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Masteroppgave

Bone mineral density and RED-S among young cyclists – a cross sectional study

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Forord

Denne oppgaven markerer slutten på to svært lærerike år ved Høgskolen i Innlandet. Først og fremst vil jeg takke min veileder Anne Mette Rustaden for mange gode samtaler og veiledning underveis i prosjektet og i skriveprosessen. Takk for at du har motivert meg til å stå på og hele tiden hatt troen på meg.

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Abstract

Purpose

Cycling is a high energy demanding and weight-sensitive sport, with little or no weight-bearing load on the skeleton. Thus, cyclists are at risk of developing low bone mineral density (BMD), and at a high risk of developing low energy availability (LEA). However, little is known about BMD and relative energy deficiency in sport (RED-S) in young male cyclists. Therefore, this study aimed to investigate BMD and symptoms of RED-S in well-trained adolescent male cyclists.

Methods

In total, 18 well-trained adolescent male cyclists (age 16.3 ± 0.7) and 11 age-matched non-athlete controls (16.6 ± 1.0) were recruited to this cross-sectional study. The cyclists were tested at three different time points over a 1-year period (at off-season, post-season and pre-season), and the controls were tested only once. Lumbar spine BMD was measured using dual energy X-ray absorptiometry (DXA) and RED-S was measured with the questionnaire "low energy availability among males- questionnaire" (LEAM-Q).

Results

At pre-season, 50 % of the included cyclists had Z-scores in the osteopenic range (< - 1), compared to 73% post-season and 50 % at off-season. Additionally, in the subgroup questions about dizziness in LEAM-Q, more than half of the cyclists responded that they felt dizzy at times. The result showed no significant change in BMD throughout one year, off-season to pre-season (Jan 2020- April 2021) within the cyclists ($p > 0.05$). However, a significant increase in BMD from post-season to pre-season were observed ($p < 0.05$). There was no significant difference in lumbar spine BMD Z-score between the cyclists and the controls (L1-L4: - 0.578 ± 0.703 vs - 0.327 ± 0.889, $p = 0.407$).

Conclusion

Adolescent cyclists had low BMD during a 1-year period, with 50 %, 73 % and 50 % of the participants qualifying to osteopenia at pre-season, post-season and off-season, respectively. However, cyclists did not have a lower BMD compared to controls.

Abbreviations

Abbreviation	Description
ACSM	American College of Sports Medicine
BMD	Bone Mineral Density
BMC	Bone Mineral Content
DXA	Dual energy X-ray Absorptiometry
EA	Energy Availability
EEE	Energy Exercise Expenditure
EI	Energy Intake
FFM	Fat Free Mass
Triad	Female Athlete Triad
GP	General Practitioner
IGF-1	Insulin-like growth factor 1
IOC	International Olympic Committee
LEA	Low Energy Availability
NTG	Norges Toppidrettsgymnas
PBM	Peak Bone Mass
RED-S	Relative Energy Deficiency in Sport
RER	Respiratory Exchange Ratio
RMR	Resting Metabolic Rate
TDEE	Total Daily Energy Expenditure
T_3	Triiodothyronine
WHO	World Health Organization

Appendices

1. Theory

1.1 Relative Energy Deficiency in Sport (RED-S)

A balanced diet with a sufficient energy intake (EI) is important for optimal body functions and a healthy lifestyle (Torstveit, Fahrenholtz, Stenqvist, Sylta, & Melin, 2018). Athletes performing in leanness sports, where a low body weight is of importance for performance, such as endurance sports, are at a high risk of restricted eating behaviour and a relative energy deficiency. The negative balance may also be affected by a high energy expenditure in exercise and competition. Thus, in 1992 the term "Female Athlete Triad" (triad) was defined by the American College of Sports Medicine (ACSM), and included disordered eating, amenorrhea and osteoporosis (Yeager, Agostini, Nattiv, & Drinkwater, 1993). Furthermore, in 2007 the ACSM redefined the triad as "*the interrelationships among energy availability, menstrual function and bone mineral density, which may have clinical manifestation including eating disorders, functional hypothalamic amenorrhea and osteoporosis*" (Nattiv et al., 2007, p. 1867) (Figure1).

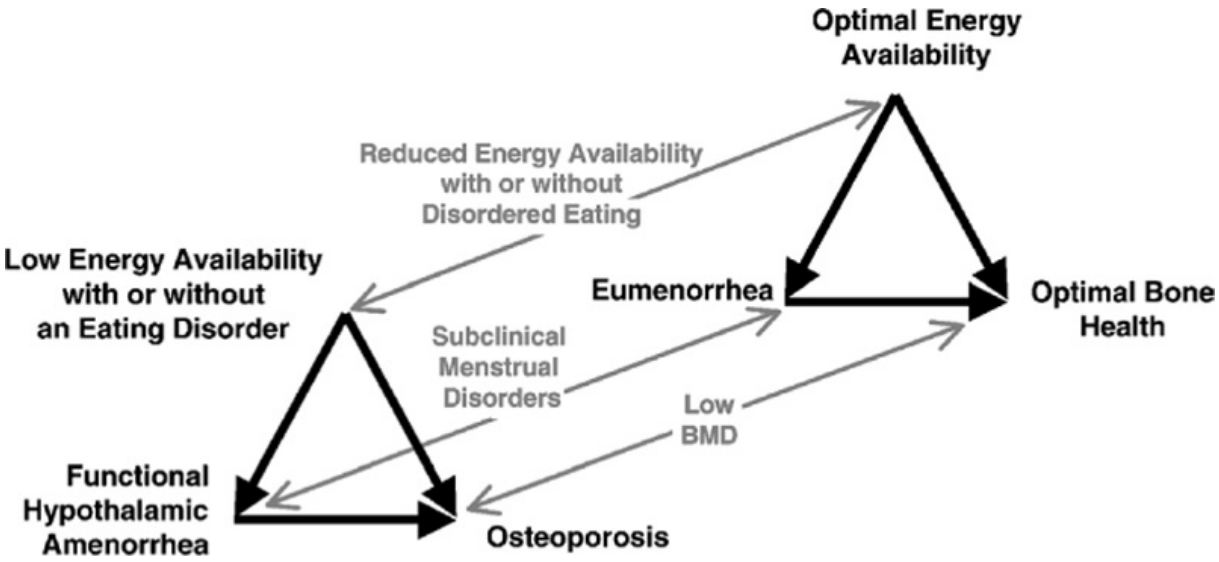

Figure 1. The triad ranges from optimal energy availability, eumenorrhea and optimal bone mineral density, to low energy availability, osteoporosis and amenorrhea in female athletes (Nattiv et al., 2007).

As the term triad had some limitations due to both genders and the consequences of low energy availability (LEA), the International Olympic Committee (IOC) introduced a new term in 2014, "Relative Energy Deficiency in Sport" (RED-S) (Mountjoy et al., 2014). Previous, the triad was only limited to female athletes, and the research in this area was mostly concerning females. RED-S expands upon the triad and include a broader range of health and performance concerns

and consequences for both male and female athletes. RED-S is defined by the IOC consensus statement from 2014 as "*impaired physiological function including, but not limited to, metabolic rate, menstrual function, bone health, immunity, protein synthesis, cardiovascular health caused by relative energy deficiency*" (Mountjoy et al., 2014, p. 491). RED-S is a generic term for a syndrome primarily caused by a mismatch between an athletes EI and energy availability (EA). The inadequacy of energy to support various body functions involved in maintaining optimal health and performance is defined as LEA. EA is defined as the following:

Energy Availability (EA) =

Energy Intake (EI) (kcal)
– Exercise Energy Expenditure (EEE) (kcal)
/ Fat Free Mass (FFM) (kg)

The IOC consensus statement from 2014 classified the cut-off points for LEA in females as ≤ 30 kcal/kg FFM/day, as this appears as the threshold where severe health implications have been observed after only 5 days in healthy, young, women (Mountjoy et al., 2014; Wasserfurth, Palmowski, Hahn, & Krüger, 2020). Reduced EA is classified as 30 – 44 kcal/kg FFM/day and optimal EA as ≥ 45 kcal/kg FFM/day (Lane et al., 2019; Mountjoy et al., 2014). At present, it is uncertainty about the cut-off points in male athletes, with too little research conducted to determine male-specific thresholds (Lane et al., 2019). However, a study by Koehler et al. (2016) on aerobically exercising men found that 40 kcal/kg FFM/day is enough to support energy balance, though, this is a study with a small sample size (n = 6).

LEA occurs when there is a reduction in EI or when there is an increased exercise load, causing adjustments to various body systems to reduce energy expenditure (Mountjoy et al., 2014). Furthermore, psychological stress and depression can both result in LEA and eating disorders, however, these factors can also be a result of LEA. Disordered eating follows when an athlete start to diet to enhance performance and thereby use extreme weight loss strategies, or when they have an abnormal eating behaviour, a distorted body image, low self-esteem, are exposed to social pressure, perfectionism and a varying athletic performance (Basková, Holubcikova, & Baska, 2017; Francisco, Narciso, & Alarcão, 2013; Mountjoy et al., 2014; Werner et al., 2013). The scale ends with eating disorders such as anorexia nervosa, bulimia nervosa, binge or other eating disorders.

Athletes with long-term LEA may develop nutrient deficiencies, chronic fatigue and have an increased risk of infections and illnesses, which all have the potential to negatively affect health and performance (Mountjoy et al., 2014). RED-S can cause severe implications in several physiological systems, and thus result in both short- and long-term compromise of optimal health, including menstrual function, bone health, immunological factors, endocrine factors, metabolic factors, haematological factors, psychological factors, gastrointestinal factors and cardiovascular factors in addition to growth development (Figure 2).

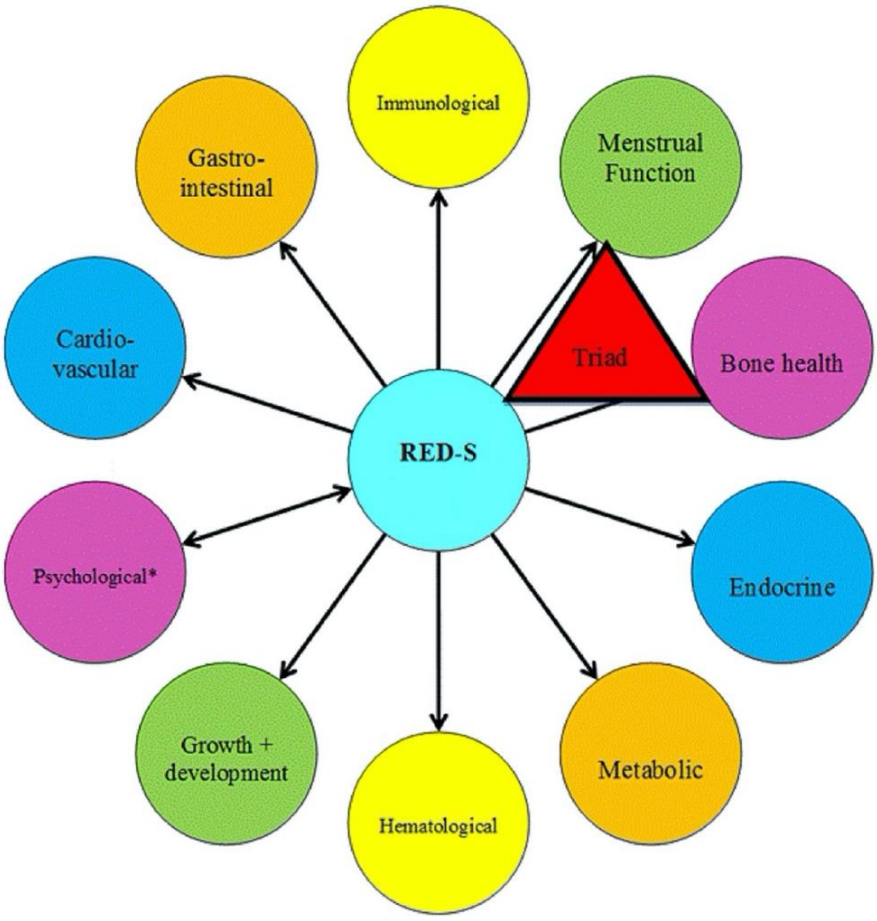

Figure 2. Health consequences of RED-S (Mountjoy et al., 2014)

Furthermore, RED-S can affect athletic performance by increasing the injury risk, decreasing training response, decreasing endurance performance, decreasing muscle strength, decreasing glycogen stores, decreasing concentration and coordination, impairing judgement as well as causing depression and irritability (Figure 3) (Mountjoy et al., 2014).

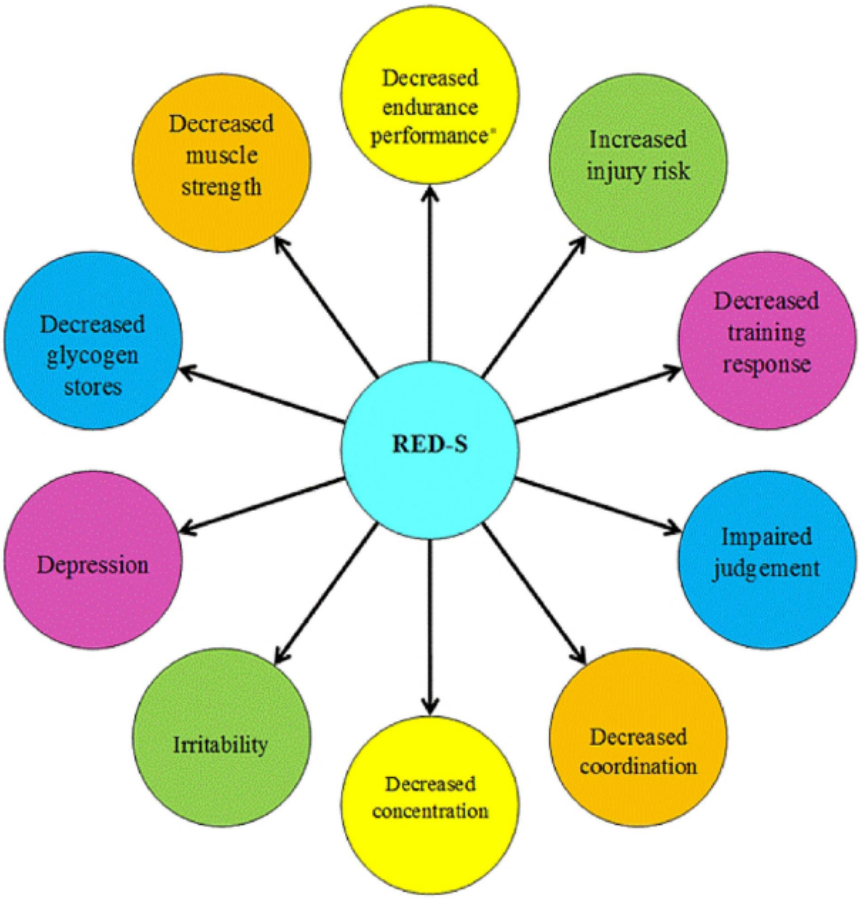

Figure 3. Potential performance effects of RED-S (Mountjoy et al., 2014).

1.1.1 Who is at risk?

All athletes are potentially at risk of RED-S, however, athletes participating in endurance sports and weight-sensitive sports in which leanness or weight are of importance for either performance, appearance, or as a requirement to meet a competition weight category are at greater risk of developing LEA and disordered eating, and thereby also RED-S (Mountjoy et al., 2014; Margo Mountjoy et al., 2018; Torstveit et al., 2019). Cycling is a sport of which are associated with high energy expenditure and low body weight, and the prevalence of LEA and risk of RED-S in male cyclists has been observed to be high (50%) (Mountjoy et al., 2014).

A study by Viner et al. (2015) identified that 67 % of male cyclists, and 75 % of female cyclists were restrained eaters who consciously restricted their EI for weight control. During pre-season, competition seasons and off-season, respectively 70 %, 90 % and 80 % of the subjects in the study had LEA (< 30kcal/kg FFM/day). Additionally, Keay, Francis and Hind (2018) included 50 male cyclists in their cross-sectional study, and identified that 28 % of the subjects had LEA, based on limited fuelling around training (non-restrictive eating and little variation in body

weight throughout a season) and 20 % with chronic LEA, based on disordered eating, eating disorder or intentional restrictive eating to achieve substantial weight loss of which sustained over more than one cycling season (Table 1).

However, RED-S is also a relatively usual occurring syndrome in athletes performing sports of which are not endurance- or weight-sensitive and in athletes who are not diagnosed with either disordered eating or eating disorders (Melin et al., 2016; Mountjoy et al., 2014). A Swedish study examined mental health problems in young elite athletes (n = 333), and found a prevalence of 51.7 %, with stress and disordered eating amongst the most common underlying causes (Åkesdotter, Kenttä, Eloranta, & Franck, 2020). A study comparing different factors associated with eating behaviours among young female and male athletes (n = 580), and non-athletes (n = 362) found that 18 % of female athletes and 14 % of male athletes, 26 % of female controls and 15 % of male controls had symptoms of eating disorders (Fortes, Kakeshita, Almeida, Gomes, & Ferreira, 2014). Additionally, the prevalence of dieting among young adolescent athletes are 15 % among males and 33 % among females, and 17 % and 44 % among non-athlete males and females (Rosendahl, Bormann, Aschenbrenner, Aschenbrenner, & Strauss, 2009). Approximately 38 % of adolescent sports students reported to have disordered eating, and 50 % of students in general programs (Torstveit, Aagedal-Mortensen, & Stea, 2015). The prevalence was found to be significantly higher in females compared to males, 64 % and 45 % respectively.

There are up to this date little research on the prevalence of RED-S among different sports, however, Rogers and collegues (2021) reported the prevalence of symptoms described by RED-S in a mixed-sport cohort of female athletes (n = 112), including sports such as weightlifting, water polo, triathlon, netball, rowing, boxing and basketball. They identified that 80 % of the participants demonstrated with at least one symptom related to RED-S and 37 % presented with two or three symptoms.

1.2 Bone Mineral Density (BMD)

Bone health is one of the physiological health consequences of which is adversely affected by RED-S (Mountjoy et al., 2014). Bone turnover is a slow process, ongoing throughout life, with approximately 10 % of the skeleton remodelled every year (Andersen, Clarsen, Garthe, Mørland, & Stensrud, 2018; Areta, Taylor, & Koehler, 2021). Bone turnover is a result of the

relationship between bone remodelling and bone resorption and is dependent on factors, such as gender, endocrine factors, strain applied to the skeleton and nutrition (Goolsby & Boniquit, 2017; Nattiv et al., 2007). Diet and exercise are significant factors for optimal peak bone mass (PBM), this includes EA, vitamin D and calcium, weight-bearing sports and multidirectional exercise (Mountjoy et al., 2014; Fredericson et al., 2007). In adolescent and young adulthood, the gain of bone mass is rapid and PBM is normally achieved by the age between 20 and 30 (Baxter-Jones, Faulkner, Forwood, Mirwald, & Bailey, 2011; Mountjoy et al., 2014). After that point on, BMD can only be maintained (Baxter-Jones et al., 2011).

Evidence indicates that athletes with long-term LEA is presented with altered bone metabolism due to raised bone resorption, reduced bone mass and decreased bone strength, which causes increased risk of stress fractures and decreased sports performance (Papageorgiou, Dolan, Elliott-Sale, & Sale, 2018). Additionally, LEA has been found to be an independent factor for poor bone health as there is found a decrease in insulin-like growth factor 1 (IGF-1) levels and bone formation markers. However, males are potentially more resilient to the bone turnover markers affected by LEA than females (Areta et al., 2021; Murphy & Koehler, 2020; Papageorgiou et al., 2017).

Osteoporosis is a serious skeletal disease of which is characterised by low BMD and microarchitectural deterioration of bone tissue, affected by PBM (Rapún-López et al., 2019). It is found that people with osteoporosis are presented with bone fragility and fracture risk, resulting in a deterioration in quality of life and increased mortality. Approximately 60 % of the risk of osteoporosis can be explained by the amount of bone mineral attained by early adulthood. Therefore, the age from 15-25 years is a crucial period in which one forms the basis for a lifelong bone health (Baxter-Jones et al., 2011; Kohrt, Bloomfield, Little, Nelson, & Yingling, 2004; Scofield & Hecht, 2012). Doing weight-bearing activities during adolescence may contribute to the prevention of osteoporosis (Mountjoy et al., 2014). Stress fractures occur when normal remodelling and reparative processes are overwhelmed by increased load and strain leading to an increased bone resorption that outpaces bone formation (Scofield & Hecht, 2012). Stress fractures usually strike when athletes increase their training frequency, intensity or duration, and continued repetitive stress may eventually result in a stress fracture.

The World Health Organization (WHO) has defined osteoporosis in postmenopausal women as a T-score ≤ -2.5 standard deviation (SD), and low bone mass (osteopenia) between -1.0 and

– 2.5 SD below peak young adult BMD measured with dual-energy X-ray absorptiometry (DXA) (Scofield & Hecht, 2012). However, when assessing BMD in premenopausal women and men under 50, it is recommended using Z-scores, which compare bone density with age- and gender-matched controls. In the athlete population, low bone mass, or osteopenia, is defined as a Z-score between −1.0 and −2.0, together with a history of nutritional deficiencies, hypoestrogenism, stress fracture or other secondary clinical risk factors for fracture (Mountjoy et al., 2014). A Z-score below – 2.0 is considered osteoporosis with the occurrence of secondary clinical risk factors. ACSM recommended these definitions when evaluating bone health in athletes, as athletes participating in sports that involve high-impact loading are found to have a 5 - 15 % higher BMD compared to the general population (Andersen et al., 2018; Adam S. Tenforde & Fredericson, 2011). However, athletes in non-weight-bearing sports, and/or endurance athletes are often found to have a BMD below average (Tenforde, Barrack, Nattiv & Fredericson, 2016)

1.2.1 Bone Health Among Cyclists

Cycling is a demanding sport combining both extreme exercise durations, intensity and frequency (Jeukendrup, Craig, & Hawley, 2000). Professional road cyclists have approximately 60-100 race days per year, with several race situations and durations (sprints, time trials and mass-start road races), and thus have a very high energy expenditure (Burke et al., 2018; Jeukendrup et al., 2000). The power-to-weight ratio or watt per kilogram is the most important performance marker in cycling, and a reduction in bodyweight (reduced resistance) will increase cycling performance as long as the power is sustained (Andersen et al., 2018). A sustained high energy expenditure combined with challenges of optimising physique can result in LEA and thereafter, RED-S (Burke et al., 2018; Logue et al., 2020). A high energy expenditure presents an increased risk of an unintentional LEA from a combination of factors, including lack of knowledge, access to energy sources when exercising and gastrointestinal challenges (Burke et al., 2018). The biomechanics of cycling also makes it a non-weight-bearing sport with little or no osteogenic stimulus to bones and may also adversely affect bone mass during adolescence (Keay, Francis, Entwistle, & Hind, 2019; Rapún-López et al., 2019; Smathers, Bemben, & Bemben, 2009). Andersen et al. (2018) evaluated the bone health in Norwegian male and female road cyclists and middle-and long-distance runners and identified that over 50 % of the cyclists had osteopenia, whilst none of the runners were presented with osteopenia (Table 1). Several studies have found a high prevalence of osteopenia and

osteoporosis in professional and master cyclists (Table 1) (Andersen et al., 2018; Keay, Francis, & Hind, 2018; Medelli, Lounana, Menuet, Shabani, & Cordero-MacIntyre, 2009; Nichols, Palmer, & Levy, 2003; Rector, Rogers, Ruebel, & Hinton, 2008; Smathers et al., 2009).

1.3 Metabolic Factors

1.3.1 Resting Metabolic Rate in Athletes

Athletes who are doing multiple intense training sessions throughout the week are likely to have a higher total daily energy expenditure (TDEE) compared to sedentary individuals (Jagim et al., 2018). Resting metabolic rate (RMR) is the minimum energy the body requires to perform basic functions, as growth, reproduction, immunity, thermoregulation, physiologic functions and cellular maintenance (Schofield, Thorpe, & Sims, 2019). RMR is principally dependent on lean mass, and can be used as an indicator of EA, defined as the energy remaining for metabolic processes as soon as the energy cost of exercise has been subtracted from dietary intake. Homeostasis is centrally regulated, and RMR is closely linked to appetite and EI. Consequently, when EI is insufficient to support an intensified training load, athletes are more likely to suffer from suboptimal EA and lower RMR. RMR is the largest component of TDEE, accounting for 50 – 70 %, of which fat free mass (FFM) is the major contributor accounting for approximately 60 – 70 % of RMR (Schofield et al., 2019). A response of the body when an individual has LEA is to suppress RMR (Melin et al., 2015). When measuring RMR through indirect calorimetry, we obtain the respiratory exchange ratio (RER), which reflects the respiratory exchange of carbon dioxide and oxygen (Deuster & Heled, 2008). RER can be used as an indicator of metabolic substrate use in tissues, and a ratio of 0.7 indicates mixed fat use, and a ratio of 1.0 indicate an exclusive use of carbohydrates.

An elevated RMR has been reported in trained endurance athletes for at least 39 hours after the last training session (Torstveit et al., 2019). Associations between suppressed RMR and elevated LEA risk scores has been observed in female ballet dancers and in male ballet dancers with higher training volume (Logue et al., 2020). Hence, low RMR ratio indicate a potential surrogate marker for LEA. Females with exercise-associated amenorrhea caused by LEA has been found to present with lower RMR than expected (Koehler et al., 2016). Additionally, significant lower RMR has been observed in female athletes with amenorrhea compared to eumenorrheic athletes (Lebenstedt, Platte, & Pirke, 1999).

A significant reduction of 5 % in absolute RMR and relative RMR from pre- to post have been observed in elite male, and female rowers completing four weeks of intensified training (Woods, Garvican-Lewis, Lundy, Rice, & Thompson, 2017). Furthermore, a Norwegian study did also identify a significant reduction of approximately 3 % from pre- to post in absolute and relative RMR and in RMR_{ratio} in well-trained male cyclists who had undertaken a four-week intensified endurance training intervention (Stenqvist, Torstveit, Faber, & Melin, 2020). There was also found a low RMR_{ratio} in 72 % of male endurance athletes, including triathletes, long-distance runners and cyclists participating in a study by Torstveit and co-workers (2019) (Table 1).

1.4 Bone health and RED-S in cyclists

To date, the primary RED-S health variable observed in road cyclists is poor bone health with lower BMD in the lumbar spine compared to other athletes (Burke et al., 2018; Rector et al., 2008). This is observed in adult cyclists, whereas little is known about RED-S and associated bone health in adolescents. A mean loss of BMD reported over a cycling season has been found to be approximately 1.5 % (Barry & Kohrt, 2008). LEA has been reported in male athletes and is appearing to be one of the most significant factors associated with an athlete's illness or injury rate (Tenforde et al., 2017; Viner, Harris, Berning, & Meyer, 2015). LEA appears to be a possible reason for low BMD in cyclists, however, as cycling is a non-weight-bearing activity providing little osteogenic stimuli, the activity in itself may contribute as a possible reason to low BMD (osteopenia) in cyclists (Burke et al., 2018). Several studies have reported a high prevalence of restrained eating practices and suboptimal EA in road cyclists, and some have been associated with low BMD (Keay et al., 2018; Viner et al., 2015) (Table 1).

To summarise the existing literature on bone health and RED-S in cyclists, a systematic search was conducted in three online databases. Searches were conducted in PubMed, SPORTDiscuss and Scopus, which are all databases providing access to appropriate evidence-based peer-reviewed research. The following search term were decided upon and applied in all databases: ("relative energy deficiency in sport" OR "RED-S") AND (athletes OR cyclists)

The search was carried out by screening the titles of the articles. Furthermore, the articles were either excluded or included for further review of full text. Language limiters were applied inn all databases for restricting search to articles published in English, Norwegian, Danish and

Swedish. Additionally, in Scopus the filter "articles" was applied. The flow diagram is describing how the search were narrowed down to six articles of which were included in the literature review (Figure 4). The findings from the six articles are summarised in Table 1.

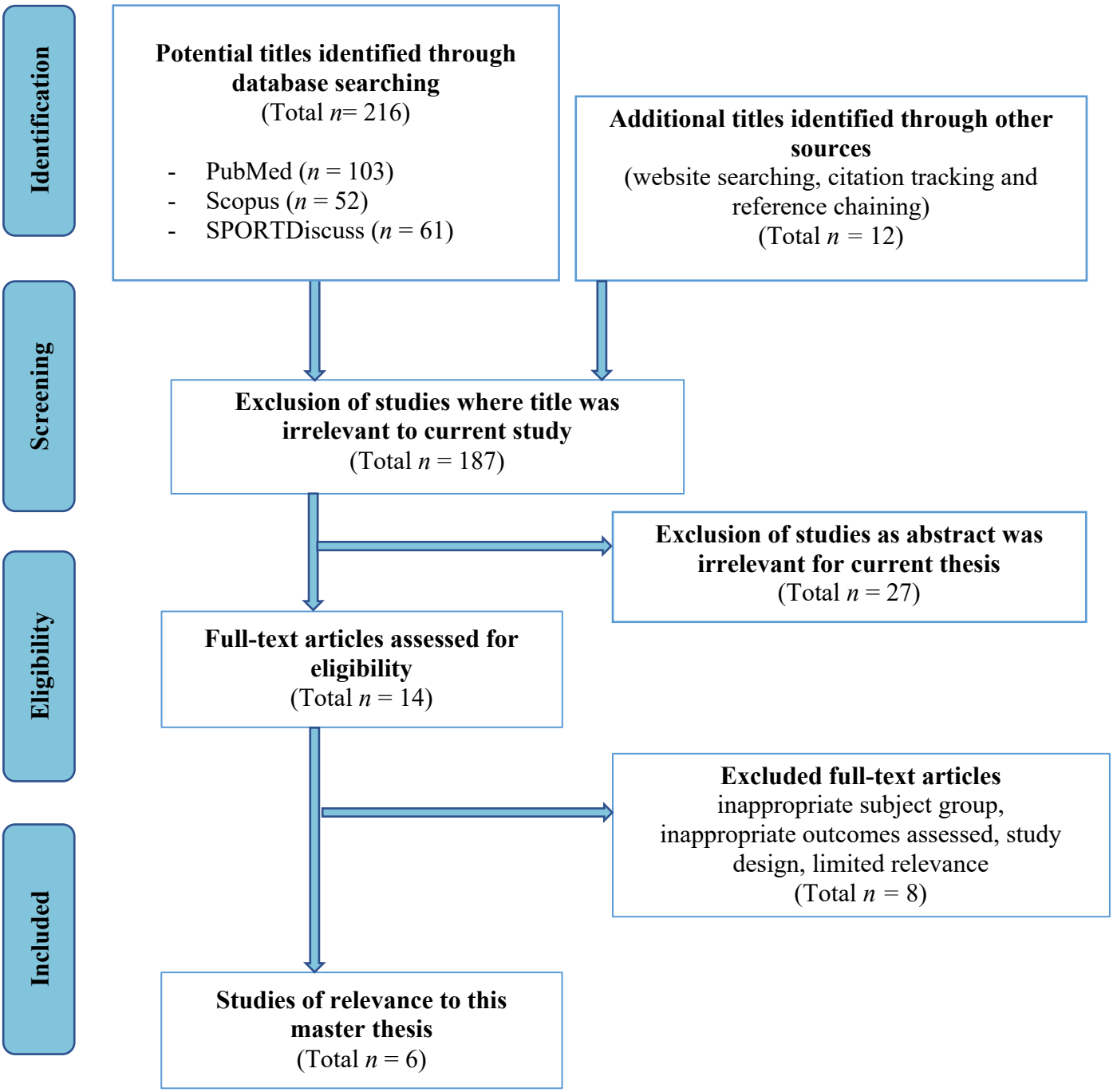

Figure 4. Flow diagram of the screening process

Table 1. Summary of studies examining RED-S/bone health/EA in competitive cyclists

Reference	Population	Study design	Main measures	Key findings
Torstveit et al. 2019	CYC n = 32 RUN n = 5 Triathletes (TRI) n = 16 Male (53) 35.3 ± 8.3y 180.9 ± 5.4 cm 75.2 ± 6.9kg	Cross-sectional	RMR Dietary intake and training sessions (EEE) over 3-4 days Questionnaires Exercise dependence scale (EXDS) Eating disorder examination questionnaire (EDE-Q) DXA Fasting blood samples Cortisol, testosterone, T_3, IGF-1, insulin, glucose	**Questionnaires** Subjects w/higher EXDS score = higher EEE (P = 0.00), lower energy balance (P= 0.008) & a trend towards LEA compared with subjects with lower EXDS score. No difference in overall injuries between high- and low- EXDS score groups. Tendency towards higher EDE-Q score and shape and weight concern among those with higher EXDS score. EXDS total score positively correlated with EDE-Q global score (P < 0.05), & subscale score for restraint and weight concern (p < 0.05). **RMR:** Low RMR_{ratio} in 72 % of participants, no difference between groups. RMR (kcal/kg FFM/day) = 26.0 ± 1.9 **Blood samples** n = 3 with higher EXDS score had elevated cortisol levels. 50 % of those with higher EXDS score had cortisol levels above the highest quartile of ref. range. Testosterone above lowest quartile of ref. range in all subjects. T_3, glucose and IGF-1 in normal range.
Keay, Francis and Hind, 2018	CYC Males n = 50 35.0 ± 14.2y 1.81 ± 0.06m 72.3 ± 6.7kg	Cross-sectional	Questionnaire Sport-specific energy availability questionnaire and interview (SEAQ-I) DXA Total body, lumbar spine (L1-L4) and femoral neck Fasting blood samples Total testosterone (TT), Vit. D, T_3, albumin, calcium, corrected calcium, alkaline phosphatase	**Dietary/Questionnaire** 28 % identified with LEA from SEAQ-I: n = 5 had ED or DE, n = 5 had long-term intentional restrictive nutrition to sustain low body weight. All expressed strong views that achieving low body weight & body fat was critical to maximise cycling performance (watts/kg). **Blood samples** Mean vit.D relatively low (74.8 ± 33.4nmol/L), testosterone in the lower end of ref. range (14.7 ± 4.23 nmol/L), T_3 in lower half of ref. range (4.83 ± 0.71 nmol/L) **BMD** L1-L4, Z-score: -0.8 ± 1.2 (range: -3.2 to 1.6) 14 CYC had LEA: Lumbar spine Z-score of -2.0 ± 0.6, which is significantly lower (P < 0.05) than in CYC w/ adequate EA: Lumbar Spine Z-score of -0.4 ± 1.1 **Body composition** CYC with LEA (n = 14): lower % body fat (P = 0.019), lower visceral fat (P = 0.002) and lower BMI (P = 0.018) compared to CYC with adequate EA.
Andersen et al. 2018	CYC n= 19 24.0 ± 4.0y 177.1 ± 7.6 cm 70.1 ± 10.0kg Males (21), females (19) Middle/long-distance runners (RUN) n = 21 25.4 ± 4.4y 178.1 ± 11.8 cm 65.4 ± 10.3kg	Cross-sectional	DXA Total body, lumbar spine (L2-L4), femoral neck Questionnaires 1: health variables, training and injuries 2: daily calcium intake	**Body composition** RUN lower BMI compared to CYC (P ≤ 0.001). No other differences in demographic/anthropometrical measures between groups. **BMD** RUN significantly higher BMD (P ≤ 0.05) all measured sites. Total BMD largest difference (P ≤ 0.01). None in RUN group had Z-score ≤ -1. Z-score ≤ -1 found in 53% of CYC (females n = 4/7, males n = 6/12) Low BMD in L2-L4 (n = 7), femoral neck (n = 4), total BMD (n = 1) Osteoporotic (Z-score ≤ -2) in L2-L4, n = 1 **Calcium intake** sufficient in all athletes, not associated with low BMD in CYC.

Table 1. Continued

Reference	Population	Study design	Main measures	Key findings
Viner et al. 2015	(Mountain Bike (MB) n = 5 Road Cyclist (RC) n = 5 Males n = 6 42.0 ± 7.7y 177.9 ± 4.2 cm 72.4 ± 6.8kg Females n = 4 38.4 ± 10.3y 165.4 ± 6.4 cm 62.8 ± 12.2kg	Longitudinal, cross-sectional	Dietary intake + exercise diary 3days/month through one cycling season BMD (at 0, 5 and 10 months) Total body, lumbar spine, proximal femur Questionnaire Factor-1 of the Three-Factor Eating Questionnaire (TFEQ) at 0, 5 and 10 months	**Body composition/BMD:** No changes in mean body mass, % body fat, FFM or BMD at any site across season in any group. 40 % had low BMD (Z-score ≤ - 1) in lumbar spine, 10 % (n = 1) had low BMD at the femoral neck **Dietary/Questionnaire** Mean EA below threshold (30kcal/kg FFM/day), no change across seasons. No change in mean EA across season, but EEE changed significantly (P = 0.03). EEE decreased from competition season to off-season (P = 0.02) In post-season (P < 0.001), Competition season (P = 0.005) and off-season (P = 0.01) CHO intake were below minimum sport nutrition recommendations. 40 % used multivitamins and 30 % used fish oil (>3days/week). Subjects consumed average 5 ± 1 meals/day across season. **TFEQ scores:** no change from 0-10 months. No difference between males and females. RC scored higher than MB, but not significantly higher. 70 % were identified as restrained eaters through the TFEQ (67 % males, 75 % females / 40 % MB, 100% RC).
Olmedillas et al. 2011	CYC Males n = 22 16.9 ± 1.9y 173.2 ± 6.7 cm 61.3 ± 7.7kg CON Males n = 22 16.7 ± 2.1y 176.1 ± 8.9 cm 74.4 ± 16.8kg	Cross-sectional	Cardiorespiratory VO_{2peak} DXA Total body, pelvis, hip, lumbar spine, head, average of arms & legs	**Body composition** CYC: lower body mass, total lean mass, body fat (%), total body fat and BMI (P < 0.01). **BMD** CYC had lower bone mineral content (BMC), BMD and bone area compared to CON (P < 0.05). Lumbar spine (BMD ($g\ cm^{-2}$): CON: 0.998 ± 0.157, CYC: 0.875 ± 0.111* (P < 0.005) CYC <1 7years had 10 % lower BMC in legs & 8 % higher total hip area compared to CON <17 years (P < 0.05). CYC >17 years had 26.5 %, 15.8 % and 14.4 % lower BMC at pelvis, femoral neck and legs than CON >17 years (P < 0.05).
Smathers et al. 2009	Competitive Road cyclists (CYC) Males n = 32 31.9 ± 1.2y, 174 ± 1.1 cm, 72.6 ± 1.3kg Recreationally active controls (CON) Males n = 30 30.2 ± 1.0y 176.7 ± 0.9cm 72.7 ± 1.7kg	Cross-sectional	DXA Total body, lumbar spine, lateral spine, dual proximal femur Fasting blood samples Total testosterone (TT), free testosterone (FT)	**Body composition** % body fat significantly lower in CYC (P = 0.001) Bone-free lean mass significantly higher in CYC (P = 0.012) **BMD** No significant differences between groups in total BMD (P = 0.349), T-score (P =0.354) or Z-score (P = 0.381). L1-L4 and L2-L4 lower in CYC (P = 0.017, P = 0.028). T-score and Z-score for all the spine sites lower in CYC (P < 0.05). No correlation between BMD variables and number of years training, training volume, calcium intake or total physical activity score (P > 0.05). Bone-free lean mass was in CYC positively correlated to L1-L4 and L2-L4 (P = 0.029, P =0.030). 25 % of CYC had lumbar spine (L2-L4) T-scores in osteopenia range, 9 % in osteoporosis range. **Calcium intake:** higher in CYC than in CON (P = 0.004) **TT and FT:** No significant differences between CYC and CON, all were within ref. range of TT, but 6 was below 30.2nmol/L in FT (CON n= 2, CYC n= 4).

1.5 Research Question

As table 1 shows, previous studies in this topic include adult cyclists only, except the study by Olmedillas et al. (2011). All are cross-sectional with one measure point, except one study by Viner et al. (2015). Most of the studies are exploring BMD, body composition, dietary habits and hormonal markers. Hence, there is need for longitudinal cross-sectional studies to increase the understanding of seasonal changes in bone health and RED-S, metabolic health and other health variables associated with RED-S in adolescent male cyclists. Therefore, this study aims to investigate bone mineral density and symptoms of RED-S in well-trained adolescent male cyclists.

1.5.1 Hypothesis

Primary:

Cycling during adolescent is associated with low bone mineral density in addition to RED-S related symptoms

Secondary:

Cyclists have lower BMD than a group of age-matched controls

There are differences in BMD in pre-season versus off-season among young cyclists

There are associations between BMD and muscle mass, BMD and RER and BMD and body fat.

2. Introduction

Sports participation offers many health benefits in both male and female athletes; however, some individuals may experience adverse effects on health associated with sports participation (Mountjoy et al. 2014). Energy deficiency has been reported as an issue in athletes, particularly in athletes participating in weight sensitive sports (Mountjoy et al., 2014). The female athlete triad has been well studied among young adult and collegiate female athletes, however, male athletes is also found to experience similar conditions (Tenforde et al., 2016). Thus, RED-S was first described in 2014 in the IOC consensus statement and refers to the situation in which an athlete has insufficient EI relative to the undertaken training amount (Mountjoy et al., 2014).

Male athletes participating in leanness and weight-sensitive sports including endurance sports, have been found to present with LEA, nutritional deficiencies, impaired bone health, lower RMR, hypogonadotropic hypogonadism (little production of sex hormones) and bone stress injuries (Mountjoy et al., 2014; Tenforde et al., 2016). LEA has also, in experimentally exposed exercising men been associated with lower testosterone levels, suppressed IGF-1, lowered triiodothyronine (T_3) and insulin as well as increased cortisol and cholesterol levels (Torstveit et al., 2019). Low levels of these metabolic hormones in addition to long-term LEA is associated with adverse health consequences (Mountjoy et al., 2014; Margo Mountjoy et al., 2018; Torstveit et al., 2019). Male adolescent athletes competing in sports such as football, ice hockey and other ball- and team sports was found to have a sufficient and relative energy intake, ranging from 40-60kcal/kg (Mountjoy et al., 2014; Tenforde et al., 2016). Cycling, long distance running, and swimming are sports of which do not seem to have osteogenic advantages to bones (Smathers et al., 2009). Additionally, low body weight and low body fat will confer a performance advantage in cycling, meaning that cyclists are at a high risk of developing LEA, restrictive nutrition and furthermore, RED-S (Margo Mountjoy et al., 2018).

A report including 20 male adolescent cyclists and 17 controls in recreational sports found that the energy intake of the cyclists did not significantly exceed that of controls, even though they exercised a fivefold more hours per week, and appeared to fall below recommended intake levels (Julián-Almárcegui et al., 2013). Another study including 61 male cyclists and 63 non-cyclists demonstrated that the cyclist population had significantly higher scores towards disordered eating compared to the age-matched controls, with an elevated disordered eating behaviour (Riebl, Subudhi, Broker, Schenck, & Berning, 2007). Results from this study also

suggest that male cyclists may have an inadequate nutritional intake for sustaining metabolic needs.

The prevalence of eating disorders in Norwegian elite athletes and non-athlete controls were obtained from 687 male athletes and 629 male controls (Sundgot-Borgen & Torstveit, 2004). The study found that 8 % among the male athletes met the criteria for eating disorders, compared to a 0.5 % prevalence among the male non-athlete controls. Furthermore, males participating in sports where leanness is of importance, including aesthetic, weight class, endurance and antigravitation sports were presented with an eating disorders prevalence of 13 %, compared to 5 % in athletes participating in non-leanness sports. This means that male athletes competing in leanness sports have approximately 25 times higher prevalence of eating disorders compared to the general non-athlete population. Furthermore, a study examined the associations between perfectionism and symptoms of eating disorders in 42 young male cyclists (Ferrand & Brunet, 2004). Of the 42 cyclists, 24 obtained a score > 20 on the eating attitudes test (EAT-26), indicating disordered eating.

Cyclists with low BMD are at risk of developing osteoporosis at a young age, as their PBM is attenuated and they might experience bone loss when continuing with cycling (Smathers et al., 2009). The little osteogenic stimulus provided when cycling, combined with the drive for low body weight and LEA, can potentially cause health and performance issues, and furthermore, RED-S (Margo Mountjoy et al., 2018). Long-term LEA may have negative effects on bone health, but also many other factors associated with optimal health and performance (Mountjoy et al. 2014). As adolescent is a critical phase for the acquisition of bone mass, this study aims to get a further understanding about BMD and symptoms of RED-S in well-trained adolescent male cyclists.

3. Methodology

3.1 Research Design

This study is using a cross-sectional longitudinal research design, consisting of correlational and descriptive statistical analyses, aiming to describe bone mineral density and the risk of RED-S and possible associated health variables. This master thesis is part of a research project at Høgskolen i Innlandet, Lillehammer and includes data gathered from January 2020 until April 2021. The main project is aiming to gather data during a 10-year period.

All testing has taken place at the test lab at Høgskolen i Innlandet, Lillehammer, and consisted of physiological measurements and questionnaires. Some of the cyclists have been tested up to three times, first in January 2020, and last in April 2021, which makes it possible to see whether on- and off- season affects different physiological measurements. Test 1 is undertaken January 2020, and is an off-season test, Test 2 is undertaken in October 2020, and is a post-season test, whereas Test 3 is undertaken in March/April 2021, and is a pre-season test. This project also includes a control group which is tested at one time-point, January 2021.The control group consists of age-matched subjects, which are non-athletes and therefore unaffected of on-and off-season.

3.2 Participants and Recruitment Strategy

In total, 18 well-trained male adolescent cyclists within both road cycling and mountain biking were recruited to the study in three phases (Figure 5). The first group of cyclists were born in 2003 and were recruited in December 2019. Thereafter, cyclists were recruited during August 2020 and February/March 2021, and they were born in 2004. Additionally, 11 controls born in 2004 were recruited at one time-point, December 2020. The included cyclists were 1st year students at Norges Toppidrettsgymnas (NTG), and the control group were 1st year students at Gausdal Videregående Skole. All recruited participants in this study had to answer a health check questionnaire (Appendix 1). The health check questionnaire included the exclusion criteria for participating in this study (Table 2).

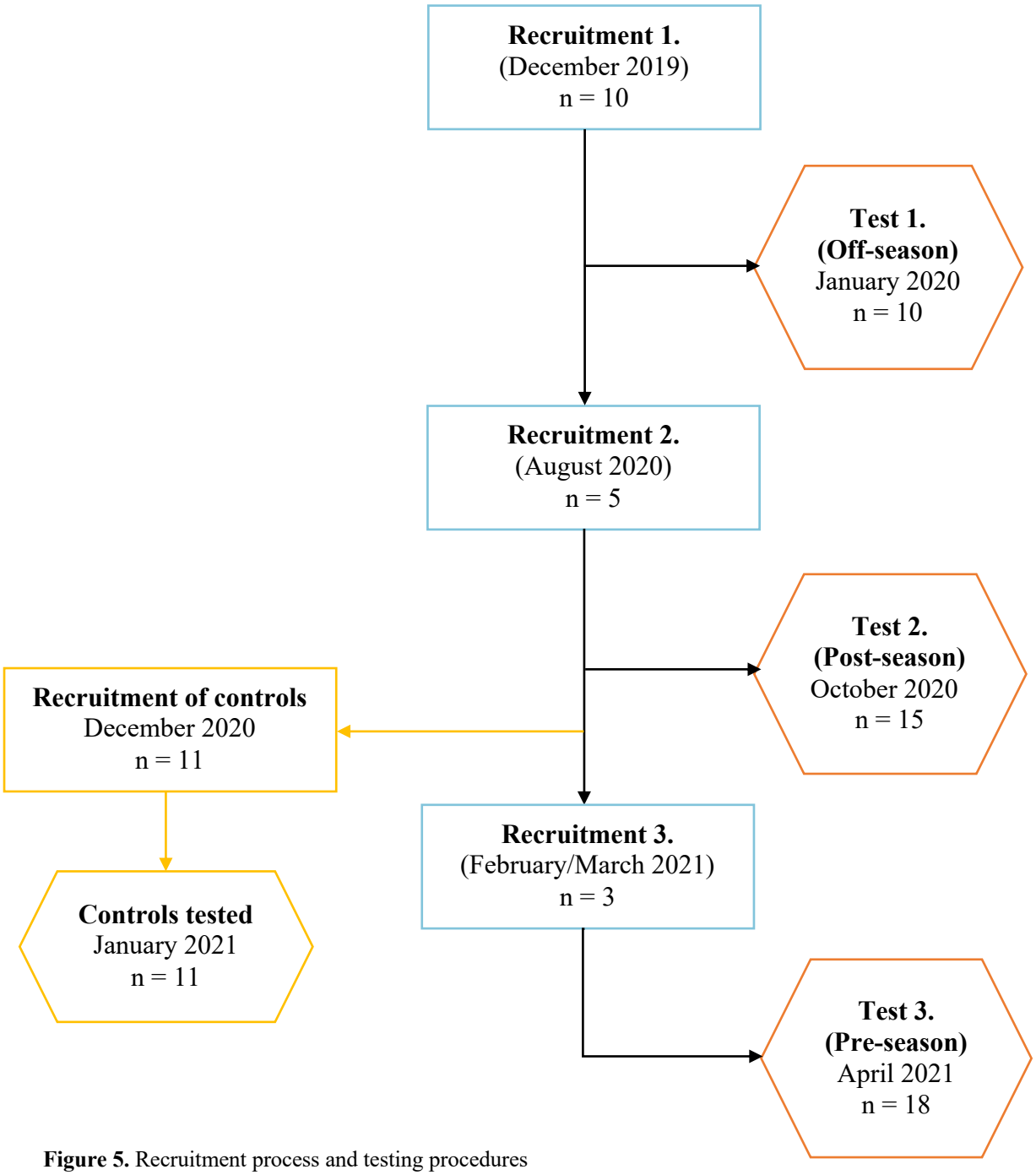

Figure 5. Recruitment process and testing procedures

Participants in the cycling group were recruited in collaboration with coaches, teachers and other contact persons at NTG (Lillehammer). Participants in the control group was recruited from Gausdal Videregående skole. There were held an informational meeting about the study for all students and their parents/guardians at the upper secondary schools. Additionally, a letter with information were handed out about the project for cyclists (Appendix 2) and controls (Appendix 3).

Table 2. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
First year students at NTG With cycling as their chosen sport Control group Non-athlete (no organised sports other than physical activity at school last 12 months), age-matched adolescents from an ordinary upper secondary school in Norway Norwegian language Orally and in writing to be able to answer the questionnaires	Tobacco All kinds: smoking, snus or e-cigarettes Known disease o Metabolic disease o Diabetes o Inflammatory bowel disease o Kidney disease o Rheumatism o Chronic bone marrow disease o Other severe mental illness

Those who wanted to participate in the study and were under the age of 18 had to get a signed declaration of consent from their parents or guardians, this was included in the informational letter. Additionally, all who chose to participate were given a letter with information prior to the test day about fasting, suitable clothing for DXA scan, exercise restrictions etc (Appendix 4).

3.3 Data Collection

Data collection was performed over several consecutive days, with totally four subjects every test day in each test-period (Table 3). Subjects arrived at the test lab in fasted state (minimum 12 hours) between 7 and 10 a.m. and were recommended to travel to the lab by motorised transportation. Testing on each subject was estimated to last about 1.5 hours. All subjects were instructed to refrain from hard exercise 48 hours prior to attendance and to keep their activity level as low as possible on test days. Each participant was given a unique identification number to provide confidentiality, which were used as coding on all tests throughout the study period.

Table 3. Test day protocol

Subject ID	Time	1	2	3	4
1	**7:10 am**	DXA scan			
	7:20 am	DXA scan			
	7:30 am	RMR			
	7:40 am	RMR			
	7:50 am	RMR			
	8:00 am	Blood samples			
2	**8:10 am**	Questionnaires	DXA scan		
	8:20 am	Questionnaires	DXA scan		
	8:30 am		RMR		
	8:40 am		RMR		
	8:50 am		RMR		
	9:00 am		Blood samples		
3	**9:10 am**		Questionnaires	DXA scan	
	9:20 am		Questionnaires	DXA scan	
	9:30 am			RMR	
	9:40 am			RMR	
	9:50 am			RMR	
	10:00 am			Blood samples	
4	**10:10 am**			Questionnaires	DXA scan
	10:20 am			Questionnaires	DXA scan
	10:30 am				RMR
	10:40 am				RMR
	10:50 am				RMR
	11:00 am				Blood samples
	11:10 am				Questionnaires
	11:20 am				Questionnaires

3.4 Outcomes

3.4.1 Anthropometry

Anthropometric measures were measured prior to the DXA scan at all test points. Both height and weight were measured without shoes and in light clothing. Height was measured using a centimetre scale affixed to the wall. Body weight was measured using an electronic weighing scale, and BMI was calculated as body weight (kg) divided by height squared (m^2).

3.4.2 Bone mineral density

The body composition and BMD were measured using a Dual-energy X-ray absorptiometry (DXA, GE-Lunar Prodigy, Madison, WI, USA, EnCore software version 15). DXA is a non-invasive and accurate method for assessing BMD and body composition (Wasserman, O'Donnell, & Gordon, 2017). Bone mineral content (BMC) is given in grams and the projected bone area in cm^2, with the primary outcome measure, BMD given in g/cm^2. It is considered the "gold standard" for measuring bone mass and body composition and to diagnose osteoporosis (Morgan & Prater, 2017).

Testing was performed between 7 and 11 a.m. on all test days, subjects were instructed to arrive in a fasting state and recommended to arrive by motorised transport. The DXA machine was calibrated each morning prior to the first measurement of the test day, or the night before. All standardised procedures regarding positioning, clothing, no jewellery, training status and post analyses were followed in accordance with the supplier's guidelines. Subjects were instructed to lie as shown in picture 1 when the DXA were scanning from head to toe. Thereafter a small change of position was done before measuring the lumbar spine (L1-L4). A scan of the lumbar spine was included as it is one of the most common sites for osteoporotic fractures, additionally it is found that cyclists may be at risk of low bone mass particularly in this area (Leib, Lewiecki, Binkley, & Hamdy, 2004; Nagle & Brooks, 2011; Scofield & Hecht, 2012).

Picture 1. Body composition and BMD assessed by DXA-scan (AymesMedical, 2021)

All scans were conducted on the same machine; however, the scans and post analysis were, due to practical reasons, performed by two different people. Both technicians used the same technique and equipment on the DXA scans. Additionally, the most experienced technician instructed the new technician how perform post-analysis and were engaged in the training process.

BMD is classified as recommended in athletes from the IOC position statement 2014 (Figure 6) (Mountjoy et al., 2014)

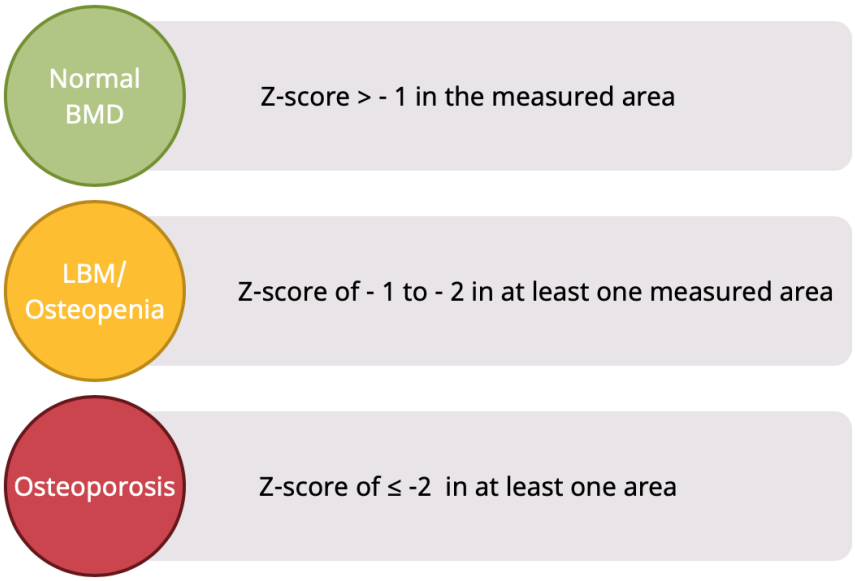

Figure 6. BMD classifications based on Z-scores (Mountjoy et al., 2014).
LBM = Low bone mass

3.5 Relative Energy Deficiency in Sport

To investigate RED-S and dietary habits in study participants, we included two questionnaires, of which were answered at the test lab at Høgskolen i Innlandet, Lillehammer, and were coded with the subjects' individual codes. The questionnaires were created on nettskjema.no and included a food frequency- and exercise questionnaire and a Low Energy Availability in Males Questionnaire (LEAM-Q) (Appendix 5 and 6). The subjects were given oral instructions about the surveys. The cyclists answered both questionnaires, however, as the LEAM-Q is developed to identify LEA and RED-S in athletes, controls did not answer this questionnaire. Cyclists answered them in the following order: 1. Food frequency- and exercise questionnaire, 2. LEAM-Q. In total, subjects used approximately 30 minutes to an hour to finish both questionnaires.

3.5.1 Low Energy Availability in Males Questionnaire (LEAM-Q)

The LEAM-Q questionnaire is a brief questionnaire regarding physiological symptoms linked to LEA, and is developed with the specific goal of identifying male athletes at risk of RED-S (Margo Mountjoy et al., 2018) (Appendix 6). The validation study of the LEAM-Q for LEA and RED-S has not yet been published, and therefore, we are not able to give subjects a RED-S score, only look at individual components from the questionnaire and describe them descriptively. This is done with permission from Torstveit and colleagues who are working on the validation process of the LEAM-Q.

<u>The LEAM-Q includes different categories of questions:</u>

1.Weight (match weight/off-season)
2. Illness and injuries
3. Gastrointestinal
4. Tiredness and fatigue
5. Recovery after exercise
6. Sleep
8. Energy levels
9. Sex drive

The answer options for these questions vary, however, most questions have four answer options similar to these:

1. Several times per day
2. Several times per week
3. 1 to 2 times per week or less
4. Rarely/Never

3.5.2 Food frequency and exercise questionnaire

The food frequency and exercise questionnaire were implemented to get an overview of the participants' dietary- and exercise habits (Appendix 5). The tool is based on an established and validated form (food frequency questionnaire) and gives a good impression of the participants' diet without weighing or measuring energy intake (Oellingrath, Svendsen, & Hestetun, 2014). The subjects enter how frequently they consume different food and drinks and can thus describe daily dietary habits. Additionally, their exercise habits were obtained from the same questionnaire.

<u>The questions are divided into different categories:</u>

1. Frequency of different food and drinks
2. Frequency of main meals
3. Frequency of additional meals outside main meals
4. Thoughts about one's own dietary habits
5. Previous and current sport experience and duration/how often
6. Transportation to and from school

The answer options vary, however, most questions regarding food frequency have six answer options similar to these:

0. Rarely/never
1. 1 to 3 times per week
2. 4 to 6 times per week
3. Once per day
4. Twice per day
5. 3 or more times per day

Most answer options regarding previous sport experience have seven options involving how many months or years the subject took part in that specific sport, or how often the subject is taking part of that specific sport per week at present time.

3.6 Resting Metabolic Rate

RMR was measured by indirect calorimetry using a canopy hood system (Oxycon Pro, Jaeger, Hoechberg, Germany) and was performed immediately after the DXA scan was finished. Subjects were rested lying down during the DXA scan and when the systems were calibrated prior to each indirect calorimetry test, approximately 15 - 20 minutes. To minimise error, the instructions from the manufacturer of the Oxycon were carefully followed when calibrating the system. Oxygen consumption (VO_2) and carbon dioxide production (VCO_2) was assessed for a 20-minute period, with continuous recordings every 30 seconds. The subjects were not allowed to talk, move or fall asleep during the test, and lab personnel were present throughout the test. This test was undertaken by two different bachelor groups in the research project, with three or four people on each group. There were one to two people present throughout each measurement, making sure the recordings were correctly. Measured resting metabolic rate (kcal/day) was thereafter calculated from the subjects' respiratory exchange ratio (RER) (Haugen, Chan, & Li, 2007).

Picture 2. Resting metabolic rate assessed by indirect calorimetry (Sportsmedizin, 2018).

3.7 Ethical Approval

The study was reviewed and approved by the Regional Ethics Committee (REK: ref. 28837) (Appendix 7). Each subject gave informed consent prior to enrolment in the study, as for those under the age of 18, their parents or guardian gave consent. The participants were healthy and received written information prior to the study about testing, different test methods and fasting before testing (Appendix 2, 3 and 4). Additionally, all participants were informed about the opportunity to withdraw from the study at any time without giving reason. They were also informed about the anonymisation of personal details, meaning that each subject got their own identification number, which were used in all tests performed throughout the test-period. No of the tests carried out constituted any kind of risk or discomfort. All collected data were deidentified and registered in the "Tjenester for Sensitive Data" (TSD). Additionally, all procedures in the project have followed the Helsinki Declaration. All controls were given written feedback on variables measured for bone health, and the cyclists with low BMD scores got written feedback with an encouragement to contact their general practitioner (GP) for follow up.

3.8 Statistical Analyses

Statistical analyses were performed using Statistical Package of Social Sciences (SPSS) version 26 (IBM Corporation, Route, Somers, Ny, USA) and Microsoft Excel 2019 (Microsoft, Redmond, WA, USA). All descriptive data are presented as mean and standard deviation (mean ± SD) unless otherwise is stated. For analysing repeated measures as lumbar spine BMD in cyclists, a two-way repeated ANOVA with Bonferroni, fitted with time and group as explanatory variables were performed. All results were considered statistically significant if $p < 0.05$. Furthermore, $p < 0.100$ were considered a tendency. To detect possible differences between groups, independent-samples T-test were performed, both for subject characteristics (Table 4) and to identify differences in lumbar spine BMD (Table 5). Additionally, a Pearson product-moment correlation coefficient test were undertaken to identify the correlation between different variables on lumbar spine BMD.

4. Results

4.1 Subject Characteristics

Eighteen young male cyclists aged 16.3 ± 0.7 years were initially recruited to participate in this study in three phases (Figure 5). The included cyclists were either doing road cycling or mountain biking. In total, 11 age-matched controls, including both males (n = 3) and females (n = 8) were recruited to the study and were tested in January 2021. All cyclists were regularly participating in competitions at a national level. Table 4 represents the physical characteristics of both cyclists and controls. As expected, age was not significantly different between the two groups, neither was body mass or body mass index (BMI) ($p > 0.05$). However, the cyclists had significantly more muscle mass and lower percent body fat than the controls ($p < 0.05$). Additionally, the cyclists were significantly taller than the controls ($p < 0.05$).

Table 4. Subject characteristics. The mean of the cyclists is based on the first test each subject undertook at the test lab.

Variables	Cyclists (n = 18)	Controls (n = 11)	p-value
Age (years)	16.3 ± 0.7	16.6 ± 1.0	0.348
Height (cm)	179.4 ± 5.2	168.6 ± 9.8	0.001*
Body mass (kg)	67.0 ± 6.7	65.9 ± 21.1	0.846
BMI (kg/m^2)	20.8 ± 1.3	22.9 ± 5.5	0.130
Muscle mass (kg)	51.8 ± 5.5	39.7 ± 10.0	< 0.000*
Body fat (%)	15.3 ± 1.6	32.1 ± 9.1	< 0.000*

Values are presented as mean ± SD.

BMI = Body Mass Index.

* $P < 0.05$, compared with control group

† Tendency $p < 0.100$

4.2 Bone Mineral Density

There were no statistical differences between cyclists and controls in any of the lumbar vertebrae ($p > 0.05$), with the mean of all 18 cyclists calculated from the first test each subject undertook at the test lab (Table 5). However, there were a tendency of lower BMD in L1 in cyclists compared to controls ($p < 0.1$). Both cyclists and controls had a mean Z-score below 0 in all lumbar measurements, however, none of the group means were below the cut-off point for neither osteopenia (≤ - 1) or osteoporosis (≤ - 2). Although, when looking at Test 1, off-season (n = 10) among cyclists, five subjects had one or more Z-score at, or below - 1, and two subjects had one or more Z-score at, or below - 2 (Figure 7). In Test 2 (n =15), which is undertaken post-season, 11 subjects were presented with one or more Z-score at or below -1, and two of these had a Z-score at, or below -2. Whereas in Test 3, pre-season (n = 18), nine cyclists had one or more Z-score at, or below – 1, and two of these had one or more Z-score at, or below – 2. In the control group (n = 11), five subjects had one or more Z-score at, or below – 1, and two of these had one or more Z-score at, or below – 2 (Figure 7).

Table 5. Z-scores for Bone Mineral Density (BMD) in cyclists and control group.
The mean of the cyclists is based on the first test each subject undertook at the lab.

Variable	Cyclists (n = 18)	Controls (n = 11)	p-value
L1	-0.933 ± 0.661	-0.445 ± 0.832	0.092†
L2	-0.650 ± 0.901	-0.336 ± 1.042	0.399
L3	-0.361 ± 0.793	-0.055 ± 0.944	0.355
L4	-0.535 ± 0.697[a]	-0.582 ± 1.001	0.886
L1 - L4	-0.578 ± 0.703	-0.327 ± 0.889	0.407

Values are presented as mean ± SD.

L1= Lumbar vertebrae 1, L2= Lumbar vertebrae 2, L3= Lumbar vertebrae 3, L4= Lumbar vertebrae 5, L1 – L4= Lumbar spine 1-4.

[a] We were not able to identify L4 (in Test 1) in one cyclist, therefore, n = 17 in L4 in cyclists.

* $p < 0.05$, † Tendency $p < 0.100$

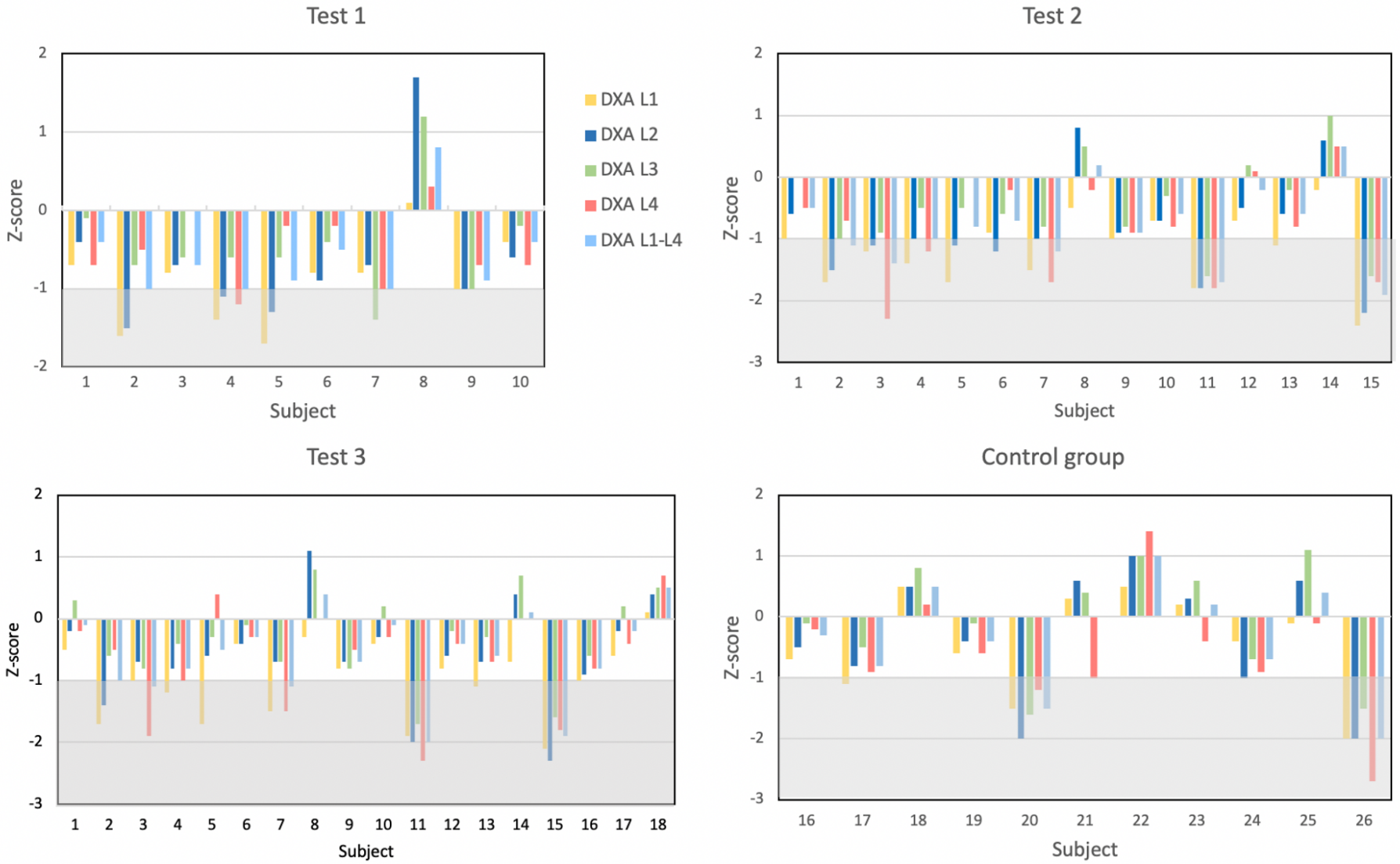

Figure 7. Z-score in lumbar vertebra 1-4 and mean L1-L4 in cyclists from Test 1, Test 2 and Test 3, in addition to controls. Grey area showing cut-off point for osteopenia (≤ - 1). L4 were not identified in subject 3 in Test 1.

4.2.1 Within differences in lumbar spine BMD in cyclists over time

The mean Z-score from measurements of all lumbar vertebrae (L1, L2, L3, L4 & L1-L4) in the first 10 recruited cyclists did significantly increase from Test 2 (post-season) to Test 3 (pre-season) ($p < 0.05$) (Table 6). Despite that, all mean values were still below 0. The only mean Z-score with a significant decrease were found in L1 from Test 1 to Test 2 in the first 10 recruited cyclists ($p < 0.05$), with the mean Z-score in L1 in Test 2 classifying as osteopenia (≤ - 1). When looking at the results from Test 2 and 3 in all 15 cyclists, there were only one statistically significant increase, this was found in L2 ($p < 0.05$). Though, a tendency were observed in L1-L4 from Test 2 to 3 in all 15 cyclists ($p < 0.1$). The partial eta square values obtained from the repeated measures ANOVA test in all measurements are > 0.14, except one, (L4 (n = 15)), this suggests, according to commonly used guidelines, a large effect size (Cohen, 1988).

Table 6. Within differences in BMD lumbar spine (Z-score) in cyclists over time. Test 1 (Jan. 2020 (n=10)), thereafter 5 new cyclists were recruited prior to Test 2 (Oct. 2020 (n=15)). Subsequently, 3 new cyclists were recruited February/March 2021, however, they were not included in this analysis as they only were tested once.

	Spring 2020	**Fall 2020**	**Spring 2021**				
Variables	T1 (n = 10)	T2 (n = 15)	T3 (n = 18)	Time P-value, T1 –T2	Time P-value T2 - T3	Within subject change P-value	Partial eta square
L1 (n = 10)	- 0.910 ± 0.549	-1.160 ± 0.414	-0.950 ± 0.552	0.038*	0.018*	0.016*	0.731
L1 (n = 15)	-	-1.187 ± 0.573	-1.073 ± 0.589	-	0.108	0.108	0.174
L2 (n = 10)	-0.650 ± 0.890	-0.830 ± 0.630	-0.470 ± 0.643	0.334	0.001*	0.005*	0.794
L2 (n = 15)	-	-0.853 ± 0.781	-0.660 ± 0.832	-	0.022*	0.022*	0.320
L3 (n = 10)	-0.440 ± 0.687	-0.490 ± 0.458	-0.240 ± 0.536	1.000	0.005*	0.033*	0.720
L3 (n = 15)	-	-0.473 ± 0.714	-0.367 ± 0.719	-	0.146	0.146	0.145
L 4 (n = 9)[a]	-0.544 ± 0.456	-0.689 ± 0.540	-0.433 ± 0.552	0.562	0.007*	0.057†	0.749
L4 (n = 15)	-	-0.813 ± 0.802	-0.733 ± 0.795	-	0.384	0.384	0.055
L1–L4 (n = 10)	-0.600 ± 0.550	-0.800 ± 0.477	-0.530 ± 0.501	0.110	0.000*	0.005*	0.836
L1–L4 (n = 15)	-	-0.793 ± 0.650	-0.673 ± 0.677	-	0.098†	0.098†	0.183

Values are presented as mean ± SD.

T1, T2, T3 represents test 1, 2 and 3.

L1= Lumbar vertebrae 1, L2= Lumbar vertebrae 2, L3= Lumbar vertebrae 3, L4= Lumbar vertebrae 5, L1 – L4= Lumbar spine 1-4.

[a] We were not able to identify L4 (in Test 1) in one cyclist, therefore, n = 9 in L4.

* $P < 0.05$, † Tendency $p < 0.100$

4.2.2 Correlations

The relationship between BMD in lumbar spine L1-L4 and muscle mass (kg), both obtained from Test 3 was investigated using a Pearson product-moment correlation coefficient test. There was found a positive correlation between BMD in L1-L4 and muscle mass (kg) (r. = 0.343, n = 18). According to Cohen (1988, pp. 79-81), this correlation is considered moderate (range = 0.30 – 0.49). The correlation represents a 12 % association between the Z-score in Lumbar spine L1-L4 and muscle mass (kg) in Test 3 (p = 0.163). Another Pearson correlation test was undertaken to explore the relationship between BMD in lumbar spine L1-L4 and body fat percentage, both obtained from Test 3. There was a negative correlation between these variables (r. = - 0.231, n = 18). Thus, the correlation is considered small (range = 0.10 – 0.29) (Cohen, 1988, pp. 79-81). Only a 5.5 % association between the two variables were found (p = 357). Furthermore, a positive correlation was found between BMD in L1-L4 and resting energy rate (RER) both measured at Test 3 (r. = 0.327, n = 18). This initiates an 11 % association between the two variables (p = 0.185), and is considered a moderate correlation (Cohen, 1988, pp. 79-81).

4.3 Relative Energy Deficiency in Sport

4.3.1 Low Energy Availability among Males Questionnaire (LEAM-Q)

According to the findings summarised in table 7, quite many of the cyclists stated to experience dizziness at some level. However, there were none in Test 1, but 13 % (n = 2) and 6 % (n = 1) in Test 2 and 3, respectively, who experienced dizziness every day. Few of the cyclists had problems concentrating and few felt that they got easily injured. Additionally, most cyclists responded to have good physical recovery after training sessions, with 50 % to 60 % recovering good from every training session (Table 7). There was one subject in each test who indicated to feel depressed and less happy several days a week, this was stated by three different subjects, and was not a reoccurring answer for any of the cyclists. However, no one stated to feel depressed and less happy “almost every day” in any of the tests.

Table 7. A selection of relevant questions from the low energy availability among men questionnaire (LEAM-Q). The proportion on each answer is given in percentage in Test 1,2 and 3.

LEAM-Q variable	Test 1 (n = 10)	Test 2 (n = 15)	Test 3 (n = 17[a])
Dizziness when standing up			
Rarely/never	60 %	-	18 %
1-2 times/week or less	40 %	60 %	53 %
Several times/week	-	27 %	24 %
Several times/day	-	13 %	6 %
Difficulty concentrating			
Rarely/never	50 %	40 %	47 %
1-2 times/week or less	40 %	53 %	47 %
Several times/week	-	-	-
Almost every day	10 %	7 %	6 %
Impaired judgement			
Rarely/never	30 %	47 %	47 %
Occasionally	60 %	40 %	47 %
Often	-	13 %	6 %
Always	10 %	-	-
Easily injured			
Rarely/never	90 %	93 %	88 %
In some training periods	10 %	7 %	12 %
In most training periods	-	-	-
Always	-	-	-
Good physical recovery			
Rarely/never	-	-	-
Occasionally, after some sessions	10 %	-	-
After several sessions	40 %	40 %	41 %
After almost every session	50 %	60 %	59 %
Feeling of a strong body			
Rarely/Never	-	-	-
1-2 times/week or less	20 %	7 %	6 %
Several days/week	30 %	67 %	65 %
Almost every day	50 %	27 %	29 %
Depressed and less happy			
Rarely/never	70 %	87 %	82 %
1-2 times/week or less	20 %	7 %	12 %
Several days/week	10 %	7 %	6 %
Almost every day	-	-	-

[a] There were one subject who did not answer the LEAM-Q in Test 3, therefore, n = 17.

4.3.2 Dietary Habits

All cyclists (n = 18) included in this study stated to have breakfast, lunch and dinner 7 out of 7 days a week, whereas only 5 out of 11 controls have breakfast every day, with a range from 0 to 7 days a week (Table 8). However, all except one control stated to have dinner every day. Cyclists have a significantly higher frequency in all main meals ($p < 0.05$), except for dinner, compared to controls. There is a relatively large SD in controls, compared to cyclists in all measurements, this is caused by a large variation in answers options by controls.

Table 8. The average number of main meals per week in cyclists and controls. The mean of the cyclists are based on the first test each subject undertook at the lab.

Meals	Cyclists (n = 17)	Controls (n = 11)	p-value
Breakfast	7.00 ± 0.00	4.91 ± 2.51	0.001*
Lunch	7.00 ± 0.00	5.73 ± 1.22	0.000*
Snack	6.22 ± 1.31	2.55 ± 2.1	0.000*
Dinner	7.00 ± 0.00	6.91 ± 0.30	0.206
Supper	6.67 ± 0.84	3.00 ± 2.65	0.000*

Values are presented as mean ± SD.

* $p < 0.05$, † Tendency $p < 0.100$

Figure 8 represents how many additional meals/snacks both cyclists and controls have besides main meals. This information is gathered from the food frequency questionnaire. Three out of eighteen cyclists responded to have 3 or more additional meals or snacks every day, whereas none of the controls have more than two additional meals/snacks per day (n = 2). The most frequently answered category by the controls was “one to three additional meals/snacks per week” (n = 4). Whereas the most frequent answer by the cyclists was “one extra meal/snack per day” (n = 6). None of the cyclists answered rarely or never, whereas one control did.

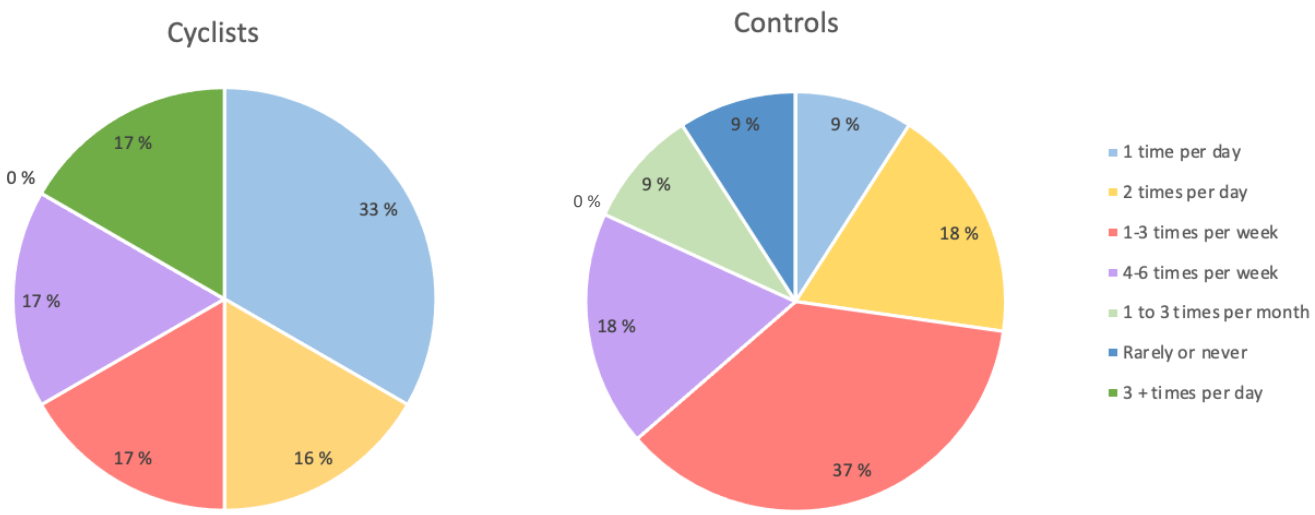

Figure 8. Percentage of additional meals/snacks beside main meals per week in cyclists and controls. The mean of the cyclists is based on the first test each subject undertook at the lab.

5. Discussion

The main finding from the present study is that the prevalence of low BMD (< -1) were respectively, 50 % in Test 1 and 3 (off-season and pre-season), and 73 % in Test 2 (post-season). Moreover, more than half of the cyclists were presented with some RED-S related symptoms at some extent according to the LEAM-Q. Though cyclists were found to have low BMD, we did not find a significant difference between BMD in cyclists and age-matched non-athlete controls. Neither did we find a significant difference between BMD from off-season (n = 10, Test 1) to post-season (n = 10, Test 2), except in one lumbar vertebra (L1). However, when comparing post-season (n = 10, Test 2) to pre-season (n = 10, Test 3) we found a significant increase in BMD in all measurements. Whereas no significant change was found between post-season (n = 15, Test 2) and pre-season (n = 15, Test 3) when comparing findings from all 15 cyclists, except in one lumbar vertebra (L2) and a tendency towards a positive change in L1-L4.

Bone mineral density in cyclists

The findings from the present study are consistent to the results of previous studies who have documented a relatively high prevalence of osteopenia and osteoporosis in cyclists. (Andersen et al., 2018; Keay et al., 2018; Nichols et al., 2003; Rector et al., 2008; Smathers et al., 2009). However, BMD in the lumbar spine measured in cyclists in the present study were not significantly different from the measurements in controls. This is similar to the findings of Nichols and Rauhn (2011), which conducted a study on master cyclists, in addition to a non-athlete control group with a 7-year follow up. They found that master cyclists had a significantly lower BMD in all sites except in the lumbar spine, which were not significantly different between cyclists and controls, both at baseline and after 7 years. However, they did exclude 4 subjects, 3 were cyclists, in the 7-year analysis, who were taking bone-building medications since the baseline tests due to their low BMD. This may have biased the change score as these subjects were included in the baseline analysis. This is in general an ethical challenge in long-term studies if medical issues appear. In the present study we did not measure BMD in other sites than the lumbar spine, and thus little is known about the differences between groups in other sites. Nichols and Rauhn (2011) did also report a worryingly high prevalence of osteopenia and osteoporosis up to 90 % in master cyclists, and a prevalence of 61 % among none-athlete controls. The number of osteoporotic cyclists increased significantly over the 7-year period, even with a significantly greater calcium intake compared to controls. This is

higher than what is reported in present study, with a prevalence of 50 % (Test 1 and 3) and 73 % (Test 2) in cyclists and 45 % in controls. A possible explanation of this is the age (40 to 60 years) of the subjects included in the study by Nichols and Rauhn (2011), as BMD generally are decreasing with age (Andersen et al., 2018). However, Rector et al. (2008) did also find a high prevalence, as 60 % of their tested cyclists had osteopenia of the lumbar spine. Whereas Andersen et al (2018) found a prevalence of low BMD in 53 % of the included cyclists. Nevertheless, Smathers et al. (2009) reported a lower prevalence where 25 % of cyclists and 10 % of controls had osteopenia, whereas respectively 9 % and 3 % of the cyclists and controls were classified with osteoporosis.

As mentioned earlier, there were no significant difference in BMD between cyclists and age-matched controls in the present study. Olmedillas et al. (2011) found a greater difference between BMD in adolescent cyclists and recreational age-matched controls over the age of 17 years, whereas the difference was reduced when analysing cyclists and controls under the age of 17 years. Hence, most studies in male cyclists are undertaken on adults. Therefore, findings from previous studies may not be comparable to the findings from our study. However, findings from studies including adult male cyclists and non-athlete controls may indicate that differences in BMD become greater with age (Barry & Kohrt, 2008; Nichols & Rauh, 2011; Smathers et al., 2009). Another possible explanation for this finding is that the recruited cyclists were males only, whereas the control group consisted mainly of females (8 of 11 subjects). Among children and adolescent, males are found to have greater BMD than females, with the differences being more pronounced with the onset and progression throughout puberty (Weaver et al., 2016). Additionally, females are found to have a lower bone mass than males throughout life, and are therefore at a higher risk of suffering from osteoporosis (Olmedillas, González-Agüero, Moreno, Casajus, & Vicente-Rodríguez, 2012). This might also be the case for the included females in the present study, as the mean Z-score in the control group were below 0 in all lumbar measurements. Z-scores compare bone density with age- and gender-matched controls, and are therefore a number representing the average person of the same age and sex, meaning that the mean BMD of the control group is below what is expected in this group (Scofield & Hecht, 2012).

Changes in BMD throughout seasons

We did not find a significant change in BMD between off-season and pre-season (Test 1 vs Test 3) in cyclists. However, we found a significant increase in all measurements from post-season

to pre-season in the first 10 tested cyclists (n = 10, Test 2 and 3). Baker, Raoul and Reiser (2017) undertook a longitudinal assessment of BMD and body composition in competitive cyclists over a whole cycling season, and found no significant changes in BMD Z-scores in any cyclists, regardless of subgroups (male, females, young, adult, competition level and road or mountain bikers). Viner et al (2015) presented similar findings in their study, as cyclists did not have a significant change in BMD at any sites across the season. Another study looking at changes through seasons are Barry and Kohrt (2008), who aimed to determine whether there are training-related decreased in BMD over a 1-year period in cyclists. They found that BMD were significantly lower at all sites at the post-season test relative to baseline, except in the lumbar spine, however there was a tendency of lower BMD at this site ($p = 0.079$). Additionally, nonsignificant trends were found for recovery in some sites, but BMD in the lumbar spine continued to decrease from post-season to off-season. A third study examining changes in BMD in cyclists over a 1-year period is undertaken on females and may not be comparable to present study (Sherk et al., 2014). Though, there were found a significant decrease in hip and subtrochanteric BMD during the observational period. Lumbar spine BMD were not significantly changed, though a tendency towards lower BMD were found.

As we only measured and analysed the lumbar spine Z-scores over time, little is known about whether there would have been a difference in BMD in other sites in the included cyclists. However, as other studies have found trends of decreased BMD in the lumbar spine and our study did not; with increased BMD from post-season to pre-season (n =10, Test 2 and 3), a possible explanation could be the age of the subjects included in the present study. The cyclists were 16 years old when they were recruited and have not yet achieved PBM. Therefore, the positive change from Test 2 to 3 found in the present study may reflect the maturation-related increases in BMD, and also why there were no significant change when looking at all cyclists (n =15, Test 2 and 3) (Baxter-Jones et al., 2011; Mountjoy et al., 2014). Additionally, in the study by Viner et al (2015), 50 % of the cyclists were mountain bikers, which is also the case for our cyclists, however, the exact number is not known. Mountain bikers are found to have higher hip and lumbar spine BMD than road cyclists (Warner, Shaw, & Dalsky, 2002). In contrast, Viner et al (2015) did not find any differences in BMD between road cyclists and mountain bikers. However, that we did not separate these cyclists into different groups can therefore have had an impact on the outcome of the results. Moreover, all cyclists who presented with low BMD at the first test in this study, were contacted and recommended to consult with their GP for further follow-up. This could potentially have influenced the outcome of the study,

as these subjects may have managed to stop the decrease, and or, possibly also increase their BMD with support from their GP and coaches throughout the period.

BMD and possible correlations

We found a moderate positive correlation between BMD and muscle mass (kg). Whereas there was a small negative correlation between BMD and body fat (%). Keay et al. (2018) explored the use of a questionnaire combined with an interview (SEAQ-I) to identify male athletes at risk of developing RED-S. The most significant factor explaining low BMD in the lumbar spine in male cyclists was found to be LEA. Cyclists with LEA who had not undertaken weight-bearing activities during youth, was presented with significantly lower BMD in the lumbar spine. LEA combined with little osteogenic stimuli during youth may impair attainment of PBM and optimal bone microarchitecture (Papageorgiou et al., 2018). However, the present study did not obtain the subjects' energy intake from food registration, neither from a dietary recall, only food frequency was obtained to get an overview of the subjects' diet. It is therefore difficult to compare these findings. However, there were one study who found a positive correlation between BMD and age, so as for lean mass and kcal ($r \geq 0.309$, $p \leq 0.047$) in the post-season analysis for correlation (Baker & Reiser, 2017). The only significant negative correlate of BMD was body fat (%) ($r = -0.359$, $p = 0.020$), which is consistent with findings from the present study.

We did also find a moderate positive correlation between BMD and RER in cyclists. Torstveit et al. (2018) explored the associations between exercise dependence, eating disorder symptoms and biomarkers of RED-S in male runners and cyclists. They found a low RMR_{ratio} in 72 % of the included subjects. A low RMR_{ratio} has been insinuated as a marker for LEA, however males with a negative energy balance in this study did not have a higher RMR_{ratio}. Additionally, Rogers et al. (2021) found that 11 % of cyclists were meeting the criteria for low RMR at the time of testing, however, this study included females only, and various sports.

LEAM-Q

No other published studies have used this questionnaire yet, and therefore, findings from present study are unique, and thereby also difficult to compare to other studies. As we are not able to score participants according to their answers, as the validation study of the questionnaire is not yet published, only descriptive data are presented. Some of the cyclists were presented with some extent of dizziness and a few felt depressed and less happy several days a week,

which are all signs of RED-S. RED-S can affect both health and performance, and have an influence on coordination, judgement, and psychological health (Mountjoy et al., 2014) (Figure 2 and 3). However, Rogers et al. (2021) reported the prevalence of symptoms of RED-S in a cohort of 112 female athletes, with a mean age of 19 years from various sports. They used various questionnaires, including LEAF-Q (same as LEAM-Q but for females). As much as 80 % of all included athletes were presented with at least one symptom consistent with RED-S, whereas 37 % were demonstrated with two and three symptoms (Rogers et al., 2021). The most prevalent body systems affected were haematological, psychological, gastrointestinal and immunological systems. Additionally, 55 % of the included athletes were found to be at risk of LEA according to the findings from the LEAF-Q.

Dietary habits

Viner et al. (2015) assessed EA and dietary patterns of adult cyclists with lower BMD than expected (Z-score < 0). They found that cyclists consumed an average of 5 ± 1 meals per day, including 1 ± 1 exercise meals per day. These findings are similar to the findings from the present study, where most cyclists consumed five main meals per day, and 66 % consumed one or more additional meal or snack per day. However, we are not able to say anything in detail about the macro-or micronutrient intake in the cyclists as we did not undertake food registration. However, in several studies, cyclists' have been found to suffer from LEA and restrictive- or disordered eating (Keay et al., 2018; Torstveit et al., 2019; Viner et al., 2015).

Strengths and limitations

Few studies have examined BMD and RED-S and associated health variables in adolescent male cyclists. Thus, is the present study involving research in a relatively new area. Strengths in this study is use of objective and gold standard measurements for bone health and RMR, additionally, we used a standardised food frequency- and exercise questionnaire and LEAM-Q. Another strength of this study is the cross-sectional longitudinal design, which allowed us to explore the outcome of BMD and other health variables throughout one year, at three different test points. We did also include a control group, which made it possible to assess whether the prevalence of osteopenia is greater among adolescent male cyclists compared to a reference population. However, the reference population were not as homogenous as the group of cyclists. This was though expected as adolescent non-athletes probably have more diverse lifestyles compared to age-matched cyclists. Moreover, both males and females were included in the control group, whereas there were only male cyclists. The reason for this is that we were not

able to recruit any female cyclists to this study, and the recruitment of controls made it difficult to limit it to males only.

A limitation in the present study is use of different study personnel. However, as the study were conducted over more than one year, and data are included in several bachelor-and master thesis's, some turnover is necessarily. However, all study personnel underwent the same training and used the same protocols for testing, which helps to minimise the bias. The absence of data on hormones and EI is a potential weakness of this study, as these factors may affect bone acquisition. Although, hormones and EI potentially can help explain the mechanisms behind observations in BMD, they should not change the main outcome of this study, that a low BMD are found in 73 % of cyclists at post-season, with no significant difference in BMD from controls. Another possible weakness is that study participants potentially do not follow the pre-testing protocol, with fasting and restricted activity prior to DXA and RMR measurements.

Practical applications

Findings from the present study along with findings from previous research in cyclists present an alarming observation for bone health in healthy, young cyclists. This study can provide an increased insight and knowledge about BMD and possible health variables in RED-S in adolescent male cyclists. However, there are need for more studies investigating the hormonal changes, as well as studies of which extends over a longer time, to be able to explore the long-term effects on BMD and RED-S in adolescent cyclists. The underlying mechanisms of low BMD and other health variables related to RED-S in adolescent cyclists are yet not well understood, and therefore further research is needed to determine causes for low BMD in young cyclists. Additionally, coaches and other health professionals communicating with adolescent cyclists need to educate and assist them in developing strategies to enhance bone health through both diet and exercise appropriate for health and age.

Conclusion

In conclusion, young cyclists were found to have a high prevalence of low BMD (defined as osteopenia, with a Z-score < -1), especially in post-season. More than half of the cyclists were presented with RED-S related symptoms at some extent according to the LEAM-Q, with dizziness as the most prominent symptom. However, there was no significant difference between cyclists and age-matched controls in lumbar spine BMD, and there was no significant change in BMD over one year (January 2020-April 2021) within the cyclists.

References

Andersen, O. K., Clarsen, B., Garthe, I., Mørland, M., & Stensrud, T. (2018). Bone health in elite Norwegian endurance cyclists and runners: a cross-sectional study. *BMJ open sport & exercise medicine, 4*(1), e000449-e000449. doi:10.1136/bmjsem-2018-000449

Areta, J. L., Taylor, H. L., & Koehler, K. (2021). Low energy availability: history, definition and evidence of its endocrine, metabolic and physiological effects in prospective studies in females and males. *Eur J Appl Physiol, 121*(1), 1-21. doi:10.1007/s00421-020-04516-0

AymesMedical (Producer). (2021). GE Lunar Prodigy. [Picture] Retrieved from https://aymes.ca/ge-lunar-prodigy/

Baker, B. S., & Reiser, R. F., 2nd. (2017). Longitudinal Assessment of Bone Mineral Density and Body Composition in Competitive Cyclists. *J Strength Cond Res, 31*(11), 2969-2976. doi:10.1519/jsc.0000000000002128

Barry, D. W., & Kohrt, W. M. (2008). BMD decreases over the course of a year in competitive male cyclists. *J Bone Miner Res, 23*(4), 484-491. doi:10.1359/jbmr.071203

Basková, M., Holubcikova, J., & Baska, T. (2017). Body-image Dissatisfaction and Weight-control Behaviour in Slovak Adolescents. *Central European Journal of Public Health, 25*, 216-221. doi:10.21101/cejph.a4724

Baxter-Jones, A. D., Faulkner, R. A., Forwood, M. R., Mirwald, R. L., & Bailey, D. A. (2011). Bone mineral accrual from 8 to 30 years of age: An estimation of peak bone mass. *Journal of Bone and Mineral Research, 26*(8), 1729-1739. doi:10.1002/jbmr.412

Burke, L. M., Close, G. L., Lundy, B., Mooses, M., Morton, J. P., & Tenforde, A. S. (2018). Relative Energy Deficiency in Sport in Male Athletes: A Commentary on Its Presentation Among Selected Groups of Male Athletes. *Int J Sport Nutr Exerc Metab, 28*(4), 364-374. doi:10.1123/ijsnem.2018-0182

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences*. New York: Routledge Academic.

Deuster, P. A., & Heled, Y. (2008). Chapter 41 - Testing for Maximal Aerobic Power. In P. H. Seidenberg & A. I. Beutler (Eds.), *The Sports Medicine Resource Manual* (pp. 520-528). Philadelphia: W.B. Saunders.

Ferrand, C., & Brunet, E. (2004). Perfectionism and risk for disordered eating among young French male cyclists of high performance. *Percept Mot Skills, 99*(3 Pt 1), 959-967. doi:10.2466/pms.99.3.959-967

Fortes, L. d. S., Kakeshita, I. S., Almeida, S. S., Gomes, A. R., & Ferreira, M. E. C. (2014). Eating behaviours in youths: A comparison between female and male athletes and non-athletes. *Scandinavian Journal of Medicine & Science in Sports, 24*(1), e62-e68. doi:10.1111/sms.12098

Francisco, R., Narciso, I., & Alarcão, M. (2013). Individual and relational risk factors for the development of eating disorders in adolescent aesthetic athletes and general adolescents. *Eat Weight Disord, 18*(4), 403-411. doi:10.1007/s40519-013-0055-6

Fredericson, M., Chew, K., Ngo, J., Cleek, T., Kiratli, J., & Cobb, K. (2007). Regional bone mineral density in male athletes: a comparison of soccer players, runners and controls. *Br J Sports Med, 41*(10), 664-668; discussion 668. doi:10.1136/bjsm.2006.030783

Goolsby, M. A., & Boniquit, N. (2017). Bone Health in Athletes. *Sports Health, 9*(2), 108-117. doi:10.1177/1941738116677732

Haugen, H. A., Chan, L. N., & Li, F. (2007). Indirect calorimetry: a practical guide for clinicians. *Nutr Clin Pract, 22*(4), 377-388. doi:10.1177/0115426507022004377

Jagim, A. R., Camic, C. L., Kisiolek, J., Luedke, J., Erickson, J., Jones, M. T., & Oliver, J. M. (2018). Accuracy of Resting Metabolic Rate Prediction Equations in Athletes. *J Strength Cond Res, 32*(7), 1875-1881. doi:10.1519/jsc.0000000000002111

Jeukendrup, A. E., Craig, N. P., & Hawley, J. A. (2000). The bioenergetics of World Class Cycling. *J Sci Med Sport, 3*(4), 414-433. doi:10.1016/s1440-2440(00)80008-0

Julián-Almárcegui, C., Gómez-Cabello, A., González-Agüero, A., Olmedillas, H., Gómez-Bruton, A., Matute-Llorente, A., . . . Vicente-Rodríguez, G. (2013). The nutritional status in adolescent Spanish cyclists. *Nutr Hosp, 28*(4), 1184-1189. doi:10.3305/nh.2013.28.4.6513

Keay, N., Francis, G., Entwistle, I., & Hind, K. (2019). Clinical evaluation of education relating to nutrition and skeletal loading in competitive male road cyclists at risk of relative energy deficiency in sports (RED-S): 6-month randomised controlled trial. *BMJ Open Sport Exerc Med, 5*(1), e000523. doi:10.1136/bmjsem-2019-000523

Keay, N., Francis, G., & Hind, K. (2018). Low energy availability assessed by a sport-specific questionnaire and clinical interview indicative of bone health, endocrine profile and cycling performance in competitive male cyclists. *BMJ Open Sport Exerc Med, 4*(1), e000424. doi:10.1136/bmjsem-2018-000424

Koehler, K., Williams, N. I., Mallinson, R. J., Southmayd, E. A., Allaway, H. C., & De Souza, M. J. (2016). Low resting metabolic rate in exercise-associated amenorrhea is not due to a reduced proportion of highly active metabolic tissue compartments. *Am J Physiol Endocrinol Metab, 311*(2), E480-487. doi:10.1152/ajpendo.00110.2016

Kohrt, W. M., Bloomfield, S. A., Little, K. D., Nelson, M. E., & Yingling, V. R. (2004). American College of Sports Medicine Position Stand: physical activity and bone health. *Med Sci Sports Exerc, 36*(11), 1985-1996. doi:10.1249/01.mss.0000142662.21767.58

Lane, A. R., Hackney, A. C., Smith-Ryan, A., Kucera, K., Registar-Mihalik, J., & Ondrak, K. (2019). Prevalence of Low Energy Availability in Competitively Trained Male Endurance Athletes. *Medicina (Kaunas), 55*(10). doi:10.3390/medicina55100665

Lebenstedt, M., Platte, P., & Pirke, K. M. (1999). Reduced resting metabolic rate in athletes with menstrual disorders. *Med Sci Sports Exerc, 31*(9), 1250-1256. doi:10.1097/00005768-199909000-00004

Leib, E. S., Lewiecki, E. M., Binkley, N., & Hamdy, R. C. (2004). Official positions of the International Society for Clinical Densitometry. *South Med J, 97*(1), 107-110. doi:10.1097/00007611-200401000-00029

Logue, D. M., Madigan, S. M., Melin, A., Delahunt, E., Heinen, M., Donnell, S. M., & Corish, C. A. (2020). Low Energy Availability in Athletes 2020: An Updated Narrative Review of Prevalence, Risk, Within-Day Energy Balance, Knowledge, and Impact on Sports Performance. *Nutrients, 12*(3). doi:10.3390/nu12030835

Medelli, J., Lounana, J., Menuet, J. J., Shabani, M., & Cordero-MacIntyre, Z. (2009). Is osteopenia a health risk in professional cyclists? *J Clin Densitom, 12*(1), 28-34. doi:10.1016/j.jocd.2008.07.057

Melin, A., Tornberg, Å. B., Skouby, S., Møller, S. S., Faber, J., Sundgot-Borgen, J., & Sjödin, A. (2016). Low-energy density and high fiber intake are dietary concerns in female endurance athletes. *Scandinavian Journal of Medicine & Science in Sports, 26*(9), 1060-1071. doi:10.1111/sms.12516

Melin, A., Tornberg, Å. B., Skouby, S., Møller, S. S., Sundgot-Borgen, J., Faber, J., . . . Sjödin, A. (2015). Energy availability and the female athlete triad in elite endurance athletes. *Scandinavian Journal of Medicine & Science in Sports, 25*(5), 610-622. doi:10.1111/sms.12261

Morgan, S. L., & Prater, G. L. (2017). Quality in dual-energy X-ray absorptiometry scans. *Bone, 104*, 13-28. doi:10.1016/j.bone.2017.01.033

Mountjoy, M., Sundgot-Borgen, J., Burke, L., Carter, S., Constantini, N., Lebrun, C., . . . Ljungqvist, A. (2014). The IOC consensus statement: beyond the Female Athlete Triad--Relative Energy Deficiency in Sport (RED-S). *Br J Sports Med, 48*(7), 491-497. doi:10.1136/bjsports-2014-093502

Mountjoy, M., Sundgot-Borgen, J. K., Burke, L. M., Ackerman, K. E., Blauwet, C., Constantini, N., . . . Budgett, R. (2018). IOC consensus statement on relative energy deficiency in sport (RED-S): 2018 update. *British Journal of Sports Medicine, 52*(11), 687-697. doi:10.1136/bjsports-2018-099193

Murphy, C., & Koehler, K. (2020). Caloric restriction induces anabolic resistance to resistance exercise. *Eur J Appl Physiol, 120*(5), 1155-1164. doi:10.1007/s00421-020-04354-0

Nagle, K. B., & Brooks, M. A. (2011). A Systematic Review of Bone Health in Cyclists. *Sports Health, 3*(3), 235-243. doi:10.1177/1941738111398857

Nattiv, A., Loucks, A. B., Manore, M. M., Sanborn, C. F., Sundgot-Borgen, J., & Warren, M. P. (2007). American College of Sports Medicine position stand. The female athlete triad. *Med Sci Sports Exerc, 39*(10), 1867-1882. doi:10.1249/mss.0b013e318149f111

Nichols, J. F., Palmer, J. E., & Levy, S. S. (2003). Low bone mineral density in highly trained male master cyclists. *Osteoporos Int, 14*(8), 644-649. doi:10.1007/s00198-003-1418-z

Nichols, J. F., & Rauh, M. J. (2011). Longitudinal changes in bone mineral density in male master cyclists and nonathletes. *J Strength Cond Res, 25*(3), 727-734. doi:10.1519/JSC.0b013e3181c6a116

Oellingrath, I. M., Svendsen, M. V., & Hestetun, I. (2014). Eating patterns and mental health problems in early adolescence – a cross-sectional study of 12–13-year-old Norwegian schoolchildren. *Public Health Nutrition, 17*(11), 2554-2562. doi:10.1017/S1368980013002747

Olmedillas, H., González-Agüero, A., Moreno, L. A., Casajus, J. A., & Vicente-Rodríguez, G. (2012). Cycling and bone health: a systematic review. *BMC Med, 10*, 168. doi:10.1186/1741-7015-10-168

Papageorgiou, M., Dolan, E., Elliott-Sale, K. J., & Sale, C. (2018). Reduced energy availability: implications for bone health in physically active populations. *Eur J Nutr, 57*(3), 847-859. doi:10.1007/s00394-017-1498-8

Papageorgiou, M., Elliott-Sale, K. J., Parsons, A., Tang, J. C. Y., Greeves, J. P., Fraser, W. D., & Sale, C. (2017). Effects of reduced energy availability on bone metabolism in women and men. *Bone, 105*, 191-199. doi:10.1016/j.bone.2017.08.019

Rapún-López, M., Olmedillas, H., Gonzalez-Agüero, A., Gomez-Cabello, A., Pradas de la Fuente, F., Moreno, L. A., . . . Vicente-Rodríguez, G. (2019). May Young Elite Cyclists Have Less Efficient Bone Metabolism? *Nutrients, 11*(5). doi:10.3390/nu11051178

Rector, R. S., Rogers, R., Ruebel, M., & Hinton, P. S. (2008). Participation in road cycling vs running is associated with lower bone mineral density in men. *Metabolism, 57*(2), 226-232. doi:10.1016/j.metabol.2007.09.005

Riebl, S. K., Subudhi, A. W., Broker, J. P., Schenck, K., & Berning, J. R. (2007). The prevalence of subclinical eating disorders among male cyclists. *J Am Diet Assoc, 107*(7), 1214-1217. doi:10.1016/j.jada.2007.04.017

Rogers, M. A., Appaneal, R. N., Hughes, D., Vlahovich, N., Waddington, G., Burke, L. M., & Drew, M. (2021). Prevalence of impaired physiological function consistent with Relative Energy Deficiency in Sport (RED-S): an Australian elite and pre-elite cohort. *Br J Sports Med, 55*(1), 38-45. doi:10.1136/bjsports-2019-101517

Rosendahl, J., Bormann, B., Aschenbrenner, K., Aschenbrenner, F., & Strauss, B. (2009). Dieting and disordered eating in German high school athletes and non-athletes. *Scand J Med Sci Sports, 19*(5), 731-739. doi:10.1111/j.1600-0838.2008.00821.x

Schofield, K. L., Thorpe, H., & Sims, S. T. (2019). Resting metabolic rate prediction equations and the validity to assess energy deficiency in the athlete population. *Exp Physiol, 104*(4), 469-475. doi:10.1113/ep087512

Scofield, K. L., & Hecht, S. (2012). Bone Health in Endurance Athletes: Runners, Cyclists, and Swimmers. *Current Sports Medicine Reports, 11*(6), 328-334. doi:10.1249/JSR.0b013e3182779193

Sherk, V. D., Barry, D. W., Villalon, K. L., Hansen, K. C., Wolfe, P., & Kohrt, W. M. (2014). Bone loss over 1 year of training and competition in female cyclists. *Clin J Sport Med, 24*(4), 331-336. doi:10.1097/jsm.0000000000000050

Smathers, A. M., Bemben, M. G., & Bemben, D. A. (2009). Bone density comparisons in male competitive road cyclists and untrained controls. *Med Sci Sports Exerc, 41*(2), 290-296. doi:10.1249/MSS.0b013e318185493e

Sportsmedizin, Z. f. (Producer). (2018). Ruheenergieumsatzbestimmung. [PIcture] Retrieved from https://www.zeitschrift-sportmedizin.de/ruheenergieumsatzbestimmung-die-anwendbarkeit-von-anthropometriebasierten-formeln-im-vergleich-zur-indirekten-kalorimetrie/

Stenqvist, T. B., Torstveit, M. K., Faber, J., & Melin, A. K. (2020). Impact of a 4-Week Intensified Endurance Training Intervention on Markers of Relative Energy Deficiency in Sport (RED-S) and Performance Among Well-Trained Male Cyclists. *Front Endocrinol (Lausanne), 11*, 512365. doi:10.3389/fendo.2020.512365

Sundgot-Borgen, J., & Torstveit, M. K. (2004). Prevalence of eating disorders in elite athletes is higher than in the general population. *Clin J Sport Med, 14*(1), 25-32. doi:10.1097/00042752-200401000-00005

Tenforde, A. S., Barrack, M. T., Nattiv, A., & Fredericson, M. (2016). Parallels with the Female Athlete Triad in Male Athletes. *Sports Med, 46*(2), 171-182. doi:10.1007/s40279-015-0411-y

Tenforde, A. S., Carlson, J. L., Chang, A., Sainani, K. L., Shultz, R., Kim, J. H., . . . Fredericson, M. (2017). Association of the Female Athlete Triad Risk Assessment Stratification to the Development of Bone Stress Injuries in Collegiate Athletes. *Am J Sports Med, 45*(2), 302-310. doi:10.1177/0363546516676262

Tenforde, A. S., & Fredericson, M. (2011). Influence of Sports Participation on Bone Health in the Young Athlete: A Review of the Literature. *PM&R, 3*(9), 861-867. doi:10.1016/j.pmrj.2011.05.019

Torstveit, M. K., Aagedal-Mortensen, K., & Stea, T. H. (2015). More than half of high school students report disordered eating: a cross sectional study among Norwegian boys and girls. *PLoS One, 10*(3), e0122681. doi:10.1371/journal.pone.0122681

Torstveit, M. K., Fahrenholtz, I., Stenqvist, T. B., Sylta, Ø., & Melin, A. (2018). Within-Day Energy Deficiency and Metabolic Perturbation in Male Endurance Athletes. *Int J Sport Nutr Exerc Metab, 28*(4), 419-427. doi:10.1123/ijsnem.2017-0337

Torstveit, M. K., Fahrenholtz, I. L., Lichtenstein, M. B., Stenqvist, T. B., & Melin, A. K. (2019). Exercise dependence, eating disorder symptoms and biomarkers of Relative Energy Deficiency in Sports (RED-S) among male endurance athletes. *BMJ Open Sport Exerc Med, 5*(1), e000439. doi:10.1136/bmjsem-2018-000439

Viner, R. T., Harris, M., Berning, J. R., & Meyer, N. L. (2015). Energy Availability and Dietary Patterns of Adult Male and Female Competitive Cyclists With Lower Than Expected Bone Mineral Density. *Int J Sport Nutr Exerc Metab, 25*(6), 594-602. doi:10.1123/ijsnem.2015-0073

Warner, S. E., Shaw, J. M., & Dalsky, G. P. (2002). Bone mineral density of competitive male mountain and road cyclists. *Bone, 30*(1), 281-286. doi:10.1016/s8756-3282(01)00704-9

Wasserfurth, P., Palmowski, J., Hahn, A., & Krüger, K. (2020). Reasons for and Consequences of Low Energy Availability in Female and Male Athletes: Social Environment, Adaptations, and Prevention. *Sports Med Open, 6*(1), 44. doi:10.1186/s40798-020-00275-6

Wasserman, H., O'Donnell, J. M., & Gordon, C. M. (2017). Use of dual energy X-ray absorptiometry in pediatric patients. *Bone, 104*, 84-90. doi:10.1016/j.bone.2016.12.008

Weaver, C. M., Gordon, C. M., Janz, K. F., Kalkwarf, H. J., Lappe, J. M., Lewis, R., . . . Zemel, B. S. (2016). The National Osteoporosis Foundation's position statement on peak bone mass development and lifestyle factors: a systematic review and implementation recommendations. *Osteoporos Int, 27*(4), 1281-1386. doi:10.1007/s00198-015-3440-3

Werner, A., Thiel, A., Schneider, S., Mayer, J., Giel, K. E., & Zipfel, S. (2013). Weight-control behaviour and weight-concerns in young elite athletes - a systematic review. *Journal of eating disorders, 1*, 18-18. doi:10.1186/2050-2974-1-18

Woods, A. L., Garvican-Lewis, L. A., Lundy, B., Rice, A. J., & Thompson, K. G. (2017). New approaches to determine fatigue in elite athletes during intensified training: Resting metabolic rate and pacing profile. *PLoS One, 12*(3), e0173807. doi:10.1371/journal.pone.0173807

Yeager, K. K., Agostini, R., Nattiv, A., & Drinkwater, B. (1993). The female athlete triad: disordered eating, amenorrhea, osteoporosis. *Med Sci Sports Exerc, 25*(7), 775-777. doi:10.1249/00005768-199307000-00003

Åkesdotter, C., Kenttä, G., Eloranta, S., & Franck, J. (2020). The prevalence of mental health problems in elite athletes. *J Sci Med Sport, 23*(4), 329-335. doi:10.1016/j.jsams.2019.10.022

Appendices

Appendix 1. Health check questionnaire

Helsevurdering

Obligatoriske felter er merket med denne stjernen *

Forsøksperson nummer *

Per idag bruker du noen av følgende?

Sett kryss bak dersom èn eller flere gjelder deg

- [ ] Røyk
- [ ] Snus
- [ ] Elsigarett

Har du/ har hatt noen av følgende sykdommer?

Sett kryss bak dersom du har fått diagnotisert èn eller flere av følgende:

- [ ] Stoffskiftesykdom
- [ ] Diabetes
- [ ] Inflammatorisk tarmsykdom
- [ ] Crohns sykdom
- [ ] Nyre sykdom
- [ ] Revmatisme sykdom
- [ ] Kronisk beinmargsykdom
- [ ] Spiseforstyrrelse

Har du kjent familiær tidlig osteoporose (≤50 år).

- [ ] Ja
- [ ] Nei

Appendix 2. Informational letter and statement of consent – cyclists

RED-S OG BENHELSE HOS UNGE SYKLISTER

BAKGRUNN OG HENSIKT

Grunnlaget for en god benhelse livet igjennom legges i ungdomsårene. Støtdempende aktivitet som hopp, løp og styrketrening anses som viktige faktorer som styrker skjelettet, i tillegg til tilstrekkelig kalsium- og energiinntak. Nyere forskning har vist at aktive syklister kan ha høyere risiko for å utvikle lav benmineraltetthet, sammenlignet med andre idretter og ikke-idrettsaktive kontroller. Dette på grunn av at sykling anses som en idrett med lav- til moderat støtdempende belastning, samt at det er en vektsensitiv idrett. Man vet allikevel fortsatt lite om langtidsutviklingen i benhelsen. I tillegg har det i senere tid blitt utviklet et kartleggingsverktøy for idrettsutøvere som vurderer risikoen for «Redusert energitilgjengelighet i idrett» (på engelsk «Relative Energy Deficiency in Sports») (RED-S).

Dette er et spørreskjema som skal hjelpe oss å vurdere om et høyt energiforbruk og lavt energiinntak over tid kan bidra til forstyrrelser i bl.a metabolismen, benhelsen, det kardiovaskulære systemet, immunsystemet og menstruasjonen. Per i dag har man liten kunnskap om denne risikoen blant syklister.

Hensikten med prosjektet er derfor å kartlegge risikoen for RED-S og benhelsen blant unge aktive syklister, og sammenligne dette med alders-matchede ungdommer som per dags dato ikke er idrettsaktive. Vi ønsker også å følge forsøkspersonene over en 10 års periode, for å se på langtidsutviklingen i de samme variablene. Dette informasjonsskrivet er til alle potensielle forsøkspersoner som er aktive syklister og deres foreldre/foresatte. Kriteriene for deltakelse er: man må være 15 år, og gå 1.året NTG Lillehammer, med sykling som valgt idrett. Man tilfredsstiller ikke kravene for å delta dersom man røyker, bruker snus eller elsigarett, har kjent stoffskiftesykdom, diabetes, inflammatorisk tarmsykdom, chrons sykdom, nyresykdom, kronisk benmargssykdom eller spiseforstyrrelser.

Prosjektet er initiert og ledet av idrettsseksjonen Lillehammer, Høgskolen Innlandet, ved Professor Bent Rønnestad og førsteamanuensis Anne Mette Rustaden. Prosjektet er også et samarbeid med OLT Innlandet v/Camilla Aasen Mæland. Det vil bli knyttet master- og bachelorstudenter opp mot prosjektet.

HVA INNEBÆRER STUDIEN?

Rekruttering vil foregå i fire omganger; høst/vinter 2019-2023. Forsøkspersonene trenger å møte opp på Høgskolen Lillehammer kun èn morgen/formiddag for å gjennomføre testene (totalt ca 2 timer) hvert semester de første tre årene. Deretter er det ønskelig med ett oppmøte per år, de resterende syv årene (frem til 2029/2034). Skulle man flytte til andre steder i

Norge, vil vi tilrettelegge for testing når man evt er i området, og/eller vil prosjektet dekke reisekostnader. For hvert testtilfelle vil man gjennomgå nøyaktig de samme testene, i samme rekkefølge. Prosjektet inkluderer ingen fysiske tester, de gjennomføres alle i hvile. Man skal svare på et spørreskjema som er et screeningverktøy som identifiserer utøvere i risikosonen for RED-S, samt et spørreskjema om kostholdsvaner og generelle aktivitetsvaner. I tillegg måles benmineraltetthet med Dual-energy X-ray absorptiometry (DEXA), hvilemetabolismen med indirekte kalorimetri, det tas en blodprøve, og hjerterytmen måles med elektrokardiografi (EKG). For at målingene skal bli så nøyaktige og standardiserte som mulig, må forsøkspersonene møte opp i fastende tilstand på testedagene, dvs ikke ha inntatt mat eller drikke siste 12 timene før testing (bortsett fra vann). Vi vil være imøtekommende og tilrettelegge testtidene så godt som mulig, slik at det for eksempel ikke går utover fravær fra skolen. Alle testene blir gjennomført på samme sted, under tilnærmet like forhold og innenfor samme tidsrom på døgnet.

Informasjon om testene:

DEXA er et røntgenapparat som måler benmineraltettheten og kroppssammensetningen. Selve undersøkelsen tar ca 20 minutter, og er helt smertefri. Man skal ligge avslappet og horisontalt i en maskin, iført kun undertøy mens målingen gjennomføres. Det er god plass mellom øvre og nedre del av maskinen, så det er ingen risiko for klaustrofobi, og du vil hele tiden kunne kommunisere med testlederne til stede.

Bilde 1: Illustrasjon av DEXA

Hvilemetabolismen måles direkte etter DEXA målingen, i samme horisontale posisjon. Målingen skjer med indirekte kalorimetri, som inkluderer en ventilert hette som legges over hodet, og som registrerer ditt oksygenopptak hvert 30.sekund i totalt 20 minutter.

Blodprøve (veneprøve) og EKG vil bli tatt av kvalifisert personell direkte etter måling av hvilemetabolismen, før man til slutt vil bli bedt om å fylle ut spørreskjemaene. Spørreskjemaet som omhandler RED-S inkluderer spørsmål rundt aktivitetsvaner, svimmelhet, magefunksjon, helseproblemer som gir avvik fra idrett, velvære, restitusjon, søvn, energinivå og menstruasjon hos kvinnelige forsøkspersoner. Det andre spørreskjemaet inkluderer spørsmål om kostholdsvaner og aktivitetsvaner. Totalt vil hele testprotokollen ta cirka to timer.

MULIGE FORDELER OG ULEMPER

Fordelene med dette prosjektet er at man får nøye kartlagt og kjennskap til flere viktige helsevariabler. Skulle noen av testene avdekke avvik, patologi eller annen uhelse, vil vi innen kort tid melde fra til deg og dine foreldre/foresatte, slik at du/dere kan iverksette videre oppfølging med medisinsk personell. Ingen av testene gir noen kjente bivirkninger eller ulemper. Måling av benmineraltetthet (DEXA) gir lave doser med stråling, men dette er langt under grensene for hva som er helseskadelig. DEXA anses som gullstandarden for kartlegging av benhelse, og benyttes mye både innen klinikk og forskning. Den eneste ulempen med deltakelse i prosjektet er den tiden og oppmerksomheten man må avsette til testtilfellene, samt at man må møte opp i fastende tilstand (12 timer fasting).

HVA SKJER MED PRØVENE OG INFORMASJONEN OM DEG?

Opplysningene som er innhentet om deltakerne (testresultatene) og informasjonen som registreres skal kun brukes slik som beskrevet i hensikten med studien. Alle opplysningene vil bli behandlet uten navn og fødselsnummer eller andre direkte gjenkjennende opplysninger. En kode knytter hver forsøksperson til sine opplysninger og prøver gjennom en navneliste, og all data registreres og lagres elektronisk i Tjenester for Sensitive Data (TSD).

Forsker er underlagt taushetsplikt og data behandles konfidensielt. Ved publisering av data vil det ikke være mulig å identifisere forsøkspersonene i resultatene. Dataene som fremkommer i studien vil i hovedsak bli benyttet i vitenskapelig artikler, samt bli presentert på nasjonale og internasjonale konferanser og seminar. Av dokumentasjonshensyn blir all data oppbevart avidentifisert i 5 år etter endt prosjekt.

DELTAKELSE OG GODKJENNING

Regional komité for medisinsk og helsefaglig forskningsetikk har vurdert prosjektet, og har gitt forhåndsgodkjenning (REK 2019/28837).

Etter ny personopplysningslov har behandlingsansvarlig (Høgskolen Innlandet, avdeling Lillehammer) og prosjektleder (Anne Mette Rustaden) et selvstendig ansvar for å sikre at behandlingen av dine opplysninger har et lovlig grunnlag. Dette prosjektet har rettslig grunnlag i EUs personvernforordning artikkel 6 nr. 1a og artikkel 9 nr. 2a og ditt samtykke.

Det er helt frivillig å delta i prosjektet og man kan når som helst trekke seg uten å måtte begrunne dette nærmere. I henhold til Personvernforordningen har man ved ønske rett til å be om at innsamlede personopplysninger slettes, med mindre opplysningene allerede er inngått i analyser eller brukt i vitenskapelige publikasjoner. Dette vil ikke få noen videre konsekvenser for den det måtte gjelde. Som deltaker har man mulighet til å klage til Datatilsynet, og man kan kontakte personvernombudet ved høgskolen. Ved deltakelse i forskningsprosjektet er man forsikret gjennom en særskilt forsikring av Høgskolen Innlandet, samt gjennom pasientskadeloven, jf. Helseforskningsloven § 50.

Ønsker dere å delta i prosjektet, avgir foreldre/foresatte samtykke under.

KONTAKTOPPLYSNINGER

Dersom du har spørsmål til prosjektet eller noen skulle ønske å trekke seg fra studien, ta kontakt med prosjektleder (Anne Mette Rustaden, anne.rustaden@inn.no, tlf 612 88 023).

Personvernombud ved høgskolen: hans.nyberg@inn.no

Jeg gir med dette mitt samtykke til å delta i prosjektet.

Foreldre/foresattes underskrift:

……

Appendix 3. Informational letter and statement of consent – controls

RED-S OG BENHELSE HOS UNGE SYKLISTER

BAKGRUNN OG HENSIKT

Grunnlaget for en god benhelse livet igjennom legges i ungdomsårene. Støtdempende aktivitet som hopp, løp og styrketrening anses som viktige faktorer som styrker skjelettet, i tillegg til tilstrekkelig kalsium- og energiinntak. Nyere forskning har vist at aktive syklister kan ha høyere risiko for å utvikle lav benmineraltetthet, sammenlignet med andre idretter og ikke-idrettsaktive kontroller. Dette på grunn av at sykling anses som en idrett med lav- til moderat støtdempende belastning, samt at det er en vektsensitiv idrett. Man vet allikevel fortsatt lite om langtidsutviklingen i benhelsen. I tillegg har det i senere tid blitt utviklet et kartleggingsverktøy for idrettsutøvere som vurderer risikoen for «Redusert energitilgjengelighet i idrett» (på engelsk «Relative Energy Deficiency in Sports») (RED-S).

Dette er et spørreskjema som skal hjelpe oss å vurdere om et høyt energiforbruk og lavt energiinntak over tid kan bidra til forstyrrelser i bl.a metabolismen, benhelsen, det kardiovaskulære systemet, immunsystemet og menstruasjonen. Per i dag har man liten kunnskap om denne risikoen blant syklister. Vi ønsker også å sammenligne unge syklister med ungdommer som per i dag ikke holder på med aktiv idrett (utover ordinær kroppsøving på skolen). Dette er derfor en forespørsel til foreldre/foresatte til potensielle kontroller til dette forskningsprosjektet.

Hensikten med prosjektet er å kartlegge risikoen for RED-S og benhelsen blant unge aktive syklister, og sammenligne dette med alders-matchede ungdommer som per dags dato ikke er idrettsaktive. Vi ønsker også å følge forsøkspersonene over en 10 års periode, for å se på langtidsutviklingen i de samme variablene. For å delta som kontroll i prosjektet må man være minst 15 år, og gå 1.året på videregående skole. Man må ikke ha drevet strukturert eller regelmessig trening mer enn tre ganger per uke de siste 12 mnd. Man tilfredsstiller ikke kravene for å delta dersom man røyker, bruker snus eller elsigarett, har kjent stoffskiftesykdom, diabetes, inflammatorisk tarmsykdom, chrons sykdom, nyresykdom, kronisk benmargssykdom eller spiseforstyrrelser.

Prosjektet er initiert og ledet av idrettsseksjonen Lillehammer, Høgskolen Innlandet, ved Professor Bent Rønnestad og førsteamanuensis Anne Mette Rustaden. Prosjektet er også et

samarbeid med OLT Innlandet v/Camilla Aasen Mæland. Det vil bli knyttet master- og bachelorstudenter opp mot prosjektet.

HVA INNEBÆRER STUDIEN?

Rekruttering av deltakere til prosjektet vil foregå i fire omganger; høst/vinter 2019-2023. Forsøkspersonene trenger å møte opp på Høgskolen Lillehammer kun èn morgen/formiddag for å gjennomføre testene (totalt ca 2 timer) hvert semester de første tre årene. Deretter vil man bli spurt om fortsatt deltakelse i prosjektet, inntil fylte 25 år. Ved fortsatt deltakelse etter videregående er det ønskelig med ett oppmøte per år. Skulle man flytte til andre steder i Norge, vil vi tilrettelegge for testing når du evt er i området, og/eller vil prosjektet dekke reisekostnader. For hvert testtilfelle vil man gjennomgå nøyaktig de samme testene, i samme rekkefølge. Prosjektet inkluderer ingen fysiske tester, de gjennomføres alle i hvile.

Man skal svare på et spørreskjema som er et screeningverktøy som identifiserer utøvere i risikosonen for RED-S, samt et spørreskjema om kostholdsvaner og generelle aktivitetsvaner. I tillegg måles benmineraltetthet med Dual-energy X-ray absorptiometry (DEXA), hvilemetabolismen med indirekte kalorimetri, det tas en blodprøve, og hjerterytmen måles med elektrokardiografi (EKG). For at målingene skal bli så nøyaktige og standardiserte som mulig, må forsøkspersonene møte opp i fastende tilstand på testedagene, dvs ikke ha inntatt mat eller drikke siste 12 timene før testing (bortsett fra vann). Vi vil være imøtekommende og tilrettelegge testtidene så godt som mulig, slik at det for eksempel ikke går utover fravær fra skolen. Alle testene blir gjennomført på samme sted, under tilnærmet like forhold og innenfor samme tidsrom på døgnet.

<u>Informasjon om testene:</u>

DEXA er et røntgenapparat som måler benmineraltettheten og kroppssammensetningen. Selve undersøkelsen tar ca 20 minutter, og er helt smertefri. Man skal ligge avslappet og horisontalt i en maskin, iført kun undertøy mens målingen gjennomføres. Det er god plass mellom øvre og nedre del av maskinen, så det er ingen risiko for klaustrofobi, og man vil hele tiden kunne kommunisere med testlederne til stede.

Bilde 1: Illustrasjon av DEXA

Hvilemetabolismen måles direkte etter DEXA målingen, i samme horisontale posisjon. Målingen skjer med indirekte kalorimetri, som inkluderer en ventilert hette som legges over hodet, og som registrerer oksygenopptaket hvert 30.sekund i totalt 20 minutter.

Blodprøve (veneprøve) og EKG vil bli tatt av kvalifisert personell direkte etter måling av hvilemetabolismen, før man til slutt vil bli bedt om å fylle ut spørreskjemaene.

Spørreskjemaet som omhandler RED-S inkluderer spørsmål rundt aktivitetsvaner,svimmelhet, magefunksjon, helseproblemer som gir avvik fra idrett, velvære, restitusjon, søvn, energinivå og menstruasjon hos kvinnelige forsøkspersoner. Det andre spørreskjemaet inkluderer spørsmål om kostholdsvaner og aktivitetsvaner. Totalt vil hele testprotokollen ta cirka to timer.

MULIGE FORDELER OG ULEMPER

Fordelene med dette prosjektet er at man får nøye kartlagt og kjennskap til flere viktige helsevariabler. Skulle noen av testene avdekke avvik, patologi eller annen uhelse, vil vi innen kort tid melde fra til dere, slik at dere kan iverksette videre oppfølging med medisinsk personell. Ingen av testene gir noen kjente bivirkninger eller ulemper. Måling av benmineraltetthet (DEXA) gir lave doser med stråling, men dette er langt under grensene for hva som er helseskadelig. DEXA anses som gullstandarden for kartlegging av benhelse, og benyttes mye både innen klinikk og forskning. Den eneste ulempen med deltakelse i prosjektet er den tiden og oppmerksomheten man må avsette til testtilfellene, samt at man må møte opp i fastende tilstand (12 timer fasting).

HVA SKJER MED PRØVENE OG INFORMASJONEN OM DEG?

Opplysningene som er innhentet om deltakerne (testresultatene) og informasjonen som registreres skal kun brukes slik som beskrevet i hensikten med studien. Alle opplysningene vil bli behandlet uten navn og fødselsnummer eller andre direkte gjenkjennende opplysninger. En kode knytter hver forsøksperson til sine opplysninger og prøver gjennom en navneliste, og all data registreres og lagres elektronisk i Tjenester for Sensitive Data (TSD).

Forsker er underlagt taushetsplikt og data behandles konfidensielt. Ved publisering av data vil det ikke være mulig å identifisere forsøkspersonene i resultatene. Dataene som fremkommer i studien vil i hovedsak bli benyttet i vitenskapelig artikler, samt bli presentert på nasjonale og internasjonale konferanser og seminar. Av dokumentasjonshensyn blir all data oppbevart avidentifisert i 5 år etter endt prosjekt.

DELTAKELSE OG GODKJENNING

Regional komité for medisinsk og helsefaglig forskningsetikk har vurdert prosjektet, og har gitt forhåndsgodkjenning (REK 2019/28837).

Etter ny personopplysningslov har behandlingsansvarlig (Høgskolen Innlandet, avdeling Lillehammer) og prosjektleder (Anne Mette Rustaden) et selvstendig ansvar for å sikre at behandlingen av dine opplysninger har et lovlig grunnlag. Dette prosjektet har rettslig grunnlag i EUs personvernforordning artikkel 6 nr. 1a og artikkel 9 nr. 2a og ditt samtykke.

Det er helt frivillig å delta i prosjektet og man kan når som helst trekke seg uten å måtte begrunne dette nærmere. I henhold til Personvernforordningen har man ved ønske rett til å be om at innsamlede personopplysninger slettes, med mindre opplysningene allerede er inngått i analyser eller brukt i vitenskapelige publikasjoner. Dette vil ikke få noen videre konsekvenser for den det måtte gjelde. Som deltaker har man mulighet til å klage til Datatilsynet, og man kan kontakte personvernombudet ved høgskolen. Ved deltakelse i forskningsprosjektet er man forsikret gjennom en særskilt forsikring av Høgskolen Innlandet, samt gjennom pasientskadeloven, jf. Helseforskningsloven § 50.

Ønsker dere å delta i prosjektet, avgir foreldre/foresatte samtykke under.

KONTAKTOPPLYSNINGER

Dersom du har spørsmål til prosjektet eller noen skulle ønske å trekke seg fra studien, ta kontakt med prosjektleder (Anne Mette Rustaden, anne.rustaden@inn.no, tlf 612 88 023).

Personvernombud ved høgskolen: hans.nyberg@inn.no

Jeg gir med dette mitt samtykke til å delta i prosjektet.

Foreldre/foresattes underskrift:

……

Appendix 4. Test day informational letter

Informasjon til forsøkspersoner, uke 4.

For at vi skal få målinger som kan gi oss god og riktig informasjon, er det viktig at du er nøye med forberedelsene.

Dagen før du skal teste:

- ✓ **Du kan kun ha lavintensiv trening**
  Ikke mer enn 60 minutter sportsspesifikk trening (helst tidlig på dagen), ingen styrketrening
- ✓ **Pass på at du er i væskebalanse**
  Drikk 2 store glass vann til hvert hovedmåltid
- ✓ **Ingen mat / drikke / kaffe / snus etter kl. 22.00 (kun litt vann hvis nødvendig)**

På testdagen:

- ✓ **På selve testdagen kan du ikke innta noe mat eller drikke, ikke engang vann**
- ✓ **Sørg for at du ikke gjør noe aktivitet etter at du har våknet, og sørg for å ta buss eller bil til høyskolen på testdagen**
- ✓ **Bruk undertøy uten metall, inkludert glidelåser**
  Du kan for eksempel bruke lycrashorts, bomullundertøy, t-skjorte eller sports-bh uten spiler
- ✓ **Ta med deg en niste som du kan spise etter at du er ferdig med testingen**

Appendix 5. LEAM-Q

LEAM SKALAEN[1]

Spørreskjema til mannlige utøvere

[1] © *Copyright Melin A & Torstveit MK, 2015*

DEPARTMENT OF NUTRITION & EXERCISE
UNIVERSITY OF COPENHAGEN

FACULTY OF HEALTH AND SPORT SCIENCES
UNIVERSITY OF AGDER

Bakgrunnsopplysninger

- ID nr: ☐☐☐
- Nåværende idrett/idrettsgren: _____
- Hvilke andre idretter/idrettsgrener har du eventuelt drevet aktivt med tidligere?
  _____
- Hvor gammel var du da du begynte å spesialisere deg i nåværende idrett?_____ år
- På hvilket nivå konkurrerer du?

Klubb ☐
Landslag ☐, evt spesifiser (sr, jr, rekrutt e.l.)_____
Profesjonelt ☐
Annet ☐,_____

- Er du idrettsutøver på heltid? Ja ☐ Nei ☐
- *Hvis nei:* Hva driver du med ved siden av idretten?

Heltidsjobb ☐
Deltidsjobb ☐
Studier/skolegang ☐
Annet ☐,_____

- Hva er ditt høyeste maksimale oksygenopptak (VO2maks) siste 12 måneder?

_____ ml/kg/min *eller*
_____ l/min *eller* Vet ikke/har ikke målt ☐

- Hva er din beste plassering i Norgesmesterskap (NM)/enkeltkonkurranse i Norgescup?

1-3 plass ☐
4-6 plass ☐
7-10 plass ☐
11. plass eller dårligere ☐
Ikke deltatt i NM eller norgescup ☐
Husker ikke ☐

- Hva er din beste plassering i VM, OL eller enkeltkonkurranse i verdenscupen?

  1-3 plass ☐
  4-6 plass ☐
  7-10 plass ☐
  11. plass eller dårligere ☐
  Ikke deltatt i VM, OL eller verdenscup ☐
  Husker ikke ☐

- Hva er din normale treningsmengde i forberedelses- og oppbyggingsfasen (ikke konkurransefasen) i gjennomsnitt per måned?

  _____ timer/måned

- Hvor gammel er du? _____(år)
- Hvor høy er du? _____(cm)
- Hva er din nåværende vekt? _____(kg)
- Hva er din høyeste vekt med nåværende høyde?_____ (kg)
- Hva er din laveste vekt med nåværende høyde?_____ (kg)
- Hva anser du som din konkurransevekt/"matchvekt"? _____ (kg)
- Hva er din fettprosent (dersom du har målt denne)?_____ (%)
- Har du kronisk sykdom (f.eks diabetes, Morbus Crohn) eller andre helseplager?
  Ja ☐ Nei ☐

  Dersom ja, hvilken/hvilke sykdom(mer)/plager?

1. Svimmelhet

Sett kryss i det svaralternativ som best beskriver din situasjon

A: Kjenner du deg svimmel når du reiser deg raskt opp?

☐ Ja, flere ganger/dag ☐ Ja, flere ganger/uke ☐ Ja, 1-2 ganger/uke eller sjeldnere
☐ Sjelden eller aldri

B: Opplever du problemer med synet ditt (uskarphet, ser prikker, tunnellsyn etc)?

☐ Ja, flere ganger/dag ☐ Ja, flere ganger/uke ☐ Ja, 1-2 ganger/uke eller sjeldnere
☐ Sjelden eller aldri

2. Magefunksjon

A: Føles din mage "oppblåst"?

☐ Ja, nesten hver dag ☐ Ja, flere dager/uke ☐ Ja, 1-2 dager/uke eller sjeldnere
☐ Sjelden eller aldri

B: Har du kramper og/eller magesmerter?

☐ Ja, flere ganger/dag ☐ Ja, flere ganger/uke ☐ Ja, 1-2 ganger/uke eller sjeldnere
☐ Sjelden eller aldri

C: Hvor ofte har du avføring i gjennomsnitt?

☐ Flere ganger/dag ☐ 1 gang/dag ☐ Annenhver dag ☐ 2 ganger/uke
☐ 1 gang/uke eller sjeldnere

D: Hvordan pleier din avføring å være?

☐ Normal (fast og myk) ☐ Løs, som diaré ☐ Hard og tørr

Eventuelle kommentarer til magefunksjon: _____

3. Temperaturregulering i hvile

A: Fryser du selv om du har normalt med klær på deg?

☐ Ja, nesten hver dag ☐ Ja, flere dager/uke ☐ Ja, 1-2 dager/uke eller sjeldnere
☐ Sjelden eller aldri

B: Har du mer klær på deg/kler deg varmere enn de utøvere/personer du omgås uavhengig av vær?

☐ Ja, nesten alltid ☐ Ja, noen ganger ☐ Sjelden eller aldri

4. Helseproblemer som gir avvik fra trening og/eller konkurranse

Sett kryss i det svaralternativ som best beskriver din situasjon

I det følgende kommer noen spørsmål om hvor ofte du har vært tvunget til å endre dine trenings- og konkurranseplaner og hvor ofte du ikke har kunnet prestere maksimalt på trening og konkurranse på grunn av idrettsskade eller sykdom siste 6 måneder.
Med *akutt skade* menes plutselig oppståtte skader som har klart definert årsak eller starttidspunkt (eks overtråkk, muskestrekk). Med *belastningsskade* menes gradvis oppståtte skader som følge av overbelastning over tid (eks. beinhinnebetennelse, achillessenebetennelse, stressfraktur).

A: Hvor mange akutte skader har du hatt i løpet av de siste 6 måneder?

_____ akutte skader.

B: Hvor mange belasningsskader har du hatt i løpet av de siste 6 måneder (om samme belasningsskade kommer tilbake regnes hver ny skadeperiode som 1 skade)?

_____ belastningsskader.

C. Hvor mange sykdomsavbrekk fra planlagt trening har du hatt i løpet av de siste 6 måneder?

_____ avbrudd fra trening på grunn av sykdom.

D. Hvor mange dager på rad har du i løpet av de siste 6 måneder vært fraværende fra trening/konkurranse eller ikke kunnet prestere optimalt på den mest omfattende akutte skaden, belastningsskaden og sykdom i løpet av de siste 6 måneder?

	Ingen	1-7 dager	8-14 dager	15-21 dager	> 22 dager
Akutt skade	☐	☐	☐	☐	☐
Belastningsskade	☐	☐	☐	☐	☐
Sykdom	☐	☐	☐	☐	☐

Eventuelle kommentarer angående dine skader:

Eventuelle kommentarer angående dine sykdomsperioder:

5. Velvære og restitusjon

Sett kryss i det svaralternativ som best beskriver din situasjon

A: Trøtthet

A:1 Jeg føler meg svært trøtt når jeg kommer hjem fra arbeid/skole

☐ Ja, nesten hver dag ☐ Ja, flere dager/uke ☐ Ja, 1-2 dager/uke eller sjeldnere
☐ Sjelden eller aldri

A:2 Jeg kjenner meg overtrøtt

☐ Ja, nesten hver dag ☐ Ja, flere dager/uke ☐ Ja, 1-2 dager/uke eller sjeldnere
☐ Sjelden eller aldri

A:3 Jeg har vanskeligheter med å konsentrere meg

☐ Ja, nesten hver dag ☐ Ja, flere dager/uke ☐ Ja, 1-2 dager/uke eller sjeldnere
☐ Sjelden eller aldri

A:4 Jeg kjenner meg sløv

☐ Ja, nesten hver dag ☐ Ja, flere dager/uke ☐ Ja, 1-2 dager/uke eller sjeldnere
☐ Sjelden eller aldri

A:5 Jeg fremskyver viktige beslutninger

☐ Ja, alltid ☐ Ja, ofte ☐ Ja, iblant ☐ Sjelden eller aldri

B: Velvære

B:1 Jeg har vondt i kroppen

☐ Ja, nesten hver dag ☐ Ja, flere dager/uke ☐ Ja, 1-2 dager/uke eller sjeldnere
☐ Sjelden eller aldri

B:2 Musklene mine føles stive og ømme på trening

☐ Ja, nesten på hver treningsøkt ☐ Ja, på mange treningsøkter
☐ Ja, iblant på noen treningsøkter ☐ Sjelden eller aldri

B:3 Jeg har muskelverk/er støl etter trening

☐ Ja, på nesten hver treningsøkt ☐ Ja, på mange treningsøkter
☐ Ja, iblant på noen treningsøkter ☐ Sjelden eller aldri

B:4 Jeg føler at jeg blir lett skadet

☐ Ja, alltid ☐ Ja, i de fleste treningsperioder ☐ Ja, i noen treningsperioder
☐ Sjelden eller aldri

B:5 Jeg har hodeverk

☐ Ja, nesten hver dag ☐ Ja, flere dager/uke ☐ Ja, 1-2 dager/uke eller sjeldnere
☐ Sjelden eller aldri

B:6 Jeg kjenner meg fysisk utmattet

☐ Ja, nesten hver dag ☐ Ja, flere dager/uke ☐ Ja, 1-2 dager/uke eller sjeldnere
☐ Sjelden eller aldri

B:7 Jeg kjenner meg sterk og har god progresjon i styrketreningen min

☐ Ja, alltid ☐ Ja, i de fleste treningsperioder ☐ Ja, i noen treningsperioder ☐ Sjelden eller aldri

5. fortsettelse

Sett kryss i det svaralternativ som best beskriver din situasjon

C: Søvn

C:1 Jeg sover tilstrekkelig

☐ Ja, nesten hver natt ☐ Ja, flere netter/uke ☐ Ja, 1-2 netter/uke eller sjeldnere
☐ Sjelden eller aldri

C:2 Jeg sovner fornøyd og avslappet

☐ Ja, nesten hver kveld ☐ Ja, flere kvelder/uke ☐ Ja, 1-2 kvelder/uke eller sjeldnere
☐ Sjelden eller aldri

C:3 Jeg våkner utsovet

☐ Ja, nesten hver morgen ☐ Ja, flere morgener/uke ☐ Ja, 1-2 morgener/uke eller sjeldnere
☐ Sjelden eller aldri

C:4 Jeg sover urolig

☐ Ja, nesten hver natt ☐ Ja, flere netter/uke ☐ Ja, 1-2 netter/uke eller sjeldnere
☐ Sjelden eller aldri

C:5 Min søvn forstyrres lett

☐ Ja, nesten hver natt ☐ Ja, flere netter/uke ☐ Ja, 1-2 netter/uke eller sjeldnere
☐ Sjelden eller aldri

C:6 I løpet av den siste måneden, hvor mange timer faktisk søvn har du fått i gjennomsnitt per natt? (PS: dette kan skille seg fra antall timer du tilbringer i sengen)

SØVN (TIMER) PER NATT: _____TIMER

D: Restitusjon

D:1 Jeg restituerer meg (henter meg inn igjen) bra fysisk

☐ Ja, etter nesten hver treningsøkt ☐ Ja, etter mange treningsøkter
☐ Ja, iblant etter noen treningsøkter ☐ Sjelden eller aldri

D:2 Jeg føler meg i god fysisk form

☐ Ja, alltid ☐ Ja, ofte ☐ Ja, iblant ☐ Sjelden eller aldri

D:3 Jeg kjenner meg energisk

☐ Ja, nesten hver dag ☐ Ja, flere dager/uke ☐ Ja, 1-2 dager/uke eller sjeldnere
☐ Sjelden eller aldri

D:4 Kroppen min føles sterk

☐ Ja, nesten hver dag ☐ Ja, flere dager/uke ☐ Ja, 1-2 dager/uke eller sjeldnere ☐ Sjelden eller aldri

5. fortsettelse

Sett kryss i det svaralternativ som best beskriver din situasjon

E: Energinivå

E:1 Jeg føler meg veldig energisk til vanlig

☐ Ja, nesten hver dag ☐ Ja, flere dager i uken ☐ Ja, en til to ganger i uken eller mindre ☐ Sjelden/aldri

---

E:2 Jeg føler meg energisk før trening og er klar til å prestere

☐ Ja, nesten hver dag ☐ Ja, flere dager i uken ☐ Ja, en til to ganger i uken eller mindre ☐ Sjelden/aldri

---

E-3 Jeg føler meg glad og på topp i livet utenfor idretten

☐ Ja, nesten hver dag ☐ Ja, flere dager i uken ☐ Ja, en til to ganger i uken eller mindre ☐ Sjelden/aldri

---

E-4 Jeg føler meg mer nedstemt og mindre glad enn jeg pleier eller ønsker å være

☐ Ja, nesten hver dag ☐ Ja, flere dager i uken ☐ Ja, en til to ganger i uken eller mindre ☐ Sjelden/aldri

---

F: Sexlyst

F:1 Din sexlyst kan være en markør for balansen mellom trening, hvile og restitusjon.

a) Jeg vil beskrive min generelle sexlyst som:

☐ høy ☐ moderat ☐ lav ☐ sex er ikke så interessant

b) Min sexlyst den siste måneden har vært:

☐ sterkere enn vanlig ☐ som vanlig ☐ litt mindre enn vanlig ☐ mye mindre enn vanlig

---

F:2 Det er vanlig med ereksjon når man våkner om morgenen.

a) I løpet av den siste måneden har du opplevd dette:

☐ 5-7 ganger per uke ☐ 3-4 ganger per uke ☐ 1-2 per uke ☐ sjelden/aldri

b) Sammenlignet med hva du anser er normalt for deg, er dette:

☐ oftere enn vanlig ☐ omtrent like ofte ☐ litt sjeldnere enn vanlig ☐ mye sjeldnere enn vanlig

Appendix 6. Food Frequency- and exercise habits questionnaire

KOSTHOLDSVANER

Spørreskjema

1 Måltider: mat og drikke

Brød/korn	Sjelden/ aldri	1-3 gang/uka	4-6 gang/uke	1 gang/dag	2 gang/dag	3+ gang/dag
Grovt brød, grove rundstykker, grovt knekkebrød, grove rundstykker						
Loff, fine rundtstykker, fint knekkebrød, fine baguetter, pitabrød						
Kornblanding uten tilsatt sukker						
Kornblanding med tilsatt sukker						
Havregrøt eller annen grøt						
Pålegg						
Vanlig kjøttpålegg (f.eks. servelat, saltpølse, leverpostei)						
Magert kjøttpålegg (f.eks. kokt skinke, mager leverpostei)						
Vanlig gulost						
Gulost med lavere fettinnhold (mager/halvfet)						
Vanlig brunost eller prim						
Brunost/prim med redusert fettinnhold (mager/halvfet)						
Fiskepålegg (makrell i tomat, kaviar, sild etc.)						
Sjokoladepålegg						
Syltetøy eller honning						
Smør eller margarin på brødet						
Middagsmat						
Fisk (frossen eller fersk)						
Behandlet fisk (fiskekaker, fiskeboller, fiskepinner etc.)						
Kjøtt (rent kjøtt av okse, svin lam, vilt etc.)						
Behandlet kjøtt (pølser, kjøttkaker, karbonader, kjøttdeig etc.)						
Kylling						
Risgrøt						
Pannekaker						
Ferdigpizza						
Middagstilbehør						
Kokte poteter/potetstappe/potetmos						
Pommes frites						
Ris						
Pasta/nudler						
Gatekjøkkenmat						
Hamburger, pizza eller kebab						
Pommes frites						
Frukt og grønt						
Grønnsaker						
Frukt og bær						

Diverse						
Kjeks, kaker, boller etc.						
Vafler						
Iskrem						
Frossen yoghurt						
Godmorgen yoghurt						
Yoghurt med lavt fett-/sukkerinnhold						
Godteri/sjokolade						
Salt snacks (potetgull, peanøtter etc.)						
Kosttilskudd	Sjelden/ aldri	1-3 gang/uka	4-6 gang/uke	1 gang/dag	2 gang/dag	3+ gang/dag
Tran eller omega 3 (flytende, kapsler)						
Vitamin D						
Multivitamintabletter						
Andre kosttilskudd						
Drikke						
Helmelk						
Lettmelk						
Ekstra lettmelk						
Skummet melk						
Sjokolademelk						
Juice						
Nektar (juice med tilsatt sukker)						
Saft (med sukker)						
Saft light (uten sukker)						
Brus (med sukker)						
Brus light (uten sukker)						
Vann						
Smoothie						
Alkohol						

2 Har du påvist noen form for matallergi og hva er du i så fall allergisk mot?

Ja, i så fall hva	Nei

3 Er du vegetarianer/veganer/peskaner?

Vegetarianer	Veganer	Peskaner

4 Hvor mange porsjoner grønnsaker eller frukt/bær spiser du i løpet av dagen?
En porsjon frukt kan for eksempel være 1 middels stor frukt (eple, pære, banen eller annet), eller en håndfull druer (1-2 dl) eller 1 glass juice (kun 1 glass kan regnes med).
En porsjon grønnsaker kan for eksempel være 1 gulrot eller 3 buketter brokkoli eller en porsjonsbolle salat. Poteter regnes ikke med.

	0	½	1	2	3	4	5+
Grønnsaker							
Frukt/bær							

5 Kryss av for hvor ofte du spiser disse hovedmåltidene

	Aldri/sjelden	1 g/uke	2 g/uke	3 g/uke	4 g/uke	5 g/uke	6 g/uke	Hver dag
Frokost								
Lunsj								
Ettermiddagsmat (etter skole, før middag)								
Middag								
Kveldsmat								

6 Spiser eller drikker du noe utenfor disse hovedmåltidene?

Aldri/sjelden	1-3 g/mnd	1-3 g/uke	4-6 g/uke	1 g/dag	2 g/dag	3+ g/dag

7 Tror du maten du spiser spiller noen rolle for helsen din?

Nei	Ikke nå, bare når jeg blir eldre	Ja, både nå og senere i livet	Vet ikke

8 Hva syns du om ditt eget kosthold?

Det er veldig sunt	Det er ganske sunt	Det er usunt	Vet ikke

10 Søvn og søvnvaner

10.1. Når går du vanligvis til sengs på ukedagene?
Klokken _____

10.2. Når går du vanligvis til sengs i helger og ferier, når du ikke trenger å stå opp til et bestemt tidspunkt for å gå på skole/arbeid eller for å holde en avtale?
Klokken _____

10.3. Når våkner du vanligvis på hverdager?
Klokken _____

10.4. Når våkner du vanligvis opp i helger og ferier, når du ikke trenger å stå opp til et bestemt tidspunkt for å gå på skole/arbeid eller for å holde en avtale?
Klokken _____

11 Fysisk aktivitet

11.1 Dersom du har bedrevet organisert idrett tidligere i livet, hva slags idrett har du bedrevet og i hvor mange måneder/år?

	Ja, jeg har bedrevet denne idretten	Antall måneder/år
Fotball		
Håndball		
Basket		
Volleyball		
Turn		
Dans, ballett		
Kampsport		
Friidrett		
Riding		
Svømming		
Tennis, badminton		
Langrenn		
Slalåm, snowboard		
Ishockey, innebandy		
Allidrett		
Turer i turlag		
Sykling		
Orientering		
Annet:		

11.2 Trener du vektbærende styrke i løpet av en vanlig uke? I så fall, hvor mange timer?

Ja	Nei	Hvis ja, antall timer

11.3 Hvordan vil du beskrive din egen fysiske aktivitet på en skala fra 1 til 5?
1 betyr at du er mindre fysisk aktiv enn andre på din egen alder, og 5 betyr at du er betydelig mer fysisk aktiv enn andre på din alder.

1	2	3	4	5

11.4 Hvordan kommer du deg vanligvis til skolen om vinteren?

Går, sykler, ski eller en annen aktiv måte frem og tilbake	Går, sykler, ski eller en annen aktiv måte en vei	Blir kjørt til og fra skolen (bil eller buss)	Annet, hva:

11.5 Hvordan kommer du deg vanligvis til skolen om våren og høsten?

Går, sykler, ski eller en annen aktiv måte frem og tilbake	Går, sykler, ski eller en annen aktiv måte èn vei	Blir kjørt til og fra skolen (bil eller buss)	Hvis annet, hva?

12 Helse

12.1 Er det kjent osteoporose (benskjørhet) i nær familie (besteforeldre/foreldre/søsken)?

Ja	Nei	Vet ikke

12.2 Har du noen gang hatt tretthetsbrudd?

Ja	Nei	Hvis ja; hvilken kroppsdel?

Appendix 7. Ethical approval, REK

REK
REGIONALE KOMITEER FOR MEDISINSK OG HELSEFAGLIG FORSKNINGSETIKK

Region:	Saksbehandler:	Telefon:	Vår dato:	Vår referanse:
REK sør-øst B	Ragnhild Aursnes Dammen		24.09.2019	28837
			Deres referanse:	

Anne Mette Rustaden

28837 Benhelse hos unge syklister

Forskningsansvarlig: Høgskolen i Innlandet

Søker: Anne Mette Rustaden

Søkers beskrivelse av formål:

Dette er en tverrsnittsstudie med langtidsoppfølging av kohorte over 10 år. Formålet er todelt; 1. kartlegge benhelse hos aktive kvinnelige og mannlige unge syklister, sammenlignet med alders-matchede kontroller som ikke er idrettsaktive, 2. undersøke langtidsutviklingen over en 10 års periode. Aktive syklister kan ha økt risiko for redusert benhelse, og ettersom grunnlaget for benhelsen legges i alderen 15-25 år, skal dette prosjektet rekruttere ca. 50 1.års elever fra idrettsgymnas med sykkel som valgt idrett, og ca. 50 1.års elever fra ordinær videregående skole som ikke er idrettsaktive. Deltakerne må gjennomføre følgende tester hvert semester de tre første årene, deretter èn gang per år (maks to timer per gang); røntgen absorbsjonsmetri (benhelse), indirekte kalorimetri (hvilemetabolismen), elektrokardiografi (hjerterytmen), samt blodprøver (biomarkører). Forsøkspersonene vil også bli bedt om å besvare et spørreskjema for å vurdere risikoen for relativ energimangel i idrett.

REKs vurdering

Vi viser til søknad om forhåndsgodkjenning av ovennevnte forskningsprosjekt, mottatt til fristen 11.06.2019. Søknaden ble behandlet av Regional komité for medisinsk og helsefaglig forskningsetikk (REK sør-øst B) i møtet 21.08.2019. Vurderingen er gjort med hjemmel i helseforskningsloven § 10.

Gammelt referansenummer for denne saken før ny saksportal i REK var 2019/1168.

Slik komitéen forstår søknad og protokoll er hensikten med prosjektet å kartlegge benhelse hos aktive kvinnelige og mannlige unge syklister samt å undersøke langtidsutviklingen over en 10 års periode.

Komitéens vurdering er at dette kan være en nyttig studie for å undersøke status og utvikling av syklisters benhelse.

Det er imidlertid behov for å gjøre noen endringer i antall og innhold i samtykkeskriv/informasjonsskriv.

Komitéen kan godkjenne prosjektet på følgende vilkår:

- Det må utarbeides et samtykkeskriv for syklistenes og kontrollenes foreldre, jf. helseforskningsloven § 17.
- Det må utformes følgende to informasjonsskriv:
  - Et informasjonsskriv til syklistene
  - Et informasjonsskriv til kontrollene
- Når deltakerne blir 18 år må de spørres om de fortsatt ønsker å delta, med samtykkeskjema som må underskrives, jf. hfl. § 17
- I alle skrivene må følgende inn:
  - Informasjon om at dersom deltaker/kontroller flytter til annet sted i Norge, så vil nødvendige reisekostnader ifbm forskningsprosjektet bli dekket av prosjektet.
  - Informasjon om hva som er behandlingsgrunnlaget etter GDPR, at det kan klages til Datatilsynet samt kontaktopplysninger til personvernombudet.
  - Under avsnittet om ulemper må det inn informasjon om at man må møte opp til testene fastende (12 timer før).
- Det vedlagte samtykkeskrivet inneholder enkelte begreper som kan oppleves som vanskelig å forstå for 15-åringer. Både i skrivet til syklistene og i skrivet til kontrollene må slike begreper tas ut slik at det som står der er forståelig for 15-åringer.

Etterspurte dokumenter inkludert reviderte dokumenter med markerte endringer skal ettersendes REK til orientering på e-post til rek-sorost@medisin.uio.no. Vennligst oppgi «REK sør-øst B» og vårt referansenummer i emnefeltet.

Vedtak

Godkjent med vilkår

REK har gjort en helhetlig forskningsetisk vurdering av alle prosjektets sider. Prosjektet godkjennes med hjemmel i helseforskningsloven § 10, under forutsetning av at ovennevnte vilkår er oppfylt.

I tillegg til vilkår som fremgår av dette vedtaket, er godkjenningen gitt under forutsetning av at prosjektet gjennomføres slik det er beskrevet i søknad og protokoll, og de bestemmelser som følger av helseforskningsloven med forskrifter.

Vi gjør samtidig oppmerksom på at etter ny personopplysningslov må det også foreligge et behandlingsgrunnlag etter personvernforordningen. Det må forankres i egen institusjon.

Tillatelsen gjelder til 01.07.2029. Av dokumentasjonshensyn skal opplysningene likevel bevares inntil 01.07.2034. Forskningsfilen skal oppbevares atskilt i en nøkkel- og en opplysningsfil. Opplysningene skal deretter slettes eller anonymiseres, senest innen et halvt år fra denne dato.

Forskningsprosjektets data skal oppbevares forsvarlig, se personopplysningsforskriften kapittel 2, og Helsedirektoratets veileder for «Personvern og informasjonssikkerhet i forskningsprosjekter innenfor helse og omsorgssektoren».

Ragnhild Emblem
Professor, dr. med.
Leder REK sør-øst B

Ragnhild Aursnes Dammen
Seniorrådgiver

Kopi sendes til:
Høgskolen i Innlandet: postmottak@inn.no

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

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