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The Association between Physical Fitness, Body Composition and Bone Mineral Density among Female Athletes

BEV 3901 Master's Thesis

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Preface

This master thesis is part of a larger research on female athletes titled "The female competitiveness study". This research project will investigate the possible association between circulating androgen levels in female athletes and physical fitness measured in power and endurance, competitiveness, body composition, bone density, symptoms of eating disorders, menstrual disturbance, mental health and sexual preferences. The scope of this master thesis will be limited to data on physical fitness, body composition and bone mineral density. The data collection ended in December 2012 and includes 73 female athletes.

Three departments from the Norwegian University of Science and Technology (NTNU) were involved in the project:

1) The Unit for Applied Clinical Research at Department of Cancer Research and Molecular Medicine, the Medical Faculty.
2) The Department of Psychology, Faculty of Social Science and Technology Management.
3) The Department of Human Movement Science, Faculty of Social Science and Technology Management.

Acknowledgements

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Further, I would like to thank my fellow students, friends and family for supporting me through the whole process of this master thesis, especially in times of adversity.

Finally, I owe great thanks to the 73 female athletes who took time to participate in this study.

Abstract

Background: Research have suggested that endurance female athletes tend to have lower bone mineral density (BMD) than power and strength athletes, as a result of maintaining low body weight in addition to perform. This study intends to investigate the association between physical fitness by power and endurance measurements, body composition and BMD. In addition, it will address the differences in BMD measured in female football players, handball players and cross-country skiers.

Methods: A cross-sectional study of 57 Norwegian female athletes aged between 18 and 36 years (mean age 22.6 years) was conducted. The sample consisted of 24 football players, 17 handball players and 16 cross-country skiers. For physical fitness examinations, a graded VO_2max (ml/kg/min) test on treadmill, squat jump on a power plate and bench press with free weights were conducted. Body weight and height was measured and BMI calculated from the aforementioned variables. Lean body mass, body fat percentage and BMD (g/cm²) was measured using Dual- Energy X-ray Absorptiometry. BMD was obtained from four different regions, in addition to total body BMD: Ward's triangle, Trochanter, femoral neck and lumbar region (L1-L4).

Results: Significant association between body composition and BMD was observed for all subjects combined. Also, significant associations between the physical fitness tests and BMD were obtained. Differences in body composition and physical fitness level among the athletes indicated that the cross-country skiers had lower body weight, BMI, lean body mass and body fat percentage. Cross-country skiers also had the highest mean oxygen consumption among the female athletes and also the lowest BMD in all regions. Handball players had higher mean body weight, BMI, lean body mass and fat percentage. Handball players also had the higher mean BMD values for all regions measured.

Conclusion: Body composition was strongly associated with BMD in all regions measured. Subjects with high oxygen had lower BMD measurements in all regions while subjects with high muscular power in lower body had the highest BMD measurements in all regions. Also, differences in BMD between the three sports suggested that cross-country skiers have lower BMD values than both football players and handball players, in all regions measured.

Keywords: Female athletes, physical fitness, body composition, bone mineral density (BMD).

Terms and abbreviations

The following terms and abbreviations are used in this thesis:

Amenorrhoea: No menstrual cycles for >90 days, in women of reproductive age.

Anthropometrics: refers to the measurement of the human individual, in this thesis including bodyweight (kg), body height (cm) and BMI (calculated from the two aforementioned variables).

BMD: (g/cm²) Bone mineral density refers to grams of bone mineral per unit of bone area scanned. (Khan et al., 2001).

BMI: Body mass index, the ratio of weight to height squared (BMI= kg/m²)

Body composition: In this thesis, including lean body mass and body fat percentage.

Circulating androgen hormones: Refers to androgen levels in the blood.

DEXA: Dual Energy X-Ray Absorptiometry, based on the decrease in photon energy of the photon beam as it passes through bone and non-mineralized soft tissue (Khan et al., 2001)

Eumenhorrea: Normal menstruation

Female athletes: For the purpose of this study an elite athlete was defined as an athlete at present competing at a national or international level.

Hypoestrogenism: Lower estrogen level than normal. Hypoestrogenism in athletes with hypothalamic amenorrhea are mediated by insufficient energy intake relative to energy expenditure (De Souza et al., 2008).

Lean body mass: Body fat weight subtracted from total body weight.

Oligo –or amenorrhea: Disrupted menstruation with 6 or fewer menstruation periods during one year.

Osteoporosis: Osteoporosis is a skeletal disease characterized by low density and general deterioration of bone tissue. Bone fragility induces fractures that represent the major clinical aspect of the disease (WHO).

Physical fitness: Physical fitness is a set of attributes that are either health- or skill-related. The degree to which people have these attributes can be measured with specific tests. (Caspersen, Powell, & Christenson, 1985)

Peak bone mass: Highest bone mineral content during adulthood (Khan et al., 2001).

Contents

Introduction

Female athletes put down a significant amount of training over several years to achieve their goals, some of them starting at young age and in some cases before puberty. To succeed they need systematical and structured training regime. However, these women are often very dedicated to their sport and they choose this lifestyle because of the intrinsic value of joy, achievement and success it gives them.

Exercise and training are endorsed by the World Health Organization (WHO) and considered to be beneficial for the general public health. Physical activity has a numerous positive effects on physical and mental health. Improved bone health has been suggested as one of these. The positive effects of physical activity and training on bone formation in athletes have also been subject of research, and weight- bearing exercise is considered to improve bone density (MacKelvie, Khan, Petit, Janssen, & McKay, 2003; McKay et al., 2000; Nikander, Sievänen, Heinonen, & Kannus, 2005). Also, athletes seem to have higher BMD than healthy non-athletic subjects (Duckham et al., 2013). Nichols et. al (2007) reviewed bone density in young athletic women and found that they have significantly higher BMD values compared to age matched non-athletic subjects, suggesting that female athletes can be expected to have up to 5-30% greater bone mineral density (BMD) then non-athletes (D. L. Nichols, Sanborn, & Essery, 2007). In recent years, research has focused on exercise as an instrument to increase bone health and prevent osteoporosis related fractures.

However, female athletes are subject to extreme physiological and psychological stress, which may lead to some adverse health effects. Higher prevalence of energy deficiency, disrupted eating habits and menstrual disturbances have been reported in female endurance athletes (Gibson, Mitchell, Harries, & Reeve, 2004). Together with osteoporosis, the aforementioned factors are associated with the female athlete triad, a condition observed in female endurance athletes (Cobb et al., 2003; Soleimany et al., 2012). Bone loss have also been associated with hypoestrogenism and observed secondary to chronic malnutrition and anorexia nervosa (De Souza et al., 2008). The complex consequences linked to low body weight and low energy availability, often seen in combination with eating disorders, are beyond the scope of this thesis.

Low BMD may increase the risk of stress and fragility fractures. For women the relative risk for fracture incidence is 1.5 to 3.5 times higher compared to male counterparts, and is more than three times higher in oligo-or amenorrheic athletes compared to eumenorrheic athletes (Ducher et al., 2011). Stress fractures may occur in cases where increased strain or loading leads to osteoclastic activity or bone resorption that outpace the osteoblastic activity of new bone formation. Numerous of factors have been linked to stress fractures and proposed as potential risk factors: low BMD, low BMI, low body fat percentage, low muscle mass, menstrual disturbance, dietary insufficiency and excessive training (Kim L Bennell et al., 1996; Scofield & Hecht, 2012).

Bone mass is an important determinant of bone strength. Achieving high bone mass in young age confers a current benefit as well as a deferred one. Women are at greater fracture risk as they experience a higher rate of bone loss after menopause, and women who suffer from substantial bone loss already at a young age may never reach their potential peak bone mass. They also have an increased fracture risk as they maintain lower BMD after menopause than women with a normal BMD when entering menopause (Braam, Knapen, Geusens, Brouns, & Vermeer, 2003).

Type of sport, frequency, intensity and amount of training are factors that may influence bone health. Braam et.al (2003) highlighted the differences observed between normal and high intensity exercise and its effect on BMD. They suggested that bone health may be explained by assuming that until a certain threshold level of exercise the bone formation is stimulated, but when the females obtain large amounts of excessive training, the beneficial effects of training is lost. In extreme cases this can even result in actual bone loss. The study also concludes that high-intensity training maintained over several years must be considered as a risk factor for osteoporosis (Braam et al., 2003). There are still uncertainties when it comes to specifying the optimal intensity, frequency, duration and type of exercise that will promote the greatest anabolic stimulus effect on bone formation (Bergmann et al., 2010; Heaney et al., 2000).

Löfman et. al (1997) registered BMD values from 429 women, randomly selected from the general Swedish population to establish normal values for BMD (Lofman, Larsson, Ross, Toss, & Berglund, 1997). Nevertheless, DEXA from spine, femoral neck, trochanter and ward's triangle for the general population of Swedish women was used to establish the normal values for BMD: BMD spine (mean= 1.03 g/cm^2), BMD FN (mean= 0.81 g/cm^2), BMD Trochanter (mean: 0.69 g/cm^2) and BMD Ward's (mean= 0.71 g/cm^2). Although, values obtained from the general population may not be equivalent with values for female athletes.

Wight bearing athletes seem to have higher BMD values compared to gender-matched athletes in non-weight bearing sports and endurance sports (Arasheben, Barzee, & Morley, 2011; Duncan et al., 2002; Ferry et al., 2011; Tenforde & Fredericson, 2011). Dynamic, weight-bearing activities and strength training seem to be more effective to increasing bone formation, compared to repetitive endurance sports like distance running and non-weight bearing sports (K. L. Bennell, Malcolm, Wark, & Brukner, 1997; Ferry et al., 2011). Regardless of type of sport, elite athletic performance is a complex fitness phenotype substantially determined by genetic potential. Genetically predisposed athletes seem to choose sports and activities that suit them well. Endurance sports may seem to favor small and lightweight athletes, in the same way that power sports often may favor more muscular athletes (MacArthur & North, 2005).

Body composition has been suggested as a predictor for physical performance, proposing that higher muscle mass percentage can be linked to maximal oxygen consumption and muscle strength (Hogstrom, Pietila, Nordstrom, & Nordstrom, 2012). Hage et.al (2012) argued that lean mass was the strongest anthropometrical predictor for whole body and femoral neck BMD. Further, they also suggested that body weight was the strongest anthropometrical predictor of lumbar spine and total hip BMD. They found that BMI, lean mass and fat mass were all positively associated with whole body BMD, L2-L4 BMD and total hip BMD (El Hage et al., 2012). Lean mass and body weight was found to be strong determinants of BMD at all sites in females. The result from Hage et. al (2012) pointed out that increased body weight and fat mass have been associated with increased estrogen in women (El Hage et al., 2012).

The muscle contraction force acting directly or indirectly on bone has been presented as an important determinant of skeletal adaptation to exercise, both in children and adults (Duncan et al., 2002; Taaffe, Robinson, Snow, & Marcus, 1997). The influence of mechanical loading on the skeleton has been extensively researched, most often measured by isokinetic and isometric strength (Duncan et al., 2002; Madsen, Adams, & Van Loan, 1998). But the associations between endurance capacity, measured by a VO_2max test, and BMD in female athletes are less studied. Not found on Google Scholar or PubMed (Key words: physical performance, VO_2max, endurance, BMD, maximal aerobic power, oxygen consumption).

The aim of this study is to investigate the association between physical performance, body composition and BMD in female football players, handball players and cross-country skiers. The following sub questions are desired to be answered:

1) Is there an association between physical fitness, measured in Squat jump (N), bench press (N) and VO_2max (ml/kg/min), and BMD in female athletes?

2) Is there an association between body composition and BMD, measured by lean body mass and body fat percentage, in female athletes?

3) Is there an association between physical fitness, measured in Squat jump (N), bench press (N) and VO_2max (ml/kg/min), and body composition in female athletes?

4) Are there differences in BMD between female football players, handball players and cross-country skiers?

Methods

Design

A cross-sectional study of female football players, handball players and cross-country skiers, living in Mid-Norway.

Subjects

A total of 57 healthy female athletes were recruited in Sør-Trøndelag, all at present actively competing in sports. The subjects were between 18-36 years of age (mean age 22.6). Athletes that were pregnant, breast feeding or unfit for participation for any reason were excluded in order to avoid potentially misleading values.

Procedures

Subjects were recruited between September 2011 and December 2012. Two representatives from the research project attended at a training session and informed about the project, with approval from the coach. Contact information on the females who volunteered was noted, they were later contacted for testing at Dragvoll. All participants received a written informed sheet beforehand and signed a written consent before they were tested (Copy of the information letter and declaration of consent can be found in appendix 2 and 3, respectively). All physical tests were conducted at the Department of Human Movement science, Dragvoll, NTNU. None of the participants reported any discomfort on the day that the physical tests were performed. DEXA scan was conducted at St. Olavs Hospital, Trondheim University Hospital, at appointed time. To ensure consistency in instructions and implementation method during testing throughout the study, the measurements of DEXA were performed by professionals at the hospital. The physical performance tests were conducted by the same three master students accompanying this research. All data was stored for offline analysis.

Measurements

Physical examination from fitness tests

Each subject completed three physical performance tests: squat jump, bench press and last a stepwise treadmill VO_2max test.

Maximal muscular force in the lower body was assessed by squat jump, performed on AMTI Biomechanics Force Platform (Model bp6001200, Massachusetts, USA). Each subject was instructed to stand on both feet with shoulder width-apart, with both hands placed on their hip throughout the jump. Then they were instructed to squat down in a freely chosen squat depth where they felt most capable to produce the greatest possible force and jump as high as possible. The test was completed when the subject had been registered with three approved trials, i.e. a jump with both hands attached to the hips, and no countermovement registered. Jump height, rate of force development, maximal force and time to peak power was calculated from the Biojump force plate (Biojump Program version 2.2, Oslo, Norway). The focus of interest here was force development in lower body during squat jump, calculated as maximal force (N).

Average muscular force in upper body was assessed by subjects performing bench press on a standard bench press set up with a rack, Olympic barbell and free weights. Power, force and velocity were measured using a linear encoder (MuscleLab, Ergotest Technology A/S, Langesund, Norway). Subjects were instructed to lie on the bench with both feet on the floor, with 90° knee angle in order to prevent arching of the back and use of the legs during the test. The subjects were instructed to place their index finger immediately perpendicular to the acromion process. The 50 % bodyweight of each subject were calculated and set as resistance. On command from the test leader, the subjects lowered the bar to the chest vertically on the end of sternum and pressed the bar to extended arms with maximally voluntary effort. Each subject performed 3 lifts with 15-30 sec rest between each lift. If subjects were unable to lift 50% of their own body weight, the resistance was slightly reduced, but as close to 50% bodyweight as possible.

Maximal aerobic power was measured during a stepwise increased VO_2 max test on a treadmill. Each subject had a warm up period for 15 minutes, at approximately 60% of maximal heart rate before the test started. The test was performed at 10,5% incline with stepwise speed increase by 1 km/h every minute until exhaustion. Test duration lasted between 3 and 8 minutes. VO_2 was measured through pulmonary gas exchange, using an Oxycon Pro (Jaeger GmbH, Hoechberg, Germany) with a sample frequency of 0,1 Hz. The average of the six highest 10-s consecutive measurements determined VO_2 max. Heart rate was registered every minute during the test with a standard heart rate monitor. Maximal heart rate was self-reported. Blood lactate was measured right after completing the VO_2 max test, using Lactate Pro (LT-1710, ArkRay Inc, Kyoto, Japan). The test was considered valid when two of the following criteria were met: a plateau in VO_2 with increasing exercise intensity, respiratory exchange ratio above 1.0 and a blood lactate concentration exceeding 8 mmol·L-1.

Antropometric data

Body height was measured standing without shoes, using standard stadiometer and calculated to the nearest whole centimeter. Body weight was measured with light weight exercising clothes and without shoes, calculated to the nearest kg. Body mass index (BMI) was calculated from the two previous parameters.

Dual energy X-ray absorptiometry (DEXA)

The Dual- Energy X-ray Absorptiometry (DEXA) scan was performed with a Hologic Discovery A scanner (version 12.7.3.1, Hologic, USA). Areal BMD ($g \cdot cm^2$) was measured for ten separately body parts: head, neck, thorax, abdomen, girdle, right and left arm and right and left lower extremity. BMD for total body was calculated as the mean BMD for the whole body. This thesis focused on the total body (TB) BMD and the four following regions: Ward's triangle, Spine (L1-L4), femoral neck (FN) and Trochanter. DEXA scan was also used to establish body fat percentage and lean body mass for whole body by means of DEXA. DEXA measurements were performed at St. Olavs Hostital, Trondheim University Hospital.

Statistics

The primary outcome variables for BMD were measured in ward's triangle, lumbar region (L1-L4), femoral neck (FN), trochanter and total body (TB). Outcome variables for body composition and anthropometrical measures were lean body mass (kg), body fat percentage, body weight (kg), height (cm) and BMI (kg/m^2). Physical fitness was measured by VO_2max (ml/kg/min) in aerobic power, maximal force (N) in squat jump and average force (N) in bench press. Descriptive statistics (Mean and SD) were computed for each variable of interest for football players, handball players and cross-country skiers. A one way ANOVA was used to determine whether a significant difference existed among groups for descriptive variables, body composition, anthropometrics, physical performance and BMD values. If F-ratio was significant, differences among groups were subsequently identified using a Tukey post hoc analysis. Bivariate Pearson's correlation analysis was used to examine the relationship between BMD measures and selected descriptive variables as well as the physical performance tests and BMD. Significance was defined as two –tailed, $p < 0.05$. Scatter plots illustrate the sample distribution in BMD and body composition (body fat percentage and lean body mass) and BMD and physical performance tests (VO_2max and Squat jump). Standard multiple regression was used to assess the ability to control measures from VO_2max, maximal force (N) in Squat Jump and average force (N) in bench press to predict levels of BMD in L1-L4. BMD L1-L4 was the BMD variable that strongest correlated with all of the descriptive variables. All data was analyzed using IBM SPSS statistical programs version 20.0 for Windows (SPSS Inc., Chicago, Illinois, USA). Statistical significance was set at $p<0.05$ and Confidence interval (CI) at 95%.

Ethics

This project was approved by The Regional Ethical Committee in Mid-Norway (copy of the approval from REK in Appendix 1). Participants were included after signing a declaration of consent. All the results were anonymously stored and analyzed. Study participation was evaluated to involve minimal health risk. In accordance to the Declaration of Helsinki, participants had full access to withdraw from the study at any time, without giving any reason.

Results

A total of 57 female athletes (24 football players, 17 handball players and 16 cross country skiers) were included in the statistical analysis. Athletes were divided into three groups based on sport discipline, as shown in Table 1.

Subject characteristics

Groups did not differ in height or maximal muscular force obtained in bench-press (N). Body weight, BMI and lean body mass were higher in handball players than football players and cross-country skiers ($p < 0.000$, $p < 0.000$ and $p = 0.001$, respectively). Total body fat percentage was lower in cross-country skiers compared to football players ($p = 0.005$) and handball players ($p < 0.000$). Body fat percentage did not differ from football and handball players. VO_2max was higher among cross-country skiers than football ($p < 0.000$) and handball players ($p < 0.000$). Also, football players had higher VO_2max than handball players ($p = 0.003$). Squat jump (N) was higher in handball players than cross-country skiers ($p < 0.000$) and higher in football players than cross-country skiers ($p = 0.018$). Squat jump (N) did not differ between football and handball players.

Table 1

Characteristics of the female football players, handball players and cross-country skiers, presented as Mean and (SD). P-value represent differences between groups obtained from ANOVA.

Variables	Football (n= 24)		Handball (n= 17)		Cross-country (n= 16)		
	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range	*P* value
Age (years)	22.7 (3.8)	18-34	20.2 (2.4)	18-27	23 (2.7)	19-28	0.023
Weight (kg)	62.7 (6.5)	52-76	74.9 (10.0)	58-91	60.0 (5.9)	53-71	< 0.000
Height (cm)	167.5 (4.7)	161-178	171.1 (8.3)	156-183	169.7 (5.3)	161-179	0.167
BMI (kg/m²)	22.3 (1.9)	19.5-25.3	25.5 (2.3)	21.9-29.7	20.9 (1.5)	19.1-25.3	< 0.000
Lean Body Mass (kg)[a]	48.3 (5.0)	40.3-58.1	55.7 (5.1)	46.8-62.9	48.7 (3.4)	42.0-54.0	< 0.000
Total body fat %[a]	20.4 (3.0)	14.4-24.1	23.2 (5.3)	14.9-34.3	16.2 (3.2)	12.5-23.6	< 0.000
VO_2max	53.5 (3.6)	46.6-60.4	48.1 (5.7)	38.8-57.8	61.2 (5.2)	49.0-67.0	< 0.000
Squat jump (N)	1308.7 (163.7)	1040.3-1658.0	1445.7 (238.1)	1114.5-1896.9	1138.8 (135.2)	881.8-1394.0	< 0.000
Bench Press (N)	466.6 (188.7)	268.3-793.9	402.8 (49.6)	339.4-498.7	393.1 (134.0)	281.3-684.9	0.262
BMD Ward's Triangle (g/cm²)[a]	0.949 (0.116)	0.782-1.184	1.071 (0.094)	0.954-1.223	0.870 (0.158)	0.551-1.058	0.001
BMD L1-L4 (g/cm²)[a]	1.115 (0.115)	0.831-1.296	1.248 (0.098)	1.137-1.430	1.000 (0.114)	0.832-1.287	< 0.000
BMD Neck (g/cm²)[a]	1.042 (0.112)	0.824-1.266	1.131 (0.109)	0.962-1.295	0.923 (0.127)	0.706-1.141	< 0.000
BMD Trochanter (g/cm²)[a]	0.880 (0.078)	0.703-1.005	0.965 (0.098)	0.820-1.130	0.774 (0.105)	0.567-0.909	< 0.000
BMD TB (g/cm²)[a]	1.190 (0.085)	1.038-1.375	1.227 (0.054)	1.134-1.337	1.097 (0.055)	0.989-1.205	< 0.000

[a] n= 21 (football), 13 (handball), 15 (Cross-country)

*BMD= Bone mineral density, BMI= body mass index, FN= femoral neck, TB= Total body.

BMD differences between the groups

A one-way between-groups analysis of variance (ANOVA) was conducted to explore differences in BMD Ward's triangle, BMD L1-L4, BMD FN, BMD Trochanter and TB BMD measurement between football players, handball players and cross-country skiers. There was a statistical significant difference in all BMD measurements for the three sports groups, $p < 0.05$: BMD L1-L4 ($F = 17.6$, $p < 0.000$), BMD Trochanter ($F = 15.3$, $p < 0.000$), BMD Ward's Triangle ($F = 8.9$, $p = 0.001$), BMD FN ($F = 11.4$, $p < 0.000$) and BMD TB ($F = 13.7$, $p < 0.000$) (Table 1). In addition to reaching statistical significance, the actual difference in mean scores between the groups was calculated by effect size (Cohen, 1988), using eta squared: 0.4 for BMD L1-L4, BMD total body and BMD Trochanter, and 0.3 for BMD Ward's Triangle and BMD FN. Post-hoc comparisons using the Tukey HSD test indicated that there were statistical significant differences in mean BMD L1-L4 between football players and handball players ($p = 0.004$), between football players and cross-country skiers ($p = 0.010$) and between handball players and cross-country skiers ($p < 0.000$). The same statistical differences was also found in BMD Trochanter; comparing football players and handball players ($p = 0.032$), football players and cross-country skiers ($p = 0.004$) and handball players and cross-country skiers ($p < 0.000$). For BMD FN: significant statistical difference was observed between football players and cross-country skiers ($p = 0.011$), as well as between handball players and cross-country skiers ($p < 0.000$). No statistical significant difference in BMD FN was found between football players and handball players ($p = 0.087$). For Ward's triangle, a statistical significant difference was found between football players and handball players ($p = 0.024$), as well as between handball players and cross-country skiers ($p < 0.000$). No statistical significant difference was observed in BMD Ward's triangle between football players and cross-country skiers ($p = 0.160$). Also, for BMD TB a statistical significant differences was observed between football players and cross-country skiers ($p = 0.001$), and between cross-country skiers and handball players ($p < 0.000$). No statistical difference in BMD TB was observed between football players and handball players ($p = 0.301$).

Correlation analysis of BMD, body composition and physical fitness

Scatter plots of the unadjusted associations between body composition variables (Lean body mass and body fat percentage) and regional BMD measurements for L1-L4, are shown in figure 1. Both associations were statistically significant at the 0.01 level.

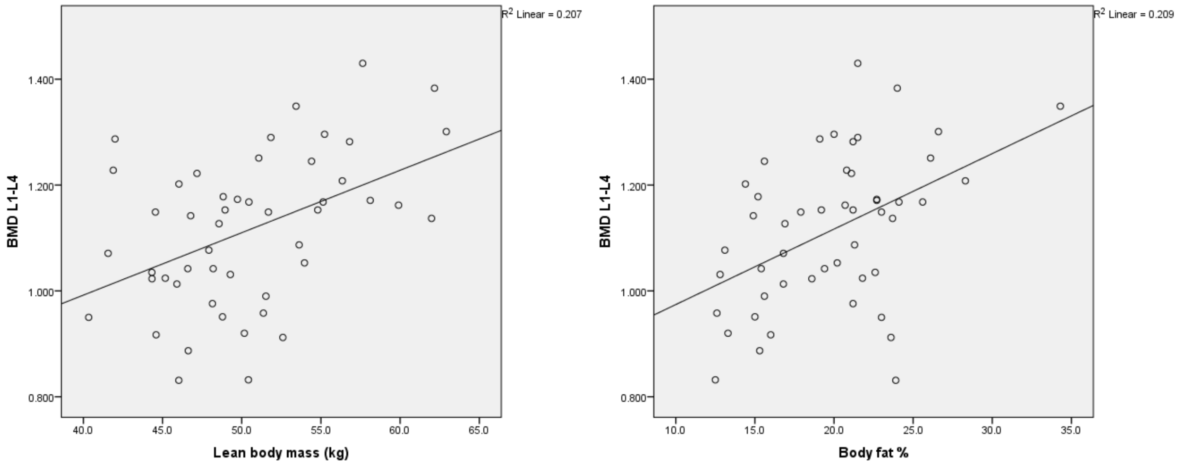

Figure 1- The correlation between LBM, body fat percentage and BMD L1-L4 for all subjects combined (N = 49).

Scatter plots of the unadjusted association between VO_2max and BMD L1-L4, as well as the association between maximal force development in lower extremity (Squat jump) and BMD L1-L4 are shown in figure 2. Both of the associations were statistical significant at the 0.01 level (2-tailed).

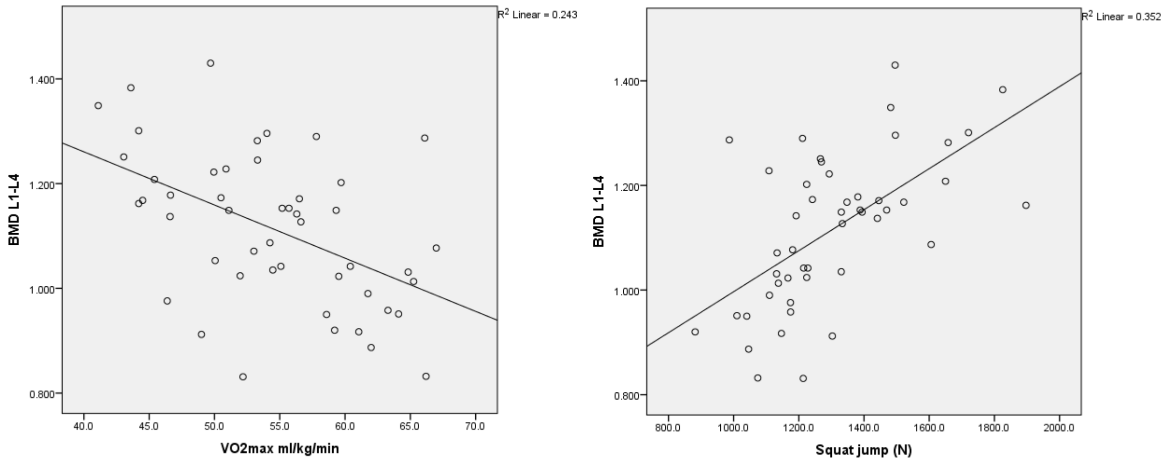

Figure 2- The correlation between VO_2max and BMD L1-L4. Correlation between maximal force in squat jump (N) and BMD L1-L4 for all subjects combined (N= 49).

Bivariate correlation analysis was conducted for all four BMD regions and TB BMD, for all subjects combined. All BMD regions were statistical significantly correlated with body-weight, BMI, lean body mass and body fat percentage. Body height was not significantly correlated with any BMD measurements. VO_2max was inverse correlated with BMD in all regions (significant at the 0.01 level). The strongest correlation was found in total body and region L1-L4. A strong and positive correlation was found between Squat jump and all of the BMD measurements. No significant correlation was observed between bench press and BMD in any of the measured regions.

The same correlation analysis was also done separately for each sport. Association between BMI and BMD Ward's Triangle in handball players was observed. Also, Squat jump (N) was statistically significant associated with BMD L1-L4 and BMD Ward's Triangle among football players. Otherwise, no association was found between BMD and covariates in football, handball or cross-country skiers.

Table 2
Bivariate relationship between BMD and selected descriptive variables for all subjects combined (football players, handball players and cross-country skiers).

Variables	*n*	BMD TB	BMD FN	BMD Ward's	BMD L1-L4	BMD Trochanter
Age (years)	49	.21	-.05	-.07	-.08	-.18
Weight (kg)	49	.39[a]	.52[a]	.46[a]	.57[a]	.44[a]
Height (cm)	49	.12	.19	.08	.24	.05
BMI (kg/m^2)	49	.41[a]	.52[a]	.49[a]	.54[a]	.49[a]
Lean body mass (kg)	49	.31[b]	.44[a]	.38[a]	.46[a]	.35[b]
Total body fat %	49	.29[b]	.41[a]	.35[b]	.46[a]	.36[b]
VO_2max (ml/kg/min)	48	-.47[a]	-.49[a]	-.38[a]	-.49[a]	-.45[a]
Squat jump (N)	48	.43[a]	.48[a]	.48[a]	.59[a]	.47[a]
Bench Press (N)	45	.18	.25	.26	.18	.13

[a] Correlation is significant at the 0.01 level (2-tailed).
[b] Correlation is significant at the 0.05 level (2-tailed).

Correlation analysis was also conducted to look at the association between physical fitness test and body composition variables in all subjects combined (Table 3). According to these analysis there were statistically significant correlation between both VO_2max (ml/kg/min), squat jump (N) and all of the body composition measurements. Also here, an inverse correlation was observed between VO_2max and all the body composition measurements. No statistically significant correlation was observed between bench press and any of the body composition measurements. The same correlation analysis was also done separately for each sport. Lean body mass was significantly correlated with squat jump and bench press for both football players and handball players. No significant association for cross-country skiers. Body fat percentage was inversely significant associated with VO_2max for cross-country skiers and handball players (sig. at the 0.01 level), but not for football players.

Table 3

Bivariate relationship between the three physical performance tests and body composition for all subjects combined (football players, handball players and cross-country skiers).

Variables	*n*	Body weight (kg)	BMI (kg/m^2)	body fat %	LBM (kg)
VO_2max (ml/kg/min)*	56	-.72[a]	-.72[a]	-.76[a]	-.46[a]
Squat jump (N)*	56	.82[a]	.73[a]	.55[a]	.77[a]
Bench Press (N)**	52	.23	.26	.20	.27

[a] Correlation is significant at the 0.01 level (2-tailed).

[b] Correlation is significant at the 0.05 level (2-tailed).

* n= 48 (body fat %, LBM)

** n= 45 (body fat %, LBM)

Regression modeling

Standard multiple regression was used to assess the ability of three physical fitness measures (VO_2max, maximal force in squat jump (N) and average force (N) in bench press) to predict the bone mineral density in the lumbar region (BMD L1-L4). Preliminary analysis was conducted to ensure no violation of the assumptions of normality, linearity, multicolinearity and homoscedasticity. Due to the co-linearity between the physical fitness measurements and body composition measures, body weight, BMI, lean mass and total body fat percentage were excluded from this analysis. The model (including VO_2max, Squat jump (N) and Bench press (N)) explained 37.8% of the variance in BMD L1-L4 (adjusted R Square: .334). Maximal force (N) from squat jump makes the strongest unique contribution to explaining the variance in BMD L1-L4 (Beta= .459), while avg. force (N) obtained from bench press seem to make the least contribution to explaining the variance in BMD L1-L4 (Beta= -0.028). The maximal force (N) had a statistically significant unique contribution to the equation (p= 0.007).

Discussion

The main findings in this study was 1) the statistical significant association between maximal force (N) in squat jump and BMD for all regions measured, as well as the inverse association between VO_2max and BMD in all regions. 2) This study also confirms earlier studies that there seem to be association between body composition and BMD in female athletes (Kathryn E Ackerman et al., 2011; Duncan et al., 2002). 3) There was a statistically significant association between the physical fitness tests VO_2max (ml/kg/min) and maximal force in squat jump (N) and body composition. 4) This study also revealed differences in BMD measurements in the female athletes, depending on sport discipline.

Although several researchers have attempted to establish a general assumption on the effects of training on BMD (D. L. Nichols et al., 2007), few studies have investigated the direct association between measured physical fitness parameters and bone health. In particular, the association between measured oxygen consumption and BMD has received little focus in research. Nevertheless, some studies have investigated the association between VO_2max and different bone structure parameters, to implement bone strength and bone health in females (De Souza et al., 2008; Gibson et al., 2004).

Gibson et. al (2004) looked at nutritional status among female runners, and how disordered eating may influence the skeleton. Maximal oxygen uptake (VO_2max) was measured during a multistage continuous running test. Height and body weight was measured and BMI calculated. Also, information on lean mass and body fat was obtained from DEXA. Results from this survey suggested that VO_2max emerged as a determinant of proteins in the bone (osteocalcin), as increased oxygen consumption showed a reduction in osteocalcin by 13% for each 1 SD increasement in VO_2max (Gibson et al., 2004). This confirms the findings in our study as the athletes with the highest oxygen consumption tended to have lower BMD values for all sites. Although, eating habits and incidence of eating disturbance was not registered in this thesis.

Several studies have investigated the association between strength parameters and BMD (Duncan et al., 2002; Madsen et al., 1998). Duncan et al (2002) looked at differences in BMD between weight-bearing ports, non-weight bearing sports and sports that combine both. Knee extension and flexion strength among female athletes was measured to assess the associations with BMD, and found that there was a small but significant correlation between knee extension and flexion strength and all of the BMD measurements (Duncan et al., 2002). This confirms the finding in our study, as there were significant associations between squat jump (N) and BMD at all sites measured. Although, considering that muscle strength in their study was measured with an isokinetic dynamometer and not as maximal force during squat jump.

The strong correlation between physical fitness and BMD found in our study may be explained by differences in sport characteristics of the female athletes. Duncan et. al (2002) primarily looked at endurance athletes competing in swimming, cycling, running and triathlon compared to non- active controls. Positive association between absolute strength and BMD was also suggested to be explained by unaccounted factors as increased lean tissue mass. Lean tissue mass was suggested as a possible explanation as it may influence strain level and BMD independent of muscle strength, as a mechanism of ground reaction and axial compressive force (Duncan et al., 2002). In our study, the athletes in all three sports had higher mean lean tissue mass than subjects reported in Duncan et. al (2002).

The association between physical fitness and body composition found in this study was not surprising; subjects with high VO_2max had low body weight, body fat percentage and lean body mass. These are factors that characterize endurance athletes. A Swedish study found that both lean body mass and body fat percentage are significantly correlated with VO_2max (ml/kg/min) in female adolescent cross-country skiers (Hogstrom et al., 2012). The same observation was made in our study, as both body fat percentage and lean body mass were significantly inverse associated with VO_2max, in cross-country skiers and handball players. Unlike the VO_2max test, the squat jump test showed that subject with higher body weight and more lean mass scored higher on maximal force (N) than subjects with low body weight and lean mass.

One explanation related to the association between physical fitness and BMD in this study may be the high correlation between body composition and BMD, as lean body mass may seem to predict the physical fitness levels in Squat jump (N) and VO_2max. Several studies have revealed a significant association between body height, body weight, percentage body fat, lean body mass and BMI on BMD (Duncan et al., 2002; Gibson et al., 2004; Hinriksdottir, Arngrimsson, Misic, & Evans, 2013; Khan et al., 2001). In a study of 104 female non-athletes aged 20-29 years and 40-85 years, Hinriksdottir et. al (2012) found that lean soft tissue mass emerged as a greater predictor of BMD than fat mass, regardless of age. Also, women with low body-weight and low BMI (< 19 kg/m²) may have greater risk for osteoporosis than normal weight woman (Hinriksdottir et al., 2013). The female athletes with low body weight, BMI, lean body mass and body fat percentage in our study, also had lower BMD values. Few studies have investigated the isolated effects of anthropometrics and body composition on BMD in healthy female athletes (El Hage et al., 2012; Hinriksdottir et al., 2013). However, several studies have approached an association between body composition and BMD based on measurements from female athletes with and without menstrual disturbances (Cobb et al., 2003; Duckham et al., 2013; Gibson et al., 2004; Nattiv et al., 2007). The strong association between body composition and BMD found in this study may therefore be explained by differences in menstrual status and the potential consequences that may arise.

Stress fractures often occur in the setting of increased training frequencies, intensity or duration (Scofield & Hecht, 2012). Knowledge about the risk factors of stress fractures can be valuable in the preparation of a training schedule. Although there is an association between mechanical loading and BMD, the differences observed in BMD between endurance sports and power sports may be explained by more complex conditions than just the differences in exercise mode. It have been suggested that the indirect mechanism of poor bone strength in some athletes, may be explained by incidents of amenorrhea. Further, amenorrhea may be a result of high energy expenditure without adequate compensation in energy intake for a prolonged period of time, which may lead to an energy deficiency. This is also a condition that is more common in endurance athletes than in power sport athletes, and may be linked to the beneficial effects of maintaining low body weight in order to perform in endurance sports (Nattiv et al., 2007).

The cross-country skiers had lower BMD measurements for all regions compared to football players and handball players. This result is consistent with earlier findings also suggesting lower BMD in endurance athletes compared to athletes from other sports, like sprinters and ball sports athletes (Barrack, Rauh, & Nichols, 2010; Duncan et al., 2002; Mudd, Fornetti, & Pivarnik, 2007; J. F. Nichols, Rauh, Barrack, & Barkai, 2007; Taaffe et al., 1997). These differences may be explained by the physical demands and training regime of the different sports. Ferry et. al (2011) pointed out that bone adapts in response to mechanical constraints and that football may be considered as high-impact sport with high intensity, accelerating and decelerating movements, often loading the body and hip region in direction not apparent in usual daily activities (Ferry et al., 2011). The same movement pattern may also describe handball, while cross- country skiing may be described with repetitive movement pattern over time, characteristic for several endurance sports. Therefore, this may contribute to the higher BMD measurements in football players and handball players compared to cross-country skiers.

Regardless of type of sport, it is still difficult to specify the type, intensity or duration of exercise that provides the maximum anabolic stimulus to bone (Wolman, 1990). High training volumes with high intensity have been suggested to have a detrimental effect on bone, both in men and women. A study of male runners suggested that the different effects of normal and high-intensity exercise on bone mineral density may be explained by assuming that, until a certain threshold level of exercise is reached, bone formation is stimulated, but that at higher training intensity the beneficial effects may be lost or even, in extreme cases, result in actual bone loss (MacDougall et al., 1992). These effects in female athletes have been suggested to be a result of hormonal mechanism, and may explain the reduced bone mineral density in endurance athletes (Braam et al., 2003).

Also, it is possible that females with genetically potential higher BMD may self-select into athletics (D. L. Nichols et al., 2007), and that their higher bone densities have allowed them to undertake intensive training rather than being secondary to it (Wolman, 1990). Genetics have a strong influence on BMD, and it have been suggested that genetic factors may account for up to 60-80% of the individual variance in areal BMD (Seeman et al., 1996). However, the contribution of genetics and environmental factors are not confirmed, it is difficult to precisely adjust for environmental and lifestyle factors (Khan et al., 2001).

Low BMD may increase fracture risk and diagnosis of osteoporosis. But it is important to illustrate some of the aspects of BMD as a measure and diagnostic method. BMD is a measure of mineral density at a given bone surface area. It is the most widely used way to refer to bone strength as it is believed to account for up to 70% of bone strength (Peer, 2004). BMD is an important factor of bone strength, since the mineral determines bone stiffness (Burr, 2002). However, bone strength encompasses the bone architecture, geometry, cortical porosity and tissue mineralization (Duckham et al., 2013). BMD gives us a limited picture of the actual bone structure, and therefore, BMD alone cannot predict the total bone strength (D. L. Nichols et al., 2007). Although, BMD does not take into account the architecture or material properties of the bone, as dual-photon energy beams provide accurate assessment of bone mass but not architecture of the bone (Peer, 2004). Bone strength and the risk of fracture depend on the density and internal structure of bone mineral and on the quality of bone protein, BMD is not the only determinant for bone fracture. This may explain why one person suffers fractures while another with the same BMD does not (Nattiv et al., 2007).

Also, fracture risk is associated with abnormal microarchitecture of the bone and may occur even in subjects with normal BMD values. This suggests microarchitecture as a more sensitive measure of fracture risk than BMD measurements alone (K. E. Ackerman et al., 2011). In addition, BMD does not account for differences in bone size. Areal BMD values are lower in smaller bones, this may imply that DEXA tends to underestimate volumetric BMD in small individuals (Hansen et al., 1990).

Normal values for BMD in females, presented by Löfman et. al showed lower BMD values in the general female population than the female athletes in our study. Although, one exception was observed for BMD spine in the cross-country skiers where mean BMD was lower than for the Swedish females (Mean= 1.00 g/cm² and 1.03 g/cm², respectively) (Lofman et al., 1997), although the difference was small. The higher BMD values observed in our study suggest that female athletes have higher BMD than non-athletic females.

Given its cross sectional design, selection bias cannot be discount as an alternative explanation for the observed differences in BMD among football players, handball players and cross-country skiers in this study. Nevertheless, several studies have suggested that BMD of the head can argue against selection bias in cross-sectional studies. The skull is a relatively unloaded skeletal region during most activities and observed differences in regional BMD among athletes may therefore be associated with sport specific loading pattern. Skull BMD was similar across all groups in this study.

The female athletes BMD reflect energy availability, menstrual status, genetic composition and environmental factors. Therefore, the changing in BMD over time is essential when evaluating the bone health perspective. A “snap-shot” of BMD may not provide as much information on bone health due to changes over time. Self-selection bias may also have affected the outcome measures in this study. To further understand the factors affecting bone mineral density in female athletes, future large-scale prospective studies are necessary.

Environmental factors affect BMD in several ways. Although, much of the variance in BMD are related to genetics (Khan et al., 2001). The full genetic potential for peak bone mass in these women is still unknown. We don’t know how high BMD they can reach or the speed of decomposition in bone after peak bone mass is reached. These are factors that will have a major impact on bone health after ended athletic career and later in life.

Research on BMD among female athletes is an important field of research, both in a performance perspective and in a health perspective as low BMD may equal poorer bone health. The long term effect of low BMD in female athletes are still widely unknown. Little research has been done with athletes after their competitive careers are finished (D. L. Nichols et al., 2007). Although, cross-sectional studies indicates that retired athletes maintain higher BMD values than controls (Bass et al., 1998). More longitudinal studies are required in terms of detecting long term effects of exercise, eating behaviors and menstrual status on BMD.

Conclusion

In conclusion, we find that anthropometrics and body composition are associated with BMD. The female athletes with higher body weight, BMI, lean body mass and body fat percentage also had higher BMD for all regions measured. In addition, this study suggests that anthropometric measures and body composition strongly associate with physical performance measured by physical fitness tests; Squat jump (N) and VO_2max (ml/kg/min). Female athletes who scored higher in Squat jump (N) also had higher BMD for all regions measured. Contrary, the female athletes with the highest oxygen consumption had lower BMD for all regions measured. These females also had lower body weight, BMI, lean mass and body fat percentage.

Differences between the sports were also observed. When comparing females participating in football, handball and cross-country skiing, this study revealed that the cross-country skiers had lower BMD for all regions compared to both football players and handball players. Handball players had the highest mean BMD measurements for all regions measured.

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Appendices

Appendix 1 – Approval from the Regional Ethics Committee

Below is a copy of the approval from Regional Ethics Committee, Mid-Norway, received October 2011.

2011/1460 Konkurranseinstinkt hos toppidrettsutøvere

Prosjektleder: Professor Sven Magnus Carlsen

Forskningsansvarlig: St. Olavs Hospital, Medisinsk klinikk v/klinikksjef Eiliv Brenna

Med hjemmel i lov om behandling av etikk og redelighet i forskning § 4 og helseforskningsloven (hfl.) § 10 har Regional komité for medisinsk og helsefaglig forskningsetikk Midt-Norge vurdert prosjektet i sitt møte 21. oktober 2011. Komiteen viser til prosjektprotokoll, målsetting og plan for gjennomføring, og finner at prosjektet har et forsvarlig opplegg som kan gjennomføres under henvisning til evt. merknader og vilkår for godkjenning, jf. hfl. § 5.

Merknader og vilkår:

- -Komiteen ber om at grunnlagsdata ikke blir anonymisert, slettet eller destruert, men blir oppbevart på en betryggende måte i minimum 5 år etter prosjektslutt av kontrollhensyn. Instanser som kan tenkes å kontrollere grunnlagsmaterialet er f.eks. forskningsansvarlige, Uredelighetsutvalget for forskning og Helsetilsynet.
- -Komiteen minner om at de aller fleste kliniske studier skal registreres i det offentlig tilgjengelige registeret www.clinicaltrials.gov. Prosjektleder er ansvarlig for å avgjøre om forskningsstudien omfattes av kravet til registrering.
- -Prosjektleder skal sende sluttmelding til den regionale komiteen for medisinsk og helsefaglig forskningsetikk når forskningsprosjektet avsluttes. I sluttmeldingen skal resultatene presenteres på en objektiv og etterrettelig måte, som sikrer at både positive og negative funn fremgår, jf. hfl. § 12.

Vedtak

"Regional komité for medisinsk og helsefaglig forskningsetikk, Midt-Norge godkjenner at prosjektet gjennomføres med de vilkår som er gitt."

Vennlig hilsen

Sven Erik Gisvold

Professor, dr.med.

Leder, REK midt

Arild Hals

Appendix 2 –Information letter

Forespørsel om deltagelse i forskningsprosjekt:

”The Female Competitiveness Study” – er det sammenheng mellom hormonnivåer og konkurranseinstinkt hos kvinnelige toppidrettsutøvere?

Bakgrunn og hensikt

Toppidrettsutøvere presser sin fysiske og psykiske kapasitet til det ytterste. De fysiske og psykiske aspektene og sammenhengen med hormonnivåer har vært studert tidligere, spesielt hos menn. Sammenhengen mellom hormonnivåer, fysisk kapasitet og mentale faktorer hos kvinner er derimot lite studert.

Nivået av androgene hormoner (hormoner med testosteronvirkning) og spesielt testosteron er noe forhøyet hos kvinner med polycystisk ovarialsyndrom (PCOS). Kvinner med PCOS utgjør 10-15 % av kvinner i fruktbar alder, de synes å ha høyere konkurranseinstinkt og delta mer i idrett enn kvinner uten PCOS. Det synes også å være en svak sammenheng mellom PCOS, humørsvingninger og spiseadferd. Vi tror mye av dette kan ha sammenheng med de noe økte nivåene av hormoner med testosteronvirkning og at kvinner med økte testosteronnivå i spesiell grad trekkes mot idrett generelt og toppidrett spesielt.

Vi henvender oss til deg fordi du er en kvinnelig toppidrettsutøver for å be om ditt samtykke til deltakelse i dette forskningsprosjektet. Formålet med studien er å få økt kunnskap om sammenhengen mellom hormonnivåer hos kvinnelige toppidrettsutøvere og konkurranseinstinkt, muskelmasse, fysisk kapasitet, beintetthet, mentale forhold inkludert seksuell orientering og forekomsten av PCOS. Studien er et samarbeidsprosjekt mellom Avdeling for endokrinologi, St. Olavs hospital, Institutt for Bevegelsesvitenskap og Psykologisk Institutt, Norges teknisk- naturvitenskaplige universitet (NTNU) og Olympiatoppen Midt-Norge. Denne forespørselen går til toppidrettskvinner mellom 18 og 40.

Hva innebærer deltagelse i studien?

Den enkelte deltager vil få utført en DEXA-scan og taking av fastende blodprøve ved Avdeling for endokrinologi, St. Olavs hospital. Ved DEXA-scan ligger man stille i truse på ryggen i 10 minutter og det hele er helt smertefritt. Ved denne undersøkelsen bestemmes fettmasse, muskelmasse, beinmasse og beintetthet. I tillegg besvares spørreskjema om konkurranseinstinkt, spenningssøking, spiseadferd, mental helse og seksuell orientering. Vi vil også registrere resultatene fra fysiske tester (VO_2 max, laktat, maksimal muskelkraft ved spensthopp og benkpress). Medisinbruk, spesielt hormonpreparater (p-pille, p-stav, p-sprøyte, hormonspiral etc.) vil bli registrert.

I tillegg håper vi å kunne tilby en gynekologisk undersøkelse for deltagerne i studien.

Mulige fordeler og ulemper

Som deltager har du mulighet til å bidra til ny kunnskap om sammenhengen mellom forhold knyttet til idrettsprestasjoner og toppidrettskvinners helse. Deltagelse i prosjektet medfører testing og analyse av blant annet beintetthet og muskelmasse. Lav beintetthet og menstruasjonsforstyrrelser kan være et problem hos kvinner som trener mye. Dersom dette påvises kan fagpersonene i prosjektgruppen vurdere spesielle tiltak dersom du ønsker det.

Opplever du noen av spørsmålene som ubehagelige er det greit å unnlate å besvare dem. Data vil uansett ikke kunne spores tilbake til enkeltpersoner etter at de er registrert i en database. Vi har dessverre ikke anledning til å gi deltagerne økonomisk kompensasjon så deltagere i prosjektet må selv dekke eventuelle reiseutgifter.

Den fysiske testingen vil bli gjennomført etter standard prosedyrer for slik fysiologisk testing og risikoen for at noe kan skje er minimal. VO_2 max kan oppleves som anstrengende, men gi nyttig informasjon som kan brukes til videre treningsplanlegging. Prestasjonstester vil også være standard og gjennomføres i tråd med trening du som utøver gjennomfører til daglig. Den eneste reelle forskjellen fra den daglige trening og testing er at dataene fra testene vil bli systematisert og lagret for brukt i prosjektet.

Viktig! Dine forberedelser

Blodprøvene vil bli tatt om morgenen, og du må faste 8 timer (dvs. fra midnatt) i forkant (inkludert røyk/snus-avhold). Dersom du er veldig tørst kan du evt. drikke et halvt glass vann morgenen før prøvene tas.

Hva skjer med testene og informasjonen om deg?

Dine resultater fra undersøkelsene vil bli behandlet i ikke identifiserbar form, dvs. uten navn, fødselsnummer eller andre identifiserende opplysninger. En kode knytter deg til dine opplysninger og prøver, gjennom en navneliste. Denne koden oppbevares uavhengig av selve databasen med alle opplysningene fra studien. Det er kun autorisert helsepersonell knyttet til prosjektet som har adgang til navnelisten og som eventuelt kan finne tilbake til deg. Det vil ikke være mulig å identifisere deg i resultatene av studien når disse publiseres. Når prosjektet er avsluttet vil også koden som knytter deg til enkeltdata i databasen slettes.

Dersom du ønsker det kan vi gi deg tilbakemelding på testresultatene (som for eksempel kroppssammensetning, VO_2 max, styrketestene, og evt. gynekologisk undersøkelse). Vi kan eventuelt også informere om eventuelle andre helseproblemer vi måtte påvise ved de undersøkelsene du gjennomgår. Dette vil foregå ved studiemedarbeiderne (kroppssammensetning, VO_2 max, styrketestene) eller lege (gynekologisk undersøkelse, beintetthet, evt. andre forhold). Olympiatoppen, trenere eller andre vil ikke på noe tidspunkt få tilgang til informasjon om enkeltpersoner utover resultater fra de fysiske testene Olympiatoppen får tilgang på slik de gjør ved tilsvarende rutinetesting av utøvere.

Studien er vurdert og godkjent av Regional komité for medisinsk forskningsetikk, Midt-Norge og vil bli gjennomført etter de regler og retningslinjer som er nedfelt i Helsinkideklarasjonen. Når studien er avsluttet vil resultatene bli publisert i et engelskspråklig internasjonalt medisinsk tidsskrift.

Frivillig deltakelse

Studien er frivillig, du kan på hvilken som helst tidspunkt trekke deg uten nærmere begrunnelse eller uten at det får noen negative konsekvenser for deg. Dette gjelder selvfølgelig også videre oppfølging fra Olympiatoppen. Dersom du trekker deg fra studien har du rett til innsyn i data registrert om deg. Du kan også trekke tilbake samtykket. Da vil alle innsamlede opplysninger om deg bli slettet og frosne blodprøver vil bli destruert med mindre opplysningene allerede er inngått i analyser eller brukt i vitenskaplige publikasjoner.

Vi ber også om tillatelse til eventuelt å kontakte deg senere for oppfølgning. Dette er kun en forespørsel om vi får lov å ta kontakt med deg senere og ikke noe løfte fra deg om at du vil stille opp. Dette er ingen forutsetning for å delta i studien. Hvis du samtykker i å delta i studien må du undertegne en samtykkeerklæring lik den som er vedlagt før du deltar. Personopplysninger som knytter deg til data vil bli oppbevart til utgangen av 2014 og deretter slettet.

Personvern

Opplysninger som registreres om deg er:

- Helseopplysninger som du selv gir oss
- Opplysninger om din aktuelle medisinbruk
- Resultater av blodprøveanalyser som tas
- Opplysninger om de tester og undersøkelser du gjennomgår
- Svar på de spørreskjema du besvarer
- Enkle kliniske data (høyde, vekt, blodtrykk etc.)

Opplysningene legges inn i en database ved Enhet for anvendt klinisk forskning, NTNU i avidentifisert form, dvs. ikke med ditt navn eller fødselsnummer men kun med ditt deltagernummer.

Alt personell som er involvert i studien og behandlingen av innsamlede data har taushetsplikt.

Representanter for kontrollmyndigheter kan få utlevert studieopplysninger og gis innsyn i relevante deler av din journal. Dette er lovpålagt. Formålet er å kontrollere at studieopplysningene stemmer overens med tilsvarende opplysninger i din journal. Alle som får innsyn i informasjon om deg har taushetsplikt.

Forskningsbiobank

Blodprøvene som blir tatt og informasjonen utledet av dette materialet vil bli lagret i en forskningsbiobank som professor Sven M. Carlsen er ansvarlig for. De vil bli lagret i ikke personidentifiserbar stand, dvs. bare identifisert med deltagernummer.

Utlevering av materiale og opplysninger til andre

Hvis du sier ja til å delta i studien, gir du også ditt samtykke til at prøver og avidentifiserte opplysninger kan utleveres til våre samarbeidspartnere i forskning.

Innsynsrett og oppbevaring av materiale

Hvis du sier ja til å delta i studien, har du rett til å få innsyn i hvilke opplysninger som er registrert om deg. Du har videre rett til å få korrigert eventuelle feil i de opplysningene vi har registrert. Dersom du trekker deg fra studien, vil det ikke samles inn flere opplysninger eller mer materiale. Opplysninger som allerede er innsamlet fra deg vil ikke bli slettet.

Finansiering

Studien og biobanken er søkt finansiert av forskningsmidler fra Olympiatoppen og forskningsmidler som professor Sven M. Carlsen har innestående ved Unimed Innovation. Sponsor (ansvarlig myndighet for studien) er Institutt for kreftforskning og molekylærmedisin, NTNU.

Forsikring

Du er forsikret gjennom Pasientskadeerstatningsordningen.

Med vennlig hilsen

____

Sven M. Carlsen
Professor dr. med. Prosjektleder

Prosjektgruppe:

Prosjektleder og medisinsk ansvarlig: Sven M. Carlsen, professor, spesialist i indremedisin og endokrinologi,
Enhet for anvendt klinisk forskning, NTNU og Avdeling for endokrinologi, St. Olavs hospital
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Prosjektmedarbeider: Brit Dregelid, masterstudent, Institutt for Bevegelsesvitenskap, SVT-Fak., NTNU
Email: britd@stud.ntnu.no, Tlf: 47247103

Appendix 3 –Declaration of Consent

SAMTYKKEERKLÆRING

For deltakeren:
Jeg bekrefter med dette at jeg har fått den informasjon jeg ønsker om og er villig til å delta i ***"The Female Competitiveness Study"***. Jeg vet at jeg uten nærmere begrunnelse kan trekke med fra studien på et hvert tidspunkt dersom jeg skulle ønske det uten at det vil ha konsekvenser for meg. Jeg er klar over at de innsamlede data brukes utelukkende til forskning og eventuell egen nytte ved økt kunnskap om meg selv.

Jeg samtykker i å delta i prosjektet som innebærer følgende:

- Testing av fysisk kapasitet (maksimal muskelkraft og VO_2max)
- Dexa-scan av kroppssammensetning
- Blodprøvetaking for hormonanalyser
- Spørreskjema angående konkurranseinstinkt, spenningssøking, spisevaner, mental helse og seksuell orientering
- Gynekologisk undersøkelse (ingen betingelse for å delta i resten av studien)
- Enkel klinisk undersøkelse (høyde, vekt, blodtrykk etc.)
- Fotokopi av hendene

Dersom du godkjenner at vi kontakter deg for eventuell oppfølgende forskning på et senere tidspunkt, vennligst kryss av her: ☐

Dersom du ønsker å bli kontaktet dersom blodprøver eller andre av undersøkelsene gir mistanke om spesielle medisinske problemer hos deg, vennligst kryss av her: ☐

Sted:______________________________ Dato:___/___- 2012

Navn:____
(Deltakers fulle navn med BLOKKBOKSTAVER)

____
Deltagers underskrift

Jeg bekrefter med dette at deltageren har fått muntlig og skriftlig informasjon om studien, har fått svar på de muntlige spørsmål hun hadde og har underskrevet på denne deltagerformasjonen:

Sted: _____________________________ Dato:___/___- 2012

Studiemedarbeider: ____
Ansvarlige lege for undersøkelsen:
Sven M. Carlsen, Professor, Enhet for anvendt klinisk forskning, NTNU, Overlege, Avdeling for endokrinologi, St. Olavs hospital.