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Eating behaviours, menstrual history and the athletic career: a retrospective survey from adolescence to adulthood in female endurance athletes

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ABSTRACT

Aim To evaluate differences in menstrual and pubertal history and trends in eating behaviours among women with and without a competitive sports background. Additionally, we investigated if menstrual history and eating behaviours are associated with sports career-related factors.

Methods This retrospective study was conducted on 100 women with a competitive endurance sports background and their age-matched, gender-matched and municipality-matched controls (n=98). Data were collected using a questionnaire using previously validated instruments. Generalised estimating equations were used to calculate associations of menstrual history and eating behaviours with outcome variables (career length, participation level, injury-related harms and career termination due to injury).

Results Athletes reported higher rates of delayed puberty and menstrual dysfunction than controls. No differences between the groups were observed in the Eating Disorder Examination Questionnaire short form (EDE-QS) scores at any age. Previous disordered eating (DE) was associated with current DE in both groups. Among athletes, higher EDE-QS scores during the sports career were associated with a shorter career (B=−0.15, 95% CI −0.26 to −0.05). Secondary amenorrhoea was associated with lower participation level (OR 0.51, 95% CI 0.27 to 0.95), injury-related harms during the career (OR 4.00, 95% CI 1.88 to 8.48) and career termination due to injury (OR 1.89, 95% CI 1.02 to 3.51).

Conclusion The findings indicate that DE behaviours and menstrual dysfunction, specifically secondary amenorrhoea, have a disadvantageous relationship with a sports career in women competing in endurance sports. DE during the sports career is associated with DE after the career.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Disordered eating behaviours and menstrual dysfunction are commonly observed in female endurance sports athletes.

⇒ Associations of disordered eating behaviours and menstrual function with sports career-related factors, such as length, success and injuries during the career, remain understudied.

⇒ Whether athletes with disordered eating behaviour during their sports career present with disordered eating after their career remains unknown.

WHAT THIS STUDY ADDS

⇒ Among women with a competitive sports background and a mean age of 40, higher scores on the Eating Disorder Examination Questionnaire short form during the sports career were associated with a shorter sports career.

⇒ Secondary amenorrhoea during the sports career was associated with lower participation level, injury-related harms and sports career termination due to injury.

⇒ Athletes with disordered eating during their career were more likely to report disordered eating also after their career than were athletes who did not report disordered eating during their career.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Female athletes and those working with them should acknowledge that disturbances in eating behaviours and in the menstrual cycle could have a harmful relationship on an athletic career.

INTRODUCTION

Participation in sports during adolescence is associated with mental,[1] metabolic[2] and bone[3] health benefits later in life. Nevertheless, sports-related musculoskeletal injuries are common in athletes.[4] While many of these injuries heal completely and cause no later health problems, some may induce pain and functional limitations in later life.[4–6]

Some sports-related factors are associated with a heightened risk for disordered eating (DE) behaviours. Athletes can experience pressures to have a certain body weight or composition, and thus, restrict their eating or engage in other unhealthy eating behaviours

used to control weight.[7] DE can result in low energy availability (LEA), that is, insufficient energy intake in relation to exercise energy expenditure. LEA, in turn, may lead to several health and performance issues in women, including menstrual dysfunction, impaired bone health, injuries and decreased performance.[8 9] LEA, however, can also present without DE.[9] Young athletes may be especially vulnerable to interruptions in their menstrual cycle if their energy availability is insufficient.[10] LEA may also contribute to delayed puberty or primary amenorrhoea.[9] However, the long-term consequences of LEA/DE and menstrual dysfunction in young female athletes remain poorly explored.

Findings regarding the prevalence of subclinical DE behaviours and clinical eating disorders (ED) in athletes and non-athletes are inconsistent.[11–14] The risk of DE/ED seems to be higher among lean sports (ie, sports where weight and/or leanness are considered important) than among non-lean sports athletes.[11] Whether individuals with a competitive (lean) sports background differ from their non-athletic peers after the sports career regarding DE behaviours remains unreported.

This study aimed to compare menstrual and pubertal history and trends in eating behaviours between women with a competitive sports background and their non-athletic peers. The second aim was to investigate associations of menstrual history and eating behaviours during the sports career with career length, participation level, sports injury-related harms and career termination due to sports injury in women who had engaged in competitive endurance sports in their adolescence.

MATERIALS AND METHODS

This is an observational study with retrospectively collected questionnaire data.

Participants

Inclusion criteria for athletes were as follows: (1) placement among the top 30 in cross-country running national championships in the division for girls aged 16 or 17 between the years 1990–2005 or (2) placement among the top 10 in adolescents' track and field national championships in 2000 metre running in the division for girls aged 14 or 15 between the years 1992–2003. Athletes' names and dates of birth were collected from the result lists, and their addresses were drawn from the population registry. Two controls, matched for sex, age and municipality, were randomly selected for each available athlete from the general population. The final number of invited athletes and controls were 270 and 551, respectively. Controls who reported a history of competing in sports were excluded from the analyses. The flow chart of the recruitment process is presented in figure 1.

Data collection

Questionnaire data were collected using the Webropol V.3.0 Online Survey and reporting tool (Webropol Oy 2022, Helsinki, Finland) between May 2022 and July 2022. The research team developed the questionnaire. It consisted of questions on demographics, menstrual and pubertal history and eating behaviours at different age stages along with sports career and injuries (only athletes). Questions from previously validated questionnaires[15 16] concerning eating behaviours and menstrual function, along with other previously used questions,[17–19] were included in the questionnaire. Current and previous DE behaviours were assessed using the Eating Disorder Examination Questionnaire (EDE-Q) short form (EDE-QS), which is a 12-item version of the 28-item EDE-Q[20] and has demonstrated high internal consistency (Cronbach's alpha=0.913) and convergent validity with the EDE-Q both among people with (r=0.91) and without (r=0.82) an ED.[15] EDE-QS captures respondents' DE behaviours and perceptions, such as unhealthy weight management behaviours (eg, dietary restriction or vomiting), lack of control while eating and body weight and shape dissatisfaction on a 4-point scale. Total scores of the EDE-QS range from 0 to 36, with higher scores indicating more unhealthy attitudes toward eating and body image. In this study, the participants were asked to complete the EDE-QS several times and to recall their thinking at different age periods, that is, at ages 13–15, 16–18, 19–21, 22–25 and at present. EDE-QS scores were calculated for each age period. A score of ≥15 was used as a cut-off for DE behaviour.[21] The Cronbach's alphas in this study among athletes and controls at different ages varied between 0.91 and 0.94.

Participants were also asked if they were ever diagnosed with an ED by a medical doctor. In the case of an ED, participants provided the exact diagnosis and year of diagnosis.

Questions concerning menarche and menstrual history were developed by modifying the Low Energy Availability in Females Questionnaire.[16] Athletes reported on their menstrual cycle length and regularity during their sports career, while controls were asked to answer the menstrual cycle-related questions throughout their whole life. Participants were assigned to the secondary amenorrhoea group if they reported missing periods for at least three consecutive months for any reason other than pregnancy or hormonal contraceptive use.[22] For primary amenorrhoea, age at menarche ≥16 years was used as a criterion because this criterion was effective when study participants were adolescents.[9 23] Participants were also asked if they were examined by a medical doctor or other medical personnel due to delayed puberty.

The effect of injuries and/or pain on the sports career (ie, injury-related harms) was assessed by asking the athletes if injury or musculoskeletal pain hindered their sports career. The response options were as follows: (1) not at all or very little: I usually did not have to skip competitions or pause normal training because of injury or pain, (2) somewhat: I sometimes had to skip competitions and/or pause normal training because of injury or pain, (3) quite a lot: I regularly had to skip competitions and/or pause normal training for a long time because

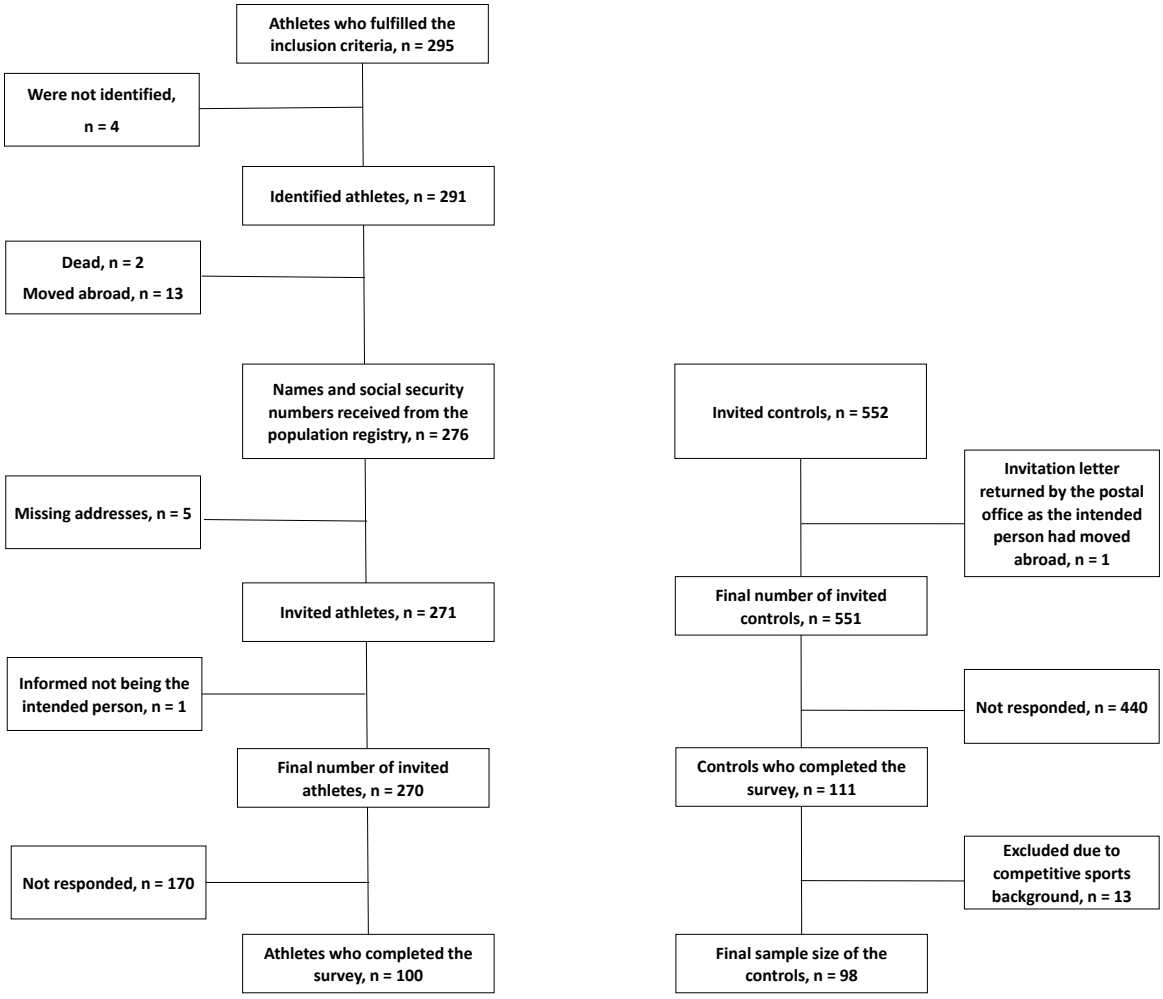

Figure 1 Flow chart of the recruitment process.

of injury or pain and (4) significant amount: I often had to skip competitions and pause training for a long time because of injury or pain. Athletes were classified into two groups based on their responses (response options 1 and 2 vs response options 3 and 4).

Retired athletes were asked if any specific injury or several injuries impacted their decision to terminate their sports career at a level they had practised and actively competed in.[17] Response options were: (1) not at all, (2) an injury or several injuries contributed to sports career termination and (3) an injury or several injuries was/were the main cause for terminating the sports career. Response options 2 or 3 were combined for analyses.

Athletes also reported if an acute or overuse injury impacted their decision to terminate their sports career. An acute injury was defined as an injury that occurs suddenly or accidentally, interrupting training or ability to compete or causing an identifiable trauma. An overuse injury was defined as an injury that causes worsening pain during or after exercise without any noticeable external cause of injury.[17] In addition, athletes provided information on the type of career-ending injury/injuries, which were then categorised by tissue, as suggested by Bahr *et al*.[24] Athletes were also asked when they started goal-oriented training (at least twice weekly) in their sports and ended their sports career at the highest level they had competed in.[17] Career length for each participant was calculated by subtracting the starting age from the age at career termination or the current age if an athlete was still active.

Athletes reported the highest level they had competed at and were grouped into national and international level athletes (Tiers 3 and 4), as recently recommended by McKay and colleagues.[25] One athlete reported that her highest competition level had been at the regional/district level, and she was combined with the national-level athletes in the analysis.

Statistical analyses

Descriptive statistics are presented as means with SD and counts with percentages. Differences between the athletes and the controls were analysed with a t-test (normal distribution) and Mann-Whitney U test (skewed distribution) or χ^2 test in case of categorical variables. Longitudinal

analyses for the EDE-QS scores were performed using Friedman's analysis of variance with post hoc pairwise comparisons. Associations between menstrual history, EDE-QS scores and sports career-related outcomes were tested using generalised estimating equations (GEE). The models used primary amenorrhoea, secondary amenorrhoea, EDE-QS scores and age phase, that is, time, as independent variables. Missing data were not imputed. In the primary analysis, only EDE-QS scores at the ages of each individual's sports career were considered. As 75% of the athletes had terminated their sports career by the age of 23, only ages 13–15, 16–18 and 19–21 were included in the models. The secondary analysis used EDE-QS scores at ages 13–15, 16–18 and 19–21 from all athletes.

Statistical analyses were conducted with IBM SPSS Statistics V.26 (Armonk, New York, USA) and R Project for Statistical Computing V.4.0.2 (Vienna, Austria). The significance level was set at <0.05.

Patient and public involvement

The questionnaire was piloted among former athletes and non-athletes before data collection, and small changes to the questionnaire were made based on their feedback.

RESULTS

Response rate and characteristics of the participants

One hundred athletes (response rate 37.0%) and 111 controls (response rate 20.1%) completed the questionnaire. Thirteen controls had participated in competitive sports and were excluded. Thus, the final control group included 98 women. The groups were similar in age (mean 39.6±4.5 years and 39.4±4.5 years in athletes and controls, respectively, p=0.801).

Table 1 Characteristics of the athletes (n=100)

First sports discipline, n (%)	
Distance running	64 (64)
Track and field (middle-distance and long-distance running)	16 (16)
Cross-country skiing	12 (12)
Other (orienteering, swimming, gymnastic, Finnish baseball)	8 (8)
Retired from sports, n (%)	94 (94)
Career length (years), mean±SD*	12.0±5.8
Highest competition level, n (%)†	
International (Tier 4)	34 (34)
National (Tier 3)	65 (65)
Local (Tier 2)	1 (1)
High amount of injury-related harm during the sports career, n (%)	16 (16)
Sports career termination due to injury, n (%)*	42 (44.7)

*Only retired athletes, n=94
†Tiers, as suggested by McKay *et al*[24] are used when classifying athletes.

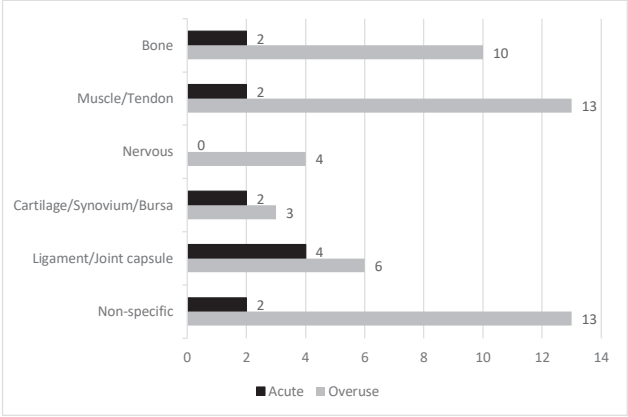

Figure 2 Types of career-ending injuries reported by the athletes. The counts present the number of injured athletes.

Characteristics of the athletes are presented in table 1. All track and field athletes had participated in middle-distance and long-distance running, and one had also competed in jumping disciplines. Participants who reported commencing their sports career in gymnastics or Finnish baseball had later changed to endurance sports.

Of the 42 athletes who had terminated their career due to injury, 10 (23.8%) reported that an acute injury contributed to their retirement. In contrast, 34 (81.0%) reported that an overuse injury impacted their career termination. Two athletes reported both acute and overuse injuries that contributed to career termination. Twenty (47.6%) athletes who had terminated their career due to injury were able to identify one single contributing injury (or bilateral injury). The remaining 22 (52.4%) athletes reported several injuries that affected career termination. Figure 2 presents the number of athletes with career-ending injuries by injured tissue and type of injury (acute/overuse). Secondary amenorrhoea was present in 5 of the 9 athletes (56%) who reported bone stress-related career-ending injuries and 7 of the 21 athletes (33%) who reported other career-ending injuries (p=0.418).

Menstrual and pubertal history and DE behaviours

Menstrual and pubertal history, ED diagnoses and EDE-QS scores at different age stages among the athletes and the controls are presented in table 2. Athletes were older at menarche, achieved regular menstruation later and had higher rates of primary and secondary amenorrhoea. No statistically significant differences between the groups were found in ED diagnoses or EDE-QS scores at any age stage.

Changes in EDE-QS scores over time in both athletes (χ^2 (4) = 24.7, p<0.001) and controls (χ^2 (4) = 9.8, p=0.044) were statistically significant. Post hoc analyses are presented in table 3. Trends in EDE-QS scores over

Table 2 Menstrual and pubertal history and trends in eating behaviours among the athletes and the controls

	Athletes (n=100)	Controls (n=98)	P value
Age at menarche (years), mean±SD	14.0±2.0	12.5 ± 1.2[a]	**<0.001‡**
Age at attaining regular menses (years), mean±SD	16.0±3.7[b]	14.7±2.9[b]	**0.005‡**
Primary amenorrhoea, n (%)	20 (20.0)	2 (2.0)	**<0.001‡**
Spontaneous menarche*, n (%)	93 (93.0)	98 (100.0)	**0.014‡**
Examined due to delayed puberty, n (%)	13 (13.0)	2 (2.0)	**<0.001‡**
Secondary amenorrhoea, n (%)†	31 (34.1)[c]	20 (20.4)	**0.035‡**
Regular menses always/nearly always, n (%)†	50 (54.3)[d]	72 (78.3)[d]	**<0.001‡**
Cycle length 21–35 days, n (%)†	55 (64.7)[e]	81 (89.0)[c]	**<0.001‡**
Eating disorder diagnosis, n (%)	7 (7.1)[f]	8 (8.4)[g]	0.740
EDE-QS, mean±SD			
Age 13–15	6.3±7.3	6.4±7.4	0.943
Age 16–18	8.4±7.9	7.3±7.7	0.340
Age 19–21	8.0 ± 8.0[h]	7.4±7.8	0.589
Age 22–25	7.2±7.4[i]	7.5±7.8	0.737
Currently	5.6±6.4	6.0 (6.2)	0.697
EDE-QS≥15, n (%)			
Age 13–15	16 (16.0)	15 (15.3)	0.893
Age 16–18	20 (20.0)	18 (18.4)	0.771
Age 19–21	19 (19.8)[h]	15 (15.3)	0.411
Age 22–25	17 (18.9)[i]	13 (13.3)	0.293
Currently	12 (12.0)	10 (10.2)	0.688

[a] n=97; [b] n=82; [c] n=91; [d] n=92; [e] = 85; [f] n=98; [g] n=95; [h] n=96; [i] n=90.
*Menarche had occurred spontaneously, that is, without any treatments.
†During the sports career (athletes) or ever (controls).
‡p<0.05
EDE-QS, the Eating Disorder Examination Questionnaire short form scores.

Table 3 Post hoc analyses of EDE-QS scores at different age stages among athletes and controls

	Athletes (n=100)		Controls (n=98)	
Age group comparisons	P value	Adjusted p value*	P value	Adjusted p value*
13–15 vs 16–18	**<0.001†**	**0.002†**	0.090	0.903
13–15 vs 19–21	**0.004†**	**0.040†**	0.119	1.00
13–15 vs 22–25	0.109	1.00	**0.013†**	0.130
13–15 vs currently	0.832	1.00	0.718	1.00
16–18 vs 19–21	0.423	1.00	0.892	1.00
16–18 vs 22–25	**0.038†**	0.381	0.429	1.00
16–18 vs currently	**0.001†**	**0.005†**	0.183	1.00
19–21 vs 22–25	0.203	1.00	0.354	1.00
19–21 vs currently	**0.008†**	0.077	0.231	1.00
22–25 vs currently	0.164	1.00	**0.034†**	0.337

*Adjusted for the Bonferroni correction for multiple tests.
†p<0.05

time were more stable among controls than among athletes (figure 3).

Nineteen (19%) of the athletes reported DE during their careers (ie, had EDE-QS scores of 15 or more), and 17 (89%) of them had ended their careers. Current DE was reported by 35% (n=6) of the retired athletes with DE during their career compared with 8% (n=6) of the retired athletes without DE during their sports career (p=0.003). Twenty-one (21%) controls reported DE during their adolescence or young adulthood (between ages 13 and 21), and current DE was reported by 43% (n=9) of them compared with one (1%) control with current DE but without DE at adolescence/young adulthood (p<0.001).

Associations of menstrual history and history of DE behaviours with a sports career

No differences were found between athletes with and without primary or secondary amenorrhoea in sports career length or participation level or between those with and without DE at ages 13–15, 16–18 or 19–21 in participation level. Athletes with DE at age 16–18 had a shorter

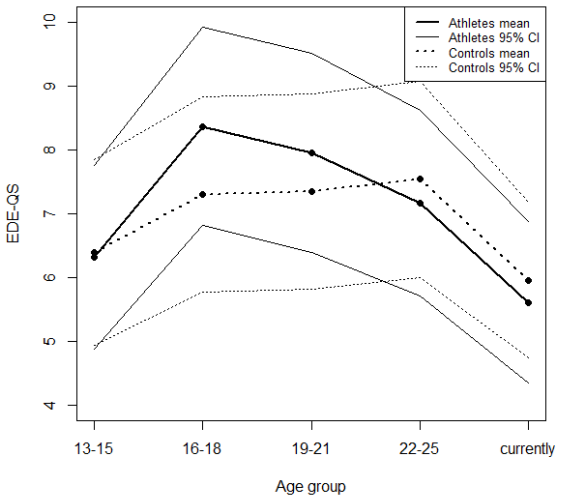

Figure 3 Eating Disorder Examination Questionnaire short form (EDE-QS) scores over time among athletes and controls.

career than those without DE at that age (10.5 years vs 14.0 years, p=0.020), while no differences in career length were found between those with and without DE at ages 13–15 and 19–21.

The GEE models for the associations of menstrual history and eating behaviours during the sports career with sports career-related factors among athletes are presented in table 4. EDE-QS scores were associated with sports career length, with one point in the EDE-QS score being associated with a 0.15-year shorter career. Those reporting secondary amenorrhoea during their sports career had 0.5 times lower odds of being competed at the international level (vs national level), 4.0 times higher odds of reporting that injuries/pain negatively affected their sports career and 1.9 times higher odds of reporting that an injury had affected their sports career termination. The secondary analysis, where EDE-QS scores at ages 13–15, 16–18 and 19–21 from all athletes were used, is presented in online supplemental file 1.

Table 4 Associations of menstrual history and eating behaviours during the sports career with career length, participation level, injury-related harms during the career and career termination due to injury

Sports career length (n=100)			
	B	95% CI	P value
Primary amenorrhoea	2.28	−0.55 to 5.11	0.115
Secondary amenorrhoea	−0.16	−2.05 to 1.72	0.864
EDE-QS	**−0.15**	**−0.26 to −0.05**	**0.003***
Time (age 16–18 vs age 13–15)	0.63	−1.47 to 2.73	0.555
Time (age 19–21 vs age 13–15)	**3.01**	**0.64 to 5.38**	**0.013***
Participation level (international vs national) (n=100)			
	OR	95% CI	P value
Primary amenorrhoea	1.09	0.54 to 2.21	0.808
Secondary amenorrhoea	**0.51**	**0.27 to 0.95**	**0.033***
EDE-QS	0.99	0.95 to 1.03	0.544
Time (age 16–18 vs age 13–15)	0.06	0.56 to 2.00	0.086
Time (age 19–21 vs age 13–15)	1.74	0.87 to 3.49	0.117
Injury-related harms during the sports career (n=100)			
	OR	95% CI	P value
Primary amenorrhoea	1.22	0.53 to 2.81	0.639
Secondary amenorrhoea	**4.00**	**1.88 to 8.48**	**<0.001***
EDE-QS	0.97	0.93 to 1.01	0.187
Time (age 16–18 vs age 13–15)	1.14	0.49 to 2.66	0.758
Time (age 19–21 vs age 13–15)	1.40	0.57 to 3.47	0.461
Sports career termination due to injury (n=94)			
	OR	95% CI	P value
Primary amenorrhoea	0.61	0.30 to 1.23	0.168
Secondary amenorrhoea	**1.89**	**1.02 to 3.51**	**0.045***
EDE-QS	1.01	0.97 to 1.05	0.598
Time (age 16–18 vs age 13–15)	0.90	0.48 to 1.69	0.747
Time (age 19–21 vs age 13–15)	1.16	0.57 to 2.37	0.683

*p<0.05
EDE-QS, the Eating Disorder Examination Questionnaire short form scores.

DISCUSSION

We found no statistically significant differences in eating behaviours between the athletes and the controls, but menstrual dysfunction and delayed puberty were more common among the athletes. Among the athletes, current EDE-QS scores were lower than earlier in life, indicating a healthier attitude toward eating and body image in adulthood than in adolescence. In contrast, among the controls, trends in EDE-QS scores over time were more stable. DE behaviour earlier in life was associated with current DE in both groups. Higher EDE-QS scores, that is, more unhealthy attitudes toward eating and body image during the sports career, were associated with a shorter career. In addition, secondary amenorrhoea during the career was associated with lower participation level, higher rates of injury-related harms and a higher likelihood of career termination due to injury.

Menstrual history and attitudes toward eating

The athletes had higher age at menarche, higher rates of delayed puberty and menstrual dysfunction and less

spontaneously occurring menarche than controls, which agrees with other studies.[13 26 27] While the mechanisms behind these associations are incompletely understood, they may be related to intensive exercise and/or LEA in athletes, which leads to decreased leptin concentrations and alterations in other peptides. This may result in disturbances in gonadotrophin-releasing hormone secretion, which further suppresses the function of the hypothalamus-pituitary-gonadal axis.[28 29]

Evidence regarding the difference in the prevalence of eating problems between athletes and non-athletes is inconclusive. A meta-analysis conducted in 2000 found that DE was more common in athletes than non-athletes, but the effect size was small.[14] In a recent meta-analysis, no differences were found in ED psychopathology between athletes and non-athletes.[12] This parallels our findings of no statistically significant differences in DE or ED between the groups. However, our athletes were lean sport athletes, among whom eating problems are thought to be more common than in non-lean sports.[12 30] The lifetime prevalence of clinical ED diagnoses in our athletes was 7.1%, lower than in our previous cross-sectional study conducted in a mixed-sport sample of Finnish athletes (18.4%).[31] The detection of EDs has improved over time,[32] which might explain the differences between the findings.

Although no differences in the EDE-QS scores between athletes and controls were found, the trends of the scores differed between the groups. Among athletes, EDE-QS scores increased significantly after the age of 13–15, while controls' scores remained more constant over time. This could be related to sports-specific pressures of controlling body weight or composition, which can lead to DE.[7] In addition, some personality traits, especially perfectionism, may increase the likelihood of both competitive environments and DE.[7 33] ED incidence generally peaks in adolescence and young adulthood.[34] In line with this, EDE-QS scores were higher in adolescence than currently also in our athletes.

A history of DE was associated with current DE among athletes and controls. While several studies have investigated DE in athletes, few studies have focused on former athletes. Oltmans and colleagues[35] found that at the baseline of their prospective study, 28% of the former elite Dutch athletes presented with DE. In another study,[36] 5.8% of former collegiate athletes reported DE. In our study, the prevalence of present DE was 12%, which falls between previously reported prevalence rates.

Associations of menstrual history and DE with a sports career

A 10-point increase in the EDE-QS score was associated with a 1.5-year shorter sports career. We are unaware of other studies investigating the association between career length and DE, and prospective studies are needed to confirm our findings. One possible mechanism behind this relationship is decreased bone mineral density (BMD) associated with DE.[8 9] Low BMD may be a risk factor for bone stress injuries, which in turn may cause long time loss from training and thus predispose to career termination. However, as the present study did not find an association of EDE-QS scores with either injury-related harms during the sports career or career termination due to injury, a possible explanation for the association between higher EDE-QS scores and shorter career length may be related to other factors than injuries. Further research with a prospective design is also needed to investigate the relationship between participation level and menstrual dysfunction, as we cannot demonstrate causality with our retrospective study design.

Secondary amenorrhoea during the sports career was associated with both injuries/pain during the sports career and career termination due to injury. These results support and extend the findings of Rauh and colleagues,[37] who found that menstrual dysfunction was associated with running-related injuries among female runners in a model adjusted for bone mineral density less than −2 SDs. Menstrual dysfunction may also be associated with a longer healing time for injuries.[31 38] The mechanism behind these associations is unclear but might be related to LEA, which increases the risk for menstrual dysfunction, poor bone quality and injuries.[8] However, not all studies have found an association between menstrual dysfunction and injuries[39–41] and thus, further studies are needed to confirm the findings.

STRENGTHS AND LIMITATIONS

Our study is the first to investigate trends over time in eating behaviours among athletes compared with controls and the first to assess the associations of menstrual history and eating behaviours with sports career length, participation level and athletic retirement due to injury among adult women with a competitive sports background. Moreover, as we recruited athletes who had succeeded in their adolescence, our sample included those who had terminated their sports careers early.

The greatest limitation of our study is that recall bias may exist because participants were asked to respond based on their memory. Athletes may recall their menstrual cycle-related attributes better than controls, at least in case of delayed puberty and/or absence of menstruation. Sampling bias is also possible because people interested in the research topic may have been more likely to participate. Moreover, our sample size was relatively small, which limited statistical power. The low response rate, especially among the controls, may limit the generalisability of our findings. Finally, due to our study design, we cannot infer causality, and some external confounding factors not considered in the analysis, such as lifestyle or personality, may have influenced the associations found in this study.

Conclusions

Athletes reported higher rates of delayed puberty and menstrual dysfunction than controls, but no differences between the groups were found in eating behaviours at any age stage. Athletes with DE during their sports career

were more likely to report DE also after their career than athletes without DE during their career. EDE-QS scores were negatively associated with sports career length. In addition, secondary amenorrhoea during the sports career was associated with lower participation level, higher rates of injury-related harms during the career, and sports career termination due to injury. These findings indicate that a regular menstrual cycle and healthy attitudes toward eating and body image may benefit an athlete's health and career. Female athletes and those working with them should be aware that disturbances in eating patterns and menstrual function could have a harmful association on a sports career. The study's findings underline the sports community's potential role in influencing female athletes' long-term health by promoting positive body image and eating behaviour.

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