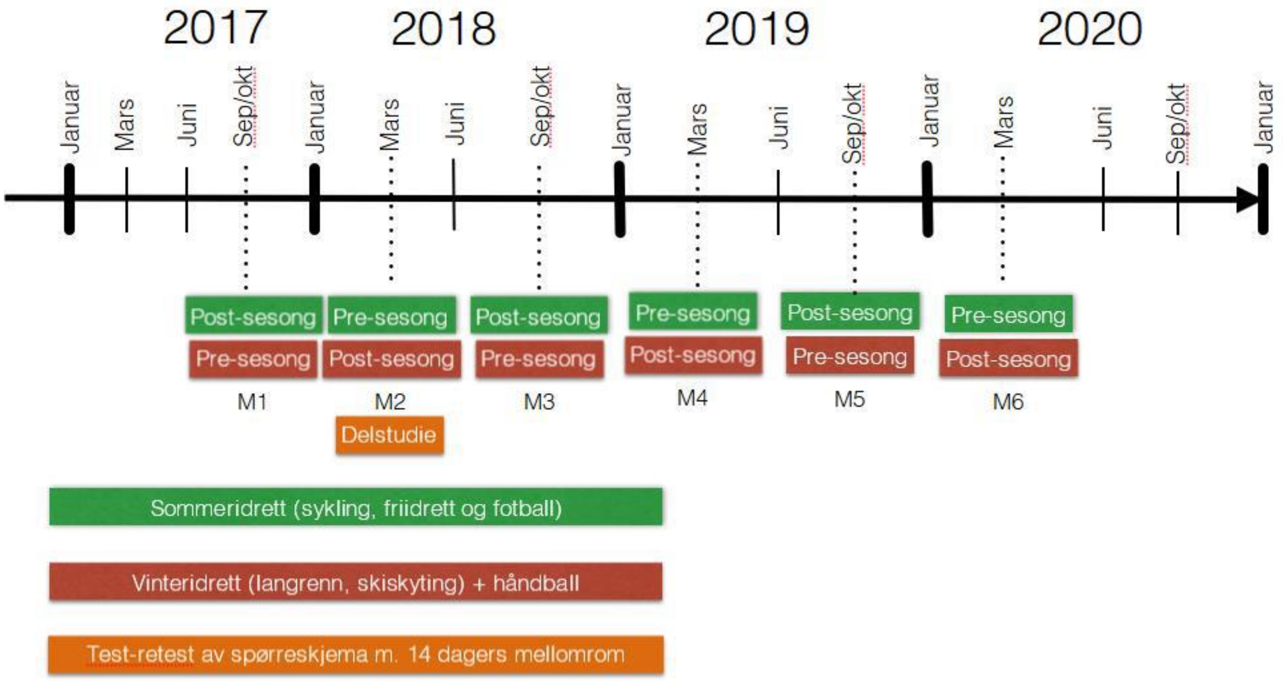
Avslutningsvis bes dere om å besvare noen spørreskjema før dere er ferdige med dagens testbatteri. Spørsmålene omhandler temaer som demografi, treningsmengde, konkurranseerfaring, forhold til trening, mat og kropp, skader/sykdommer og restitusjon/søvn/velvære.

Uken før testing:
Uken før testing vil du få utlevert en Polar pulsklokke, en aktivitetsmåler og en søvnmåler. Du skal uken før du ankommer OLT Sør (totalt 7 dager) lagre **ALLE** treningsøkter med puls på klokken! Dette er **EKSTREMT** viktig, da vi da kan estimerer energiforbruket ditt under trening. Har pulssensoren (H7) dårlig batteri, medfølger det nytt batteri til alle, som er enkelt å bytte.

Videre vil du fått utdelt en aktivitetsmåler fra Bodymedia. Denne skal festes på venstre biceps som vist på det medfølgende dokument. **VIKTIG** at du går med denne samme 7 dagene som du benytter pulsklokka inntil testing på OLT Sør. Du skal også huske at du skal **SOVE** med den på! Du skal altså **KUN** ta av deg måleren når du skal dusje, svømme og trene. **VIKTIG** at du husker å ta den på igjen når du har hatt den av!

Søvnmåleren tar du på deg når du legger deg og tar den av igjen når du står opp. Denne måler hvor mye og urolig du sover, og kan gi en indikasjon på søvnkvaliteten. Noe som er viktig i forhold til optimal restitusjon. Ved første målepunkt får du ikke søvnmåleren utlevert **FØR** dere har testet på OLT Sør, men i fremtiden vil denne ankomme sammen med Polar klokken og aktivitetsmåleren.

Tidslinje for hele prosjektet:



Figur 1: *Oversikt over prosjektet. Prosjektet består av seks målepunkter (M1 – M6) hver 6. måned, samt hvor i sesongen hhv. vinteridrett og sommeridretter befinner seg. En gang i løpet av prosjektet sendes det samme spørreskjema med 14 dagers mellomrom.*

Appendix 4:

Samtykke til deltakelse i prosjektet «Energitilgjengelighet og idrettslig prestasjon»

Ved å si ja til å delta i prosjektet, har du rett til å få innsyn i hvilke opplysninger som er registrert på deg. Du har videre rett til å få korrigert eventuelle feil i de opplysningene vi har registrert. Dersom du trekker deg fra prosjektet, kan du kreve å få slettet innsamlede opplysninger, med mindre opplysningene allerede er inngått i analyser eller brukt i vitenskapelige publikasjoner.

Ved å signere samtykkeerklæringen bekrefter du også at du ikke har kjent hjertesykdom eller andre lidelser/sykdom som medfører at din fastlege har frarådet deg å teste intensivt.

Som deltaker i prosjektet er du for øvrig forsikret via at staten er selvassurandør for universitetene.

Jeg er villig til å delta i prosjektet

(Signert av prosjektdeltaker, dato)

Jeg bekrefter å ha gitt informasjon om prosjektet

(Signert, rolle i prosjektet, dato)