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MISS SUVI RAVI (Orcid ID : 0000-0001-9706-5449)

DR MAARIT VALTONEN (Orcid ID : 0000-0001-8883-2255)

DR TOMMI VASANKARI (Orcid ID : 0000-0001-7209-9351)

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Title

Menstrual dysfunction and body weight dissatisfaction among Finnish young athletes and non-athletes

Running title

Menstrual dysfunction in young athletes

Authors

Suvi Ravi¹, Benjamin Waller², Maarit Valtonen³, Jari Villberg¹, Tommi Vasankari⁴, Jari Parkkari⁵, Olli J. Heinonen⁶, Lauri Alanko^{7,8}, Kai Savonen^{9,10}, Marja Vanhala¹¹, Harri Selänne¹², Sami Kokko¹, Urho M. Kujala¹

¹Faculty of Sport and Health Sciences, University of Jyväskylä, Jyväskylä, Finland

²Physical Activity, Physical Education, Sport and Health Research Centre, Sports Science Department, School of Social Sciences, Reykjavik University, Reykjavik, Iceland

³Research Institute for Olympic Sports, Jyväskylä, Finland

⁴UKK Institute for Health Promotion Research, Tampere, Finland

⁵Tampere Research Center of Sports Medicine, Tampere, Finland

⁶Paavo Nurmi Centre & Unit for Health and Physical Activity, University of Turku, Turku, Finland

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⁷Sports Medicine Clinic, Foundation for Sports and Exercise Clinic, Helsinki, Finland

⁸Central Finland Central Hospital, Jyväskylä, Finland

⁹Kuopio Research Institute of Exercise Medicine, Kuopio, Finland

¹⁰Department of Clinical Physiology and Nuclear Medicine, Kuopio University Hospital, Kuopio, Finland

¹¹Department of Sports and Exercise Medicine, Oulu Deaconess Institute Foundation, Oulu, Finland

Center for Life Course Health Research, Faculty of Medicine, University of Oulu, Oulu, Finland

Medical Research Center, Oulu University Hospital and University of Oulu, Oulu, Finland

¹²Faculty of Education and Psychology, Department of Psychology, University of Jyväskylä, Finland

Corresponding author: Suvi Ravi, Faculty of Sport and Health Sciences, University of Jyväskylä, Jyväskylä, Finland. Email: suvi.m.ravi@jyu.fi

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Conflict of interest

The authors have no conflicts of interest.

ABSTRACT

To determine the prevalence of menstrual dysfunction (MD; i.e. oligomenorrhea or amenorrhea) and attitudes towards body weight among athletes and non-athletes, we studied a cohort of athletes and non-athletes, in adolescence (14–16 years) and subsequently in young adulthood (18–20

years). We further studied the differences between athletes reporting MD and eumenorrheic athletes at both time periods and identified physical and behavioural characteristics that might predict MD in young adulthood. Data were collected using questionnaires, accelerometers, and a pre-participation screening. In adolescence, the athletes reported current primary amenorrhea more often than the non-athletes (4.7% vs. 0%, $p=0.03$). In young adulthood, athletes reported MD more frequently than non-athletes (38.7% vs. 5.6%, $p<0.001$). Athletes had less desire than non-athletes to lose weight at both time points, and in adolescence athletes were more satisfied with their weight. However, about one fifth of the athletes and about 40% of the non-athletes experienced body weight dissatisfaction at both time points. In adolescence, athletes reporting MD had lower BMI than eumenorrheic athletes. In young adulthood, athletes with MD were more physically active than eumenorrheic athletes. The only longitudinal predictor of MD in young adulthood was MD in adolescence. Our findings indicate that MD is relatively frequent among young Finnish athletes. However, athletes appear to have a smaller tendency to experience body weight dissatisfaction than their non-athletic peers. MD seems to track from adolescence to adulthood, suggesting that there is a need to focus on possible causes at the earliest feasible phase of an athlete's career.

Key words: menstrual dysfunction, amenorrhea, body weight dissatisfaction, exercising women, young athletes

Introduction

Menstrual dysfunction (MD) is one of the components of the Female Athlete Triad/Relative Energy Deficiency in Sport (RED-S) consisting of an irregular or absent menstrual cycle as well as subclinical MD with no perceptible symptoms, such as luteal phase deficiency and anovulation.¹⁻³ MD is fairly common among female athletes and it is suggested to be more common in athletes competing in sports that emphasise leanness.^{2,4,5} MD prevalence rates vary between studies depending on the diagnostic criteria and the population studied, with studies usually investigating only clinically detectable MD.⁴⁻¹⁴ Nevertheless, the results of studies comparing the prevalence of MD in athletes and non-athletes have been inconsistent. Hoch et al.¹² and Muia et al.⁶ found that MD was more common in runners and athletes competing in several different sports, respectively, than in sedentary controls. Contrastingly, in other studies the MD prevalence between athletes

competing in different sports and controls has been similar.^{4,7} Additionally, Fogelholm and Hiilloskorpi⁸ found no difference in the prevalence of MD between athletes and controls, although there was a trend towards a lower prevalence of MD in the control group. It has further been observed that there is a difference in menarcheal age between athletes and non-athletes with the former attaining menarche later.^{4,12}

Although there are several different reasons for MD, in short-term clinical studies, low energy availability (EA) has been found to cause metabolic and endocrine changes, indicating that it is the primary reason for MD in the Female Athlete Triad/RED-S.^{1-3,15} Nevertheless, the impact of low EA on MD is modified by several factors, including genetic and psychological factors.^{16,17} Low EA, and consequently MD, can result from intentionally or unintentionally decreased energy intake with a possible combination of increased energy expenditure.^{1,18} Thus, disordered eating (DE)/eating disorder (ED) can also result in low EA,¹⁻³ especially in sports emphasising leanness.¹⁹ One risk factor for DE/ED is body weight dissatisfaction (i.e. the discrepancy between actual and desired weight).²⁰ It has previously been observed that body weight dissatisfaction is present among young female adults²¹ and adolescents.²² Being an athlete can protect from or cause body weight dissatisfaction. On the one hand, athletes may experience pressures to change their body weight in order to meet the “ideal” body shape or for perceived performance improvements.²³ On the other hand, it has been established that lower BMI and physical activity are associated with lower body dissatisfaction.²⁴

Few studies have investigated training volume/physical activity between athletes with MD and eumenorrheic athletes. Torstveit and Sundgot-Borgen⁴ found that self-reported training volume was not associated with MD in elite athletes, while in the study conducted by Henriksson et al.,²⁵ athletes with MD reported higher training hours than eumenorrheic athletes. In addition, Tornberg et al.²⁶ found that aerobic exercise volume assessed by training logs and heart rate monitors did not differ between endurance athletes with MD and eumenorrheic endurance athletes, although amenorrheic athletes performed more resistance training. Furthermore, other studies have found no difference between amenorrheic and eumenorrheic athletes with regard to exercise energy expenditure, based on self-reported physical activity,²⁷ or on objectively measured non-exercise physical thermogenesis and exercise energy expenditure.²⁸ However, more research is needed to investigate differences in objectively measured physical activity between athletes with MD and eumenorrheic athletes.

Our study was designed to compare the prevalence of self-reported MD (irregular or absent menstrual cycles), and attitudes towards body weight in a cohort of young Finnish athletes and non-athletes at two life stages, namely adolescence (ages 14–16) and young adulthood (ages 18–20). We also analysed attitudes towards body weight by different weight categories (underweight, normal weight, and overweight). In addition, we investigated whether there were differences in BMI, objectively measured physical activity, self-reported training hours, or attitudes towards body weight among athletes reporting MD and eumenorrheic athletes. Finally, we conducted analyses to determine whether BMI, MD, attitudes towards body weight, physical activity, or age at menarche in adolescence might predict MD in young adulthood.

Materials and methods

Participants

This study formed part of the *Finnish Health Promoting Sports Club* (FHPSC) study.²⁹ In the present study, baseline and follow-up surveys were used. The baseline data were collected in 2013 in two rounds separately for participants in winter and summer sports aged 14–16 years. Detailed information on the recruiting process has been presented elsewhere.²⁹ In brief, 272 sports clubs from the 10 most popular sports disciplines in Finland were approached and from these, 156 clubs (85 winter disciplines and 71 summer disciplines) agreed to participate in the study. Comparative data for non-sports club members (non-athletes) were collected at the same time from schools. The sample for the present study consisted of the girls who underwent pre-participation screening of the FHPSC study, where medical history as well as height and weight was assessed. Participants for the pre-participation screening were randomly invited from both the sports club participants and non-participants who replied to the questionnaires administered to the whole sample of the FHPSC study. In the present study, girls who participated in a sports club and exercised at least four times a week in the training season were considered as athletes. Thus, sports club participants who exercised less than four times a week in the training season were excluded (Figure 1). There was no difference in the prevalence of MD between the excluded sports club members and the members included in the study ($p=0.48$), but the excluded members had a lower age at menarche (12.2 vs. 12.7, $p=0.02$). The final sample size at baseline (i.e. at adolescence) was 283 (178 athletes, 105 non-athletes).

The follow-up data for the FHPSC study were collected in 2017–2018 when the participants were 18–20 years of age. All the participants who had undergone the pre-participation screening at adolescence and who had given their consent to be re-contacted were invited to participate for the follow-up. In total, 227 (72.1%) of the 315 girls invited, agreed to participate. Those who refused to participate had a similar MD prevalence at adolescence to those who agreed to participate in the follow-up (23.8% and 20.0%, respectively, $p=0.61$). Sports club members who reported exercising less than four times a week in the training season were excluded (Figure 1). Those excluded had a similar prevalence of MD ($p=0.15$) and age at menarche ($p=0.11$) to the athletes included in the study. The final sample size at follow-up (in young adulthood) was 211 (52 athletes, 159 non-athletes).

Sports disciplines were categorised by modifying the criteria of Sundgot-Borgen and Torstveit³⁰ as follows: endurance (cross-country skiing, orienteering, swimming, race walking, and canoe sprint), aesthetic (synchronised skating, figure skating, synchronized swimming, gymnastics, and sport dance), technical (horse riding), ball games (soccer, basketball, floorball, badminton, water ball, ice-hockey, and ringette), and power/anti-gravitation sports (track and field, speed skating, and taekwondo).

The declaration of Helsinki was followed throughout the study, and the study was approved by the Ethics Committee of the Health Care District of Central Finland. All the participants gave written informed consent before entering the study. In addition, informed consent was requested from a guardian if a participant was under 18 years of age.

Data collection

The baseline data and the follow-up data were collected by with an identical protocol, explained elsewhere,²⁹ using structured questionnaires, pre-participation screening, and accelerometers.

Questionnaires:

Menstrual status questions included: age at menarche (if occurred), duration of the menstrual cycle, number of periods in the preceding year, and hormonal contraceptive (e.g. oral contraceptives, implants, injections, transdermal patches, vaginal rings, or intrauterine systems) use. In the case of an absence of periods, inquiry was made of the number of consecutively missed

cycles. The participants' gynaecological age was determined by subtracting the age at menarche from their chronological age. Participants who did not use hormonal contraceptives were then classified into the MD group (menarche not occurred by the age of 15, i.e. primary amenorrhea, having ≤ 9 periods in a preceding year, duration of the menstrual cycle >35 days, or missing periods in ≥ 3 previous months after menarche),¹ or the eumenorrhea group. Participants whose menstrual cycle was 36–89 days and whose gynaecological age was one year or less were excluded from this analysis; this was due to the fact that it takes some time to achieve a regular menstrual cycle, and there is great variation in durations between the first and second menstrual cycle. However, menstrual cycles exceeding 90 days are not normal, even when they occur in the first gynaecological year.³¹

The following yes/no questions were asked regarding participants' attitudes towards body weight: 'Are you satisfied with your present weight?', 'Do you think that you should lose weight?', and 'Do you think that you should gain weight?'

Weekly training hours were reported separately in the training and competition season, in addition to weekly rest days during the training and competition season.

Pre-participation screening:

In the pre-participation screening, height and weight, without shoes, were measured in the laboratory to the nearest 0.5cm and 0.1kg, respectively. BMI was calculated on the basis of these data. The adolescents' BMI was age-adjusted based on age- and gender-specific BMI international cut-off points, using the participants' mean age (15 years).^{32,33} Hence, BMI $<17.5\text{kg/m}^2$ was classified as underweight, BMI $=17.5\text{--}23.9\text{kg/m}^2$ was classified as normal weight, and BMI $>23.9\text{kg/m}^2$ was classified as overweight. At the young adulthood stage, the cut-off points were: underweight = BMI $<18.5\text{kg/m}^2$; normal weight = BMI $18.5\text{--}24.9\text{kg/m}^2$; overweight = BMI $\geq 25.0\text{kg/m}^2$. In the current study, obese participants (2 and 13 in adolescence and in young adulthood, respectively) were included in the overweight group.

Accelerometer data:

Physical activity was measured with a hip-worn, light triaxial accelerometer (Hookie AM20, Traxmeet Ltd., Espoo, Finland). The accelerometer was set up during the pre-participation screening and subsequently returned or mailed back to the research unit. Participants were asked

to wear the accelerometer during waking hours (excluding activities in water) for seven consecutive days. The analysis of the raw acceleration data was based on novel algorithms that employed the mean amplitude deviation (MAD) of the resultant acceleration in 6-s epochs, and the angle for posture estimation (APE) of the body. The analysis further incorporated consistent and accurate assessments of the intensity, volume, and daily distribution of physical activity, plus the physical activity volume for sedentary and stationary behaviours, along with its daily distribution.³⁴⁻³⁶

The MAD metric has been validated through directly measured incident oxygen uptake (VO_2) during walking or running on an indoor track.³⁶ This strong association made it possible to convert MAD values to incident energy consumption (MET). The MET was smoothed by calculating the one-minute exponential moving average of MAD values for each 6s epoch. Following recommended use,³⁷ cut-points for different activities were set as 3–6 MET for moderate activities, and over 6 MET for vigorous activities, with corresponding mean daily total times also determined. The mean times spent in moderate and vigorous activity per day were summed to obtain the total mean time spent in moderate-to-vigorous physical activity (MVPA) per day. The average daily step count during the monitoring week was also documented.

Statistical analyses

All the continuous variables were tested for normality prior to statistical analysis. Continuous variables are presented as means and standard deviations, and categorical variables as percentages and counts. The differences between groups were investigated using the two independent samples t-test for distributed data or Mann-Whitney U-test for non-distributed data. In addition, crosstabs, chi-square, and Fisher's exact test were used when appropriate for categorical data. Longitudinal analyses were performed using McNemar's test when analysing the differences in proportions of participants with MD at both time points and a binary logistic regression model when investigating the associations between adolescent's BMI, MD, attitudes towards body weight, physical activity, and age at menarche and MD in young adulthood.

Statistical analyses were conducted using IBM SPSS Statistics version 24 (Armonk, NY). The significance level was set at <0.05 , two-tailed.

Results

Based on the questionnaire, menstrual status could be determined in 149 (83.7%) adolescent athletes and 97 (92.4%) adolescent non-athletes. Out of those, 8 (5.4%) athletes and 17 (17.5%) non-athletes used hormonal contraceptives. Only participants whose menstrual status could be determined and who did not use hormonal contraceptives were included in the analysis regarding MD (Figure 1). However, all the participants were included in the analysis of other variables such as age at menarche, gynaecological age, and attitudes towards body weight.

In adolescence, the number of athletes in each sports categories were as follows: endurance $n=53$ (29.8% of the athletes), aesthetic $n=62$ (34.8%), technical $n=3$ (1.7%), ball games $n=42$ (23.6%), and power/anti-gravitation $n=18$ (10.1%).

Menstrual status in the young adult population was available for 50 (96.2%) athletes and 130 (81.8%) non-athletes. Out of those, 19 (38.0%) athletes and 59 (45.4%) non-athletes used hormonal contraceptives. Participants who used hormonal contraceptives or whose menstrual status could not be determined from the questionnaires were excluded from the analysis regarding MD.

In young adulthood, athletes were distributed to the sports categories as follows: endurance $n=22$ (42.3% of the athletes), aesthetic $n=12$ (23.1%), ball games $n=10$ (19.2%), and power/anti-gravitation $n=8$ (15.4%). There were no athletes in the technical sports group in young adulthood.

Athletes and non-athletes

Table 1 presents the characteristics of the athletes and non-athletes at adolescence and in young adulthood. At adolescence, the groups were similar in chronological age, but athletes were slightly younger in gynaecological age than non-athletes, since menarche had occurred later in athletes. Athletes also exhibited lower BMI, more MVPA, and a higher daily step count than non-athletes. There was no difference in the prevalence of MD between athletes and non-athletes at adolescence. However, primary amenorrhea (both current and lifetime) was more common among athletes than non-athletes. Non-athletes were less satisfied with their weight and had more desire

than athletes to lose weight. By contrast, athletes wished to gain weight more often than non-athletes.

In young adulthood, athletes and non-athletes were similar in both chronological and gynaecological age, and there were no differences between groups in terms of age at menarche, weight, height, or BMI. Athletes had more MVPA and daily steps than non-athletes. The prevalence of MD differed between groups, since 39% of the athletes reported MD, as opposed to 6% of the non-athletes. The groups were similar in body weight satisfaction, but there was a trend towards more satisfaction among athletes ($p=0.07$). Furthermore, non-athletes were more willing to lose weight than athletes.

Figure 2 presents attitudes towards body weight by different weight groups (underweight, normal weight, or overweight) among athletes and non-athletes in adolescence. Among the athletes, higher weight satisfaction was associated with lower BMI ($p=0.01$), while a higher desire to lose weight was associated with higher BMI ($p=0.02$). There was no association between a desire to gain weight and BMI among the athletes ($p=0.28$). Among non-athletes, lower weight satisfaction was associated with higher BMI ($p<0.001$), and a higher desire to lose weight was associated with higher BMI ($p<0.001$). Among non-athletes in adolescence, there was no difference between weight groups in terms of a desire to gain weight ($p=0.20$). Normal weight athletes were more satisfied with their weight ($p=0.006$) than normal weight non-athletes. They also wished to lose weight less often ($p=0.01$) and wanted to gain weight more often ($p=0.04$) than normal weight non-athletes. Similarly, overweight athletes were more satisfied with their weight ($p=0.004$) than overweight non-athletes. They also showed less desire to lose weight ($p=0.004$). There was no difference in the desire to gain weight between overweight athletes and non-athletes. The attitudes of underweight athletes did not differ from those of underweight non-athletes.

Among young adult athletes, there were no differences in attitudes towards weight between the three weight groups (Figure 3). Among non-athletes, higher weight satisfaction was associated with lower BMI ($p<0.001$), a higher desire to lose weight was associated with higher BMI ($p<0.001$), and a lower desire to gain weight was associated with higher BMI ($p<0.001$). Overweight athletes were more satisfied with their weight ($p=0.005$) and had less desire to lose weight ($p=0.001$) than overweight non-athletes. Athletes did not differ from non-athletes in the normal and underweight groups.

Athletes reporting MD and eumenorrhic athletes

Table 2 presents the characteristics of athletes reporting MD and eumenorrhic athletes. At adolescence, the gynaecological age of athletes with MD was lower than that of the eumenorrhic athletes. In addition, athletes with MD had a higher age at menarche and lower BMI than eumenorrhic athletes. The groups showed similar amounts of measured MVPA and steps per day; however, eumenorrhic athletes reported a higher training volume during the training season than athletes in the MD group.

In young adulthood, the only differences between athletes with MD and eumenorrhic athletes were seen in objectively measured MVPA and in step counts. Athletes with MD had on average 40 minutes more MVPA and almost 5000 more steps than the eumenorrhic athletes (Table 2). There were no significant differences in attitudes towards body weight between the MD and the eumenorrhic groups, at either adolescence or young adulthood.

There were no differences in MD prevalence between the different sports categories either in adolescence or in young adulthood.

Longitudinal analysis

In the longitudinal analysis, MD in adolescence predicted MD in young adulthood among all participants (OR 11.33, 95% CI 3.26–39.34, $p < 0.001$), and among those who had been athletes in adolescence (OR 18.00, 95% CI 3.69–87.70, $p = 0.001$). BMI, attitudes towards body weight, physical activity, or age at menarche reported in adolescence did not predict MD in young adulthood. McNemar's test showed that the MD proportions did not differ between adolescence and young adulthood, either when an analysis was conducted of all the participants ($p = 0.61$), or purely of those who had been athletes in adolescence ($p = 1.00$).

Discussion

A higher percentage of adolescent athletes than non-athletes reported primary amenorrhea. We also found that adolescent female athletes had a higher mean age at menarche than non-athletes of

similar age. In young adulthood, MD was more common in athletes than in non-athletes, and the prevalence of MD in athletes was relatively high (38.7%). In adolescence, athletes reporting MD had a lower BMI and a higher age at menarche than eumenorrheic athletes. To our knowledge, this is the first study to compare physical activity levels assessed by accelerometers in eumenorrheic athletes and athletes with MD. We found that young adult athletes with MD performed more MVPA and steps per day than eumenorrheic athletes, despite the fact that there was no difference in self-reported training volume. Body weight satisfaction was more common in adolescent athletes, and young adult athletes showed a trend towards higher body satisfaction than non-athletes. The only factor predicting MD in young adulthood was MD in adolescence, while there was no relationship between BMI, attitudes towards body weight, physical activity, or age at menarche in adolescence and MD in young adulthood.

Prevalence of menstrual dysfunction

Studies that have used the same criteria for MD as the current study are mainly consistent with our findings showing that MD in adolescent athletes ranges between 18% and 28%.^{5,9-11,13} However, in our study, the prevalence of current primary amenorrhea among adolescent athletes was 4.7%, which is higher than in several other studies conducted in athletes of a similar age.^{5,7,11,13} The characteristics and definition of an 'athlete' may contribute to the differences between the studies.

The prevalence of MD in young adult athletes in the present study was 38.7%, which is lower than has been observed among elite endurance athletes.³⁸ However, in a large study conducted among Norwegian elite athletes,⁴ the prevalence of MD was lower than in the present study. The difference applied to all the Norwegian subjects (with an MD prevalence of 16.5%), and also to the lean sports athletes (where the MD prevalence in endurance and aesthetic athletes was 30.5% and 30.0%, respectively) regardless of the fact that lean sports athletes tend to have higher rates of MD than athletes in other disciplines.^{2,4,5} In addition, in a study conducted among university athletes in all types of sports, the prevalence of MD was lower (26.8%) than in the present study.¹⁴

In a previous Finnish study,⁸ the prevalence of MD among national-level athletes was 27–37% depending on the type of sports, which is in accordance with the present study. However, among high-level Finnish endurance athletes, the reported prevalence of amenorrhea was higher than that observed in the present study.³⁹

Studies comparing the prevalence of MD in athletes and non-athletes have reported conflicting findings. Studies conducted among adolescent elite runners⁶ and varsity athletes from high school¹² found that athletes had a higher prevalence of MD than controls, which is in accordance with our findings among participants in young adulthood. By contrast, studies conducted among young elite athletes in a range of sports^{4,7} did not find any difference in MD prevalence between athletes and controls. This is consistent with our results among participants in adolescence.

In the present study, the mean age at menarche assessed in adolescence was 12.7 years in athletes, which is consistent with other studies.^{5,11,13} In addition, our finding that athletes' age at menarche was higher than that of non-athletes is in agreement with the studies conducted by Torstveit and Sundgot-Borgen⁴ and by Hoch et al.¹²

Attitudes towards body weight

We found that non-athletes had more desire to lose weight than athletes, both in adolescence and in young adulthood. The finding is consistent with the study conducted by Fogelholm and Hiilloskorpi.⁸ Our figure for body weight satisfaction among non-athletes at adolescence is about the same as has been previously reported among Finnish adolescents.²² Our finding that body weight dissatisfaction was more common among adolescent non-athletes than among athletes of the same age is consistent with a meta-analysis conducted by Hausenblas and Downs,⁴⁰ which found that athletes reported a more positive body image than their non-athletic peers. Physical activity may help athletes to maintain a healthier body composition, in line with indications that physically active persons have fewer problems related to eating control than their less active counterparts.⁴¹ It should also be noted that in our study, adolescent athletes had a lower BMI than non-athletes, and this could be one reason for the fact that athletes were more satisfied with their weight than non-athletes.

When we took weight status into account, we observed that higher weight satisfaction was associated with lower BMI in all groups except young adult athletes. The finding of an association between higher weight satisfaction and lower BMI is in accordance with other studies.^{21,24} In adolescent and young adult non-athletes, and also in adolescent athletes, an increased desire to lose weight was associated with higher BMI – a finding consistent with the results of Neighbors and Sobal.²¹ As regards our measurements of athletes in young adulthood, we may have lacked the

statistical power to detect possible effects operating between BMI, weight satisfaction, and a desire to lose or gain weight, due to the small numbers of underweight and overweight athletes.

In the current study, athletes tended to exhibit a smaller tendency to lose weight and to be more satisfied with their weight than non-athletes in the same weight group. We did not measure body composition, but it can be speculated that athletes had more lean mass than non-athletes, and that this could affect body satisfaction and the desire to lose weight.

Some normal weight participants showed a desire to lose weight, both in adolescence and in young adulthood. In fact, it has been demonstrated that many underweight and normal weight females misclassify themselves as overweight, and that some weight loss efforts among women result from body image problems, rather than any actual need to lose weight.⁴² This might have been the case among some of our participants also. It is known that some elite female athletes try to lose weight in order to improve their performance, or to meet the 'ideal' body weight and composition of an athlete.²³ In the present study, at both time-points, about one fifth of the athletes and about 40% of the non-athletes experienced body weight dissatisfaction. Since it is known that body weight dissatisfaction is a risk factor for disordered eating,²⁰ it would be important to pay attention to young people who are dissatisfied with their weight.

Athletes reporting MD and eumenorrheic athletes

Some, but not all studies have shown that amenorrheic athletes have lower BMI than their eumenorrheic peers.^{27,28,43} This was the case also in the current study, where the adolescent athletes reporting MD had lower BMI than the eumenorrheic athletes. Nevertheless, the average BMI in our MD group remained within the normal limits. Furthermore, in young adulthood, no difference in BMI between the athletes with MD and eumenorrheic athletes was seen. Low BMI does not in itself seem to cause MD; however, it may be an indication of low EA, bearing in mind that low EA has been shown to be the reason for MD in the Female Athlete Triad/RED-S, as opposed to low BMI or low body fat.⁴⁴

To our knowledge, this is the first study to compare objectively measured physical activity levels in eumenorrheic athletes and athletes with MD. Torstveit and Sundgot-Borgen⁴ found that self-reported training volume was not associated with MD in elite athletes in multiple sports

disciplines, which is in accordance with the results of the present study regarding adolescence. In addition, in the study conducted by Tornberg et al.,²⁶ there was no difference in aerobic training volume between amenorrheic and eumenorrheic athletes even though amenorrheic athletes performed more resistance training. However, Henriksson et al.²⁵ found that endurance runners with MD had more training hours per week than eumenorrheic runners. In the present study, young adult athletes with MD had more MVPA than eumenorrheic athletes and their step count was greater – this despite the fact that there was no difference between the groups in self-reported training hours. Previous studies have indicated that training volume *per se* does not cause MD, but that vigorous and regular exercise increases energy expenditure. Furthermore, increased energy expenditure could lead to low EA, and consequently to MD.⁴⁴ It is possible that this was also the case among our MD participants. We did not ask the participants about their attitudes towards eating, so we cannot know if the possible low EA resulted from DE or ED. Future studies should investigate whether the association between MD and objectively measured physical activity can be replicated with larger samples.

We did not find a difference in MD prevalence between different sports categories, which is contrary to some^{4,5} but not all⁹ previous findings. However, the statistical power of this analysis was low due to the small number of participants in different sports groups.

Longitudinal analysis

Relatively few studies have investigated the factors predicting MD in athletes. To et al.⁴⁵ conducted a prospective study in Chinese collegiate dance students and found that a decline in BMI or body fat did not explain MD in a year-long follow-up. Wiksten-Almströmer et al.⁴⁶ studied women diagnosed with MD in adolescence and found that MD was still present in 62% of subjects not using hormonal contraceptives after six years of follow-up. The only significant factor predicting resumption of regular menses was previous eating disorder (anorexia nervosa). Those who were anorexic in adolescence had the highest rate of resumption of regular menses. In our study, the only variable predicting MD in young adulthood was MD in adolescence. Further research is needed to confirm these results. However, it is important to pay attention to adolescents with MD to prevent future problems in health and/or performance.

Limitations

There are some limitations in the current study. We investigated MD on the basis of self-reported data, without additional laboratory measurements. The possible other causes for MD, such as polycystic ovary syndrome (PCOS), pregnancy, or thyroid disorders were not recorded in a structured way in our study. In addition, the range of menstrual cycles in adolescence is wider than in adulthood,³¹ complicating interpretation of the data regarding MD in adolescence. Participants were asked if they had had MD only within the preceding 12 months; hence there is a possibility that the participants had experienced secondary amenorrhea or oligomenorrhea at a previous time in their life. Furthermore, we did not measure body composition or ask about weight fluctuation. It was thus not possible to determine whether there was an association between body fat percentage and weight satisfaction, regardless of BMI. Moreover, we did not obtain data on whether a participant had recently lost or gained weight. Nor did we ask about eating disorders or assess energy intake. Finally, there is a possibility of recall bias in the reports at each time point.

Perspective

While previous studies have shown that MD is a common problem in elite and high school athletes in many countries,^{4-14,38} the findings of the present study indicate that young Finnish athletes, too, exhibit fairly high levels of MD. Our results also suggest that young female athletes may be more satisfied with their weight than their non-athletic peers. This is consistent with an earlier meta-analysis,⁴⁰ which showed that athletes had a more positive body image than non-athletes. The present study also found that young adult athletes reporting MD performed more physical activity than eumenorrheic athletes – a finding contrary to most of the previous studies investigating training volumes or exercise energy expenditure.^{4,26-28} Furthermore, it has been shown that efforts to lose weight are not necessarily related to any actual need for weight loss,⁴² as body image problems are common among young females.^{21,22} In the current study, weight dissatisfaction was seen among both athletes and non-athletes. Thus, irrespective of one's status as an athlete or non-athlete, it would be important to support young people who are dissatisfied with their weight, in order to identify or forestall disordered eating, which can result from body weight dissatisfaction.¹⁷ Finally, we found that the only factor predicting MD in young adulthood was MD in adolescence. This finding highlights the importance of identifying athletes with MD as early as possible. Increasing knowledge on the high prevalence of MD as well as body weight

dissatisfaction seen in young females is important to prevent future health problems related to MD and disordered eating and to decrease the stigma surrounding these issues.

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Table 1. Characteristics of the cohort of the athletes and non-athletes in adolescence and in young adulthood.

	Adolescence (14–16 years)					Young adulthood (18–20 years)				
	n	Athletes	n	Non-athletes	p-value	n	Athletes	n	Non-athletes	p-value
Chronological age, y	178	14.9 (0.6)	105	15.0 (0.4)	0.43	52	18.8 (0.7)	159	18.9 (0.7)	0.71
Gynaecological age, y	165	2.4 (1.2)	104	2.8 (1.1)	0.002	50	5.9 (1.6)	159	6.3 (1.4)	0.06
Age at menarche, y	165	12.7 (1.1)	104	12.2 (1.1)	0.001	50	12.9 (1.5)	159	12.5 (1.3)	0.16
Height, cm	178	166.2 (6.0)	105	165.7 (6.4)	0.45	52	168.7 (6.9)	158	167.3 (6.4)	0.19
Weight, kg	178	57.9 (7.6)	105	59.9 (9.7)	0.08	52	63.1 (8.0)	158	65.5 (11.4)	0.13
BMI, kg/m ²	178	20.9 (2.2)	105	21.8(3.1)	0.01	52	22.2 (2.4)	158	23.4 (3.9)	0.06
MVPA per day, h:mm	164	1:19 (0:28)	87	0:59 (0:23)	<0.001	39	1:21 (0:38)	130	0:54 (0:30)	<0.001
Daily step count	164	9310 (2816)	87	7674 (2535)	<0.001	39	10117 (4273)	130	7236 (3179)	<0.001
Current MD	141	17.7% (25)	80	17.5% (14)	0.97	31	38.7% (12)	71	5.6% (4)	<0.001
Current/previous primary amenorrhea	172	8.1% (14)	102	0.0% (0)	0.003	50	12.0% (6)	159	7.5% (12)	0.39
Current primary amenorrhea	172	4.7% (8)	102	0.0% (0)	0.03	50	0.0% (0)	159	0.0% (0)	-
Menarche occurred	178	92.7% (165)	104	100.0% (104)	0.003	52	100.0% (52)	159	100.0% (159)	-
Hormonal contraceptive users	178	5.1% (9)	105	17.1% (18)	0.001	51	40.4% (21)	157	49.7% (79)	0.24
Satisfied with weight	174	81.6% (142)	104	55.8% (58)	<0.001	51	76.5% (39)	157	62.4% (98)	0.07
Desire to lose weight	171	19.3% (33)	103	43.7% (45)	<0.001	51	29.4% (15)	155	46.5% (72)	0.03
Desire to gain weight	172	14.0% (24)	100	4.0% (4)	0.009	48	2.1% (1)	148	5.3% (8)	0.69

Sports category	178	-	-	52	-	-
<i>Endurance</i>	29.8% (53)	-	-	42.3% (22)	-	-
<i>Aesthetic</i>	33.7% (60)	-	-	23.1% (12)	-	-
<i>Technical</i>	2.8% (5)	-	-	0.0% (0)	-	-
<i>Ball games</i>	23.6% (42)	-	-	19.2% (10)	-	-
<i>Power/anti-gravitation</i>	10.1% (18)	-	-	15.4% (8)	-	-

The data are presented as means (standard deviations) or percentages (counts).

Table 2. Characteristics of the athlete cohort divided into menstrual dysfunction (MD) and eumenorrhea groups, in adolescence and in young adulthood.

	Adolescence (14–16 years)					Young adulthood (18–20 years)				
	n	MD [†]	n	Eumenorrhea	p-value	n	MD	n	Eumenorrhea	p-value
Chronological age, y	31	15.2 (0.5)	116	15.0 (0.6)	0.11	12	18.5 (0.5)	19	18.8 (0.8)	0.22
Gynaecological age, y	23	2.0 (1.2)	116	2.6 (1.0)	0.04	12	5.5 (1.6)	18	6.1 (1.0)	0.21
Age at menarche, y	23	13.3 (1.4)	116	12.5 (1.0)	0.008	12	13.0 (1.5)	18	12.7 (0.9)	0.61
Height, cm	31	167.8 (5.9)	116	166.2 (6.1)	0.19	12	169.8 (9.6)	19	169.0 (6.8)	0.71
Weight, kg	31	56.8 (7.4)	116	59.4 (7.5)	0.08	12	65.1 (10.2)	19	64.5 (8.3)	0.64

BMI, kg/m ²	31	20.1 (2.0)	116	21.5 (2.2)	0.002	12	22.6 (3.3)	19	22.6 (2.5)	0.99
MVPA per day, h:mm	26	1:17 (0:30)	107	1:18 (0:26)	0.91	9	1:37 (0:22)	14	0:57 (0:26)	0.001
Daily step count	26	8869 (2825)	107	9168 (2713)	0.62	9	12172 (2980)	14	7326 (2287)	<0.001
Self-reported weekly training hours in the training season	27	8.9 (3.5)	113	10.5 (4.3)	0.04	12	12.7 (4.6)	19	10.9 (4.3)	0.29
Self-reported weekly training hours in the competition season	27	9.0 (3.3)	113	10.6 (5.1)	0.10	12	11.3 (4.6)	19	10.1 (4.4)	0.82
Self-reported weekly rest days in the training season	27	1.9 (0.8)	112	1.8 (0.9)	0.53	12	1.5 (0.7)	19	1.5 (0.9)	0.82
Self-reported weekly rest days the in the competition season	27	1.9 (0.8)	112	1.6 (0.8)	0.06	12	1.5 (0.7)	19	1.6 (0.7)	0.89
Satisfied with weight	30	80.0% (24)	112	81.3% (91)	1.00	12	75.0% (9)	19	78.9% (15)	1.00
Desire to lose weight	30	13.3% (4)	109	20.2% (22)	0.34	12	33.3% (4)	19	26.3% (5)	0.70
Desire to gain weight	30	10.0% (3)	112	13.4% (15)	0.76	11	0.0% (0)	18	0.0% (0)	-
Sports category	31		116		0.674	12		19		0.300
<i>Endurance</i>		25.0% (10)		75.0% (30)			30.8% (4)		69.2% (9)	
<i>Aesthetic</i>		16.7% (9)		83.3% (45)			28.6% (2)		71.4% (5)	
<i>Technical</i>		0.0% (0)		100.0% (3)			0.0% (0)		0.0% (0)	

<i>Ball games</i>	27.0% (10)	73.0% (27)	71.4% (5)	28.6% (2)
<i>Power/anti-gravitation</i>	15.4% (2)	84.6% (11)	25.0% (1)	75.0% (3)

The data are presented as means (standard deviations) or percentages (counts). † Current MD ($n=25$) or history of primary amenorrhea within the preceding year ($n=6$).

Figure legends:

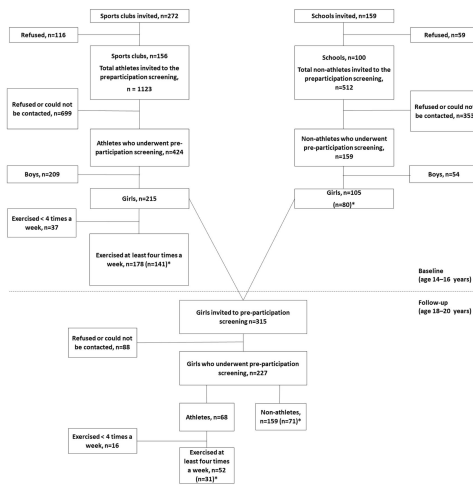
Figure 1. Data collection and final study groups.

* Number of girls who did not use hormonal contraceptives and who answered the questions regarding menstruation in such a way that it was possible to determine their menstrual status. Only these girls were included in the MD analysis.

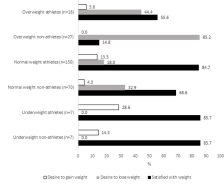
Five of the girls participating in the study in adolescence were not invited to the follow-up, as they did not want to be re-contacted.

Figure 2. Attitudes towards body weight by weight groups among athletes and non-athletes in adolescence (14–16 years of age). Bars indicate the percentages of the participants who had a desire to gain or lose weight, or who were satisfied with their weight. The sum of the percentages may deviate from 100, as the participants responded to each item separately. Some reported satisfaction with their weight, but still indicated a desire to lose or gain weight.

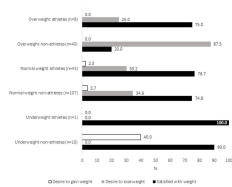
Figure 3. Attitudes towards body weight by weight groups among athletes and non-athletes in young adulthood (18–20 years of age). Bars indicate the percentages of the participants who had a desire to gain or lose weight, or who were satisfied with their weight. The sum of percentages may deviate from 100, as the participants responded to each item separately. Some reported satisfaction with their weight, but still indicated a desire to lose or gain weight.



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