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THE IMPACT OF COMPETITIVE SPORT ON THE AGE OF MENARCHE, OCCURRENCE OF AMENORRHEA, AND CHARACTERISTICS OF THE MENSTRUAL CYCLE: A RETROSPECTIVE CROSS-SECTIONAL STUDY

UTJECAJ KOMPETITIVNOG SPORTA NA DOB MENARHE, UČESTALOST AMENOREJE I KARAKTERISTIKE MENSTRUACIJSKOG CIKLUSA: RETROSPEKTIVNO, PRESJEČNO ISTRAŽIVANJE

Ellen Zaradić
Prirodoslovna škola Vladimira Preloga, Zagreb

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Corresponding author: Ellen Zaradić, ellenzaradic@gmail.com
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ABSTRACT

In recent decades, female participation in competitive sports has increased significantly. While physical activity offers numerous health benefits, intensive training can adversely affect the menstrual cycle. The aim of this study was to analyze the impact of competitive sports on menstrual disorders and cycle characteristics among female athletes from different countries and sports disciplines.

This retrospective, cross-sectional study included 369 women, of whom 298 were athletes (experimental group) and 71 were non-athletes (control group). Participants completed an online questionnaire collecting data on age at menarche, incidence of primary and secondary amenorrhea, menstrual bleeding regularity, duration and intensity, and the intensity of menstrual pain. Athletes were further categorized by sport (swimming, athletics, gymnastics, basketball, water polo) and country of training (USA, Croatia, Spain, Singapore). Statistical analyses included t-tests, chi-square tests, ANCOVA, and post-hoc tests.

Athletes experienced significantly later menarche compared to non-athletes (12.9 vs. 11.5 years; $p < 0.001$), with the highest age at menarche observed in gymnasts (13.79). Primary amenorrhea was reported in 4.7% of athletes, varying significantly by sport ($p = 0.009$), while no cases were recorded among non-athletes. Secondary amenorrhea was more prevalent among athletes (37.6%) than non-athletes (18.3%; $p = 0.002$), although there was no significant difference in its duration between groups. Athletes reported shorter menstrual bleeding (5.2 vs. 5.8 days; $p < 0.001$), with the shortest duration observed among Spanish athletes (4.8 ± 1.3), and lighter menstrual flow (3.5

SAŽETAK

Tijekom posljednjih desetljeća sudjelovanje žena u natjecateljskom sportu značajno je poraslo. Iako tjelesna aktivnost donosi brojne zdravstvene koristi, intenzivan trening može nepovoljno utjecati na menstrualni ciklus. Cilj ovog istraživanja bio je analizirati utjecaj natjecateljskog sporta na menstrualne poremećaje i karakteristike ciklusa među sportašicama iz različitih zemalja i sportskih disciplina.

Ovo retrospektivno, presječno istraživanje obuhvatilo je 369 ispitanica, od čega je 298 bilo sportašica (eksperimentalna skupina), a 71 nesportašica (kontrolna skupina). Sudionice su ispunile online upitnik kojim su prikupljeni podaci o dobi menarhe, pojavnosti primarne i sekundarne amenoreje, pravilnosti menstrualnog krvarenja, njegovom trajanju i intenzitetu te intenzitetu menstrualne boli. Sportašice su dodatno kategorizirane prema sportu (plivanje, atletika, gimnastika, košarka, vaterpolo) i zemlji treniranja (SAD, Hrvatska, Španjolska, Singapur). Statističke analize uključivale su t-test, hi-kvadrat test, ANCOVA i post-hoc testove.

Sportašice su imale značajno kasniju menarhu u usporedbi s nesportašicama (12,9 naspram 11,5 godina; $p < 0,001$), pri čemu je najviša prosječna dob menarhe zabilježena kod gimnastičarki (13,8). Primarna amenoreja prijavljena je kod 4,7% sportašica, uz značajne razlike među sportovima ($p = 0,009$), dok među nesportašicama nije zabilježena. Sekundarna amenoreja bila je češća kod sportašica (37,6%) nego kod nesportašica (18,3%; $p = 0,002$), iako nije utvrđena značajna razlika u njezinu trajanju između skupina. Sportašice su prijavile kraće menstrualno

vs 3.4, p = 0.044), which did not significantly vary by sport or country of training.

No significant difference was found in the intensity of menstrual pain between athletes and non-athletes, although differences were noted among countries, with participants from Singapore reporting the least intense pain (2.9/6).

Competitive sports are associated with alterations in menstrual function, including delayed menarche, higher prevalence of secondary amenorrhea, and shorter, lighter menstrual bleeding. These findings highlight the importance of education and monitoring of female athletes' reproductive health, with timely recognition and treatment of menstrual disorders essential to preserving long-term health and athletic performance.

Keywords: *female athlete, RED-S, menstrual disorders, menstrual characteristics, competitive sports*

krvarenje (5,2 naspram 5,8 dana; p < 0,001), s najkraćim trajanjem zabilježenim kod španjolskih sportašica (4,8 ± 1,3), te slabije menstrualno krvrenje (3,5 naspram 3,4, p = 0,044), što se nije značajno razlikovalo s obzirom na sport ili zemljiutreniranja. Nije pronađena značajna razlika u intenzitetu menstrualne boli između sportašica i nesportašica, iako su uočene razlike među zemljama, pri čemu su sudionice iz Singapura prijavile najmanji intenzitet boli (2,9/6).

Natjecateljski sport povezan je s promjenama u menstrualnoj funkciji, uključujući odgođenu menarhu, veću pojavnost sekundarne amenoreje te kraće i slabije menstrualno krvarenje. Ovi nalazi naglašavaju važnost edukacije i praćenja reproduktivnog zdravlja sportašica, pri čemu su pravodobno prepoznavanje i liječenje menstrualnih poremećaja ključni za očuvanje dugoročnog zdravlja i sportske izvedbe.

Ključne riječi: *sportašice, RED-S, menstruacijski poremećaji, menstruacijsko zdravlje, kompetitivni sportovi*

INTRODUCTION

The participation of women in competitive sports has significantly increased over the past decades. In the United States, for example, following the implementation of Title IX in 1971, the number of girls participating in high school competitive sports rose from 294,015 to 3,402,733 in 2018-19. At the collegiate level, the number of female athletes in the National Collegiate Athletic Association teams increased from 29,977 to 215,486 in 2020-21.[54] Physical activity in general offers numerous health benefits, including reduced risk of cardiovascular disease, cancer (including colorectal and breast cancer), stroke, type 2 diabetes, osteoporosis, depression, and mood disorders.[4] However, intense physical activity and participation in competitive sports can also have adverse effects on an athlete's physical and mental health. Intensive training may negatively affect mental health through overtraining, injury, burnout, anxiety, and depression.[48] In addition, factors such as social and physical isolation from family and friends, and the challenge of balancing academic and athletic obligations, further hinder psychological and physical recovery.[63]

These risks affect both male and female athletes, but female athletes are also exposed to an additional risk of menstrual disturbances, including amenorrhea (absence of menstruation).[52] A diagnosis of amenorrhea may be made if any of the following criteria are met: absence of menarche by age 15 in individuals with developed secondary sexual characteristics; absence of menstruation within three years of the onset of secondary sexual characteristics (primary amenorrhea); or absence of menstruation for 3 months or longer in women with previously regular cycles or 6 months or longer in any woman who has had at least one spontaneous menstruation (secondary amenorrhea).[44] The occurrence of menstrual disturbances is closely associated with the Relative Energy Deficiency in Sport (REDs) syndrome, a condition of impaired physiological function caused by low energy availability (LEA). It includes, but is not limited to, impaired metabolic rate, menstrual function, bone health, immunity, protein synthesis, and cardiovascular health.[37] In athletes, LEA may result from high training volumes or increased energy expenditure, but also from body dissatisfaction, pressure from coaches or teammates, or the influence of social media.[62]

Despite advances in understanding this condition and the development of monitoring methods such as stress, sleep, and training load analysis, energy imbalance remains a widespread issue.[1,29] While the impact of sports participation on the occurrence of menstrual disorders is well-documented, particularly in the context of REDs, past studies highlight that research on the relationship between sports and other aspects of menstrual health – such as menstrual bleeding characteristics – is still relatively scarce.[7] Moreover, there are significant inconsistencies in research examining the impact of sport on menstrual pain intensity and athletes' perception of how menstrual pain affects performance.[39] Another critical gap is the under-researched relationship between REDs and menstrual disorders in the context of ethnicity.[6] Similarly, a systematic review showed that 81% of studies on menstrual health in sport fail to consider the ethnic background of participants, thereby neglecting cultural and geographic factors that may influence female athletes' health.[22] These include a lack of societal acceptance of women as athletes, lower levels of

acceptance of symptoms and mental health disorders among non-white athletes, greater reliance on financial incentives, and genetic predispositions.[10] Furthermore, education on the short- and long-term consequences of LEA is often insufficient and geographically inconsistent.[23] Thus, raising awareness of these effects and of the REDs syndrome is crucial for enabling female athletes to progress in sport with a reduced risk to their health. [41]

The aim of this study is to address the aforementioned gaps and inconsistencies and to expand the current knowledge by analyzing the impact of competitive sport on the menstrual cycle through the following specific parameters: (a) age at menarche, (b) incidence of primary amenorrhea, (c) incidence and duration of secondary amenorrhea, (d) menstrual bleeding characteristics (menstrual bleeding regularity, duration, and intensity), and (e) intensity of menstrual pain. The study analyzes athletes engaged in individual sports where lower body weight may enhance performance (swimming, athletics, gymnastics), as well as team sports with lower body weight control demands (basketball, water polo), across four national contexts: the United States, Croatia, Spain, and Singapore. The countries were selected due to the differences in sports environment, cultural factors, and awareness of health issues, all of which might have a potential of influencing the impact of sports and physical activity on menstrual cycle health.[26,28,57]

MATERIALS AND METHODS

Study participants

Participants were recruited via the communication network WhatsApp and the social network Instagram, primarily through direct messaging. Potential participants, whether presumed to be athletes or non-athletes, were contacted and asked to confirm their athletic status by responding to a question regarding their participation in competitive sports, after being familiarized with the definition of the term.

After being informed about the study's purpose, basic information, and anonymity of collected data, they were provided with a link to the questionnaire created on the Microsoft Forms platform. Participants were divided into two groups: the experimental group, consisting of female athletes, and the control group, consisting of women who do not engage in competitive sports (hereafter referred to as non-athletes).

1. Inclusion criteria for participants were:
2. Age between 15 and 34 years. Participants under 15 were excluded due to the typical irregularity of the menstrual cycle during early adolescence.
3. Residence in one of the following countries: United States, Croatia, Singapore, or Spain.
4. For the experimental group: competitive engagement in one of the following sports: swimming, gymnastics, athletics, water polo, or basketball.
5. For the control group: no involvement in competitive sport (defined as a form of sport based on competition, where performance is evaluated in comparison to opponents or previous best results).[58]
6. No use of hormonal contraception before or at the time of completing the questionnaire.

Participants were excluded from the analysis if they met any of the following exclusion criteria:

1. Control group participants who answered "Yes" to the question "Do you engage in competitive sports?"
2. Participants residing in countries or engaged in sports not included in the study.
3. Use of hormonal contraception before or at the time of completing the questionnaire.

After applying the exclusion criteria, a total of 369 participants were included in the final analysis, comprising 298 athletes and 71 non-athletes. Among athletes, 92 practiced swimming, 67 athletics, 39 gymnastics, 38 basketball, and 62 water polo.

By country, 105 participants were from Croatia (92 athletes), 101 from the United States (82 athletes), 74 from Singapore (52 athletes), and 89 from Spain (72 athletes).

Participation in the study was voluntary, and anonymity was guaranteed to all participants. All participants had signed a consent form before entering the study. It was clearly stated that all data would be presented in aggregate form. The study was approved by the Ethical Committee of the Faculty of Kinesiology, University of Zagreb, Croatia.

Measurement Instruments and Data Collection

The study was conducted between August 14, 2024, and February 16, 2025, through a total of four surveys independently developed using the digital platform Microsoft Forms. Two versions were created for each group (athletes and non-athletes), in both English and Spanish, to ensure better comprehension of the questions and minimize the potential for language-related misunderstandings. The completion time for each survey was approximately 3 minutes.

The survey was divided into three sections, with the first section containing the informed consent form. The second section examined participants' age, country of residence, use of contraceptive pills, participation in competitive sports, and, for athletes, the type of sport practiced and the number of weekly training hours. The third section contained identical questions across all surveys, assessing the age at menarche, occurrence of secondary amenorrhea, the regularity, duration and intensity of menstrual bleeding and the intensity of menstrual pain. Although validated questionnaires were not used in the study, the phrasing of most questions was based on items from scientifically validated instruments. Secondary amenorrhea was assessed with the question: "After your menstruation, was it absent for 3 or more months?", which is comparable to a question from the validated LEAF-Q questionnaire.[36] Respondents

who answered affirmatively were then asked: "If yes, for how many months was it absent? (specify one number)". The question assessing the regularity of menstrual bleeding duration was: "Is the number of days of your menstruation constant (lasts around the same number of days each month)?". Only those who answered "Yes" were included in the analysis of average menstrual duration, assessed with the question: "If the number of days of your menstruation is constant, how long does it last?". Menstrual pain intensity was rated on a Likert scale from 1 to 6, where 1 indicated no pain, 2 very mild, 3 mild, 4 moderate, 5 strong, and 6 very strong pain. This scale represents a simplified version of the Verbal Rating Scale (VRS), used to evaluate menstrual pain in previous menstrual health literature (e.g. Parker et al.[42]), ranging from 0 to 10, where 0 indicates no pain, 1–3 mild, 4–6 moderate, and 7–10 severe pain. The intensity of menstrual bleeding was assessed using a Likert scale from 1 to 5, where 1 indicated very mild, 2 mild, 3 moderate, 4 strong, and 5 extreme bleeding. This item is comparable to the one in the validated Menstrual Bleeding Questionnaire (MBQ).[35] For greater clarity, the survey questions are presented in Table 1.

Table 1. Survey questions
Tablica 1. Anketna pitanja

First part of the survey:
1. What is your age?
2. Do you practice competitive sports? (the control group)/ What sport do you practice? (the athletic group)
3. Where do you live? (the control group) / In what country do you practice your sport? (the athletic group)
4. What is your average weekly training load (in hours)? (the athletic group)
5. Did you ever take birth control pills?
Second part of the survey:
6. At what age did you first start menstruating?
7. If your menstruation started after the age of 15, how old were you?
8. If your menstruation started before the age of 9, how old were you?
9. After your menstruation, was it absent for 3 or more months?
10. If yes, for how many months was it absent? (specify one number)
11. Is the number of days of your menstrual bleeding constant (lasts around the same number of days each month)?
12. If the number of your menstrual bleeding is constant, how many days does it last?
13. How would you describe the intensity of your menstrual pain? *When assessing pain, use the following scale: 1-no pain 2-very mild 3- mild 4-moderate 5-strong 6-extreme
14. How would you describe the intensity of your menstrual bleeding? *When assessing the intensity of bleeding, use the following scale: 1-very mild 2- mild 3-moderate 4-strong 5-extreme

Data analysis

Data were analyzed using IBM SPSS Statistics for macOS (version 30.0. Armonk, NY: IBM Corp; 2024). Prior to conducting statistical analyses, the required sample size was calculated using a power level of 0.8 to detect medium-sized effects (Cohen's d = 0.5 for t-tests and Cohen's f = 0.25 for analysis of variance). Assumptions of normality were assessed using visual methods, including histograms and Q-Q plots, while the homogeneity of variances was tested using Levene's test. Descriptive statistics and inferential methods were applied, including independent samples t-tests, Chi-square tests, and the Analysis of Covariance (ANCOVA). ANCOVA was used to control for the effects of country of residence, type of sport, weekly training hours, and participants' age on the variables studied. Post hoc analyses were conducted following significant results, with Bonferroni correction applied. Statistical analysis yielded tables of statistical significance.

RESULTS

Before presenting the results in tables, it is important to note that inconsistent responses Regarding age at menarche and the presence of secondary amenorrhea were excluded from the analysis. Additionally, responses that reported menstrual bleeding duration while simultaneously indicating a regular cycle length were also excluded.

The mean age at menarche was significantly higher in athletes (12.9 ± 1.4 years) compared to non-athletes (11.5 ± 1.1 years) ($t(367) = -7.978$, $p < 0.001$). No cases of primary amenorrhea were observed among non-athletes, while 4.7% of athletes reported this condition.

Secondary amenorrhea was significantly more prevalent among athletes (37.6%) than non-athletes (18.3%) ($\chi^2 = 9.509$, $p = 0.002$). However, the duration of amenorrhea did not differ significantly between groups ($t(115) = -0.432$, $p = 0.337$). Regular menstrual bleeding duration was more common among non-athletes (90.1%) than athletes (71.1%) ($\chi^2 = 10.980$, $p < 0.001$). Interestingly, the menstrual bleeding duration was significantly longer in non-athletes (5.8 ± 1.3 days) compared to athletes (5.2 ± 1.2 days) ($t(298) = 3.400$, $p < 0.001$). Menstrual bleeding intensity was rated on a scale from 1 to 5, with non-athletes reporting significantly higher intensity (3.3) compared to athletes (3.1) ($t(367) = 2.022$, $p = 0.044$). Pain intensity was assessed on a scale from 1 to 6, and no significant difference was found between non-athletes (3.5) and athletes (3.35) ($t(367) = 0.978$, $p = 0.137$).

Gymnasts had the highest mean age at menarche (13.8 ± 1.7 years), while water polo players had the lowest (12.5 ± 1.1 years). ANCOVA showed a significant effect of sport type on menarche age ($F(4) = 5.912$, $p < 0.001$). Post hoc comparisons revealed significant differences between gymnasts and swimmers ($p = 0.005$), water polo players ($p < 0.001$), basketball players ($p = 0.013$), and track and

Table 2. Descriptive Statistics for Athletes and Non-Athletes
Tablica 2. Deskriptivna statistika za sportašice i nesportašice

Study variable	Non-athletes	Athletes	p value
Age of menarche ((M± SD (min., max.)) (years)	11.5 ± 1.1 (9, 14)	12.9 ± 1.4 (9,18)	< 0.001
Primary amenorrhea (%)	0%	4.7%	0.063
Secondary amenorrhea (%)	18.3%	37.6%	0.002
Duration of SA (M±SD) (months)	6.5 ± 1.9	6.9 ± 3.5	0.337
Regular duration of bleeding (%)	90.1%	71.1%	< 0.001
Bleeding Duration (M±SD) (days)*	5.8 ± 1.3	5.2 ±1.2	< 0.001
Bleeding Intensity (1-5)	3.5	3.4	0.137
Pain Intensity (1-6)	3.3	3.1	0.044

Note: M – mean, SD – standard deviation, SA – secondary amenorrhea*Only respondents who answered "Yes" to the question "Is the number of days your period lasts constant?" were included in the analysis of average menstrual duration.

Table 3. Menstrual characteristics by sport
Tablica 3. Menstrualne karakteristike s obzirom na sport

Study variable	Swimming	Gymnastics	Waterpolo	Basketball	T&F	p value
Age of menarche ((M± SD (min., max.)) (years)	12.9 ± 1.2 (10,16)	13.8 ± 1.7 (11,18)	12.5 ± 1.1 (9,15)	12.8 ± 1.3 (11,17)	12.8 ± 1.4 (10,16)	< 0.001
Primary amenorrhea (%)	4.4%	15.4%	0%	5.3%	3%	0.009
Secondary amenorrhea (%)	40.2%	30.7%	29%	38.8%	46.3%	0.273
Duration of SA (M±SD) (months)	6.8 ± 3.6	8.4 ± 2.5	6.5 ± 2.5	6.2 ± 2.4	7.0 ± 4.3	0.588
Regular duration of bleeding (%)	70.6%	61.5%	71%	81.6%	70.5%	0.435
Bleeding Duration (M±SD) (days)*	5.1 ± 1.3	5.3 ± 1.0	5.2 ± 1.3	5.3 ± 1.0	5.2 ± 1.2	0.956
Bleeding Intensity (1-5)	3.4	2.8	3.5	3.3	3.5	0.250
Pain Intensity (1-6)	3.1	2.9	3.2	3.0	3.0	0.072

Note: M – mean, SD – standard deviation, SA – secondary amenorrhea,

*Only participants who answered affirmatively to the question "Is the number of days your period lasts constant?" were included in the analysis of the average duration of menstrual bleeding

Table 4. Menstrual characteristics by country
Tablica 4. Menstrualne karakteristike s obzirom na državu

Study variable	Croatia	USA	Spain	Singapore	p value
Age of menarche (M± SD (min., max.)) (years)	12.7 ± 1.5 (10,16)	13.2 ± 1.4 (11,18)	12.9 ± 1.2 (9,16)	12.9 ± 1.4, (11,17)	0.345
Primary amenorrhea (%)	5.4%	6.1%	1.4%	5.8%	0.500
Secondary amenorrhea (%)	42.4%	34.1%	30.6%	44.2%	0.282
Duration of SA (M±SD) (months)	7.8 ± 4.4	7.4 ± 3.2	5.9 ± 2.1	6.1 ± 2.9	0.207
Regular duration of bleeding (%)	71.7%	60.9%	70.5%	82.7%	0.066
Bleeding Duration (M±SD) (days)*	5.5 ± 1.1	5.1 ± 1.1	4.8 ± 1.3	5.3 ± 1.0	0.007
Bleeding Intensity (1-5)	3.3	3.3	3.7	3	0.609
Pain Intensity (1-6)	3.1	3.1	3.2	2.9	0.015

Note: M – mean, SD – standard deviation, SA – secondary amenorrhea,

*Only participants who answered affirmatively to the question "Is the number of days your period lasts constant?" were included in the analysis of the average duration of menstrual bleeding.

field athletes (p = 0.007). The highest prevalence of primary amenorrhea was among gymnasts (15.4%), and no cases were reported among water polo players. A significant difference in PA prevalence was confirmed (χ^2 = 13.496, p = 0.009). No statistically significant differences were found between sports in terms of SA prevalence (χ^2 = 5.140, p = 0.273) or SA duration (F(4) = 0.707, p = 0.588). Regular menstrual duration and mean number of bleeding days did not differ significantly across sports (χ^2(4) = 3.788, p = 0.435; F(4) = 0.1604, p = 0.956). Differences between sports were not statistically significant for either bleeding (F(4) = 1.354, p = 0.250) or pain intensity (F(4) = 14.271, p = 0.072).

ANCOVA showed no significant differences in menarche age across countries (F (3) = 1.111, p = 0.345). Similarly, there were no significant differences in the prevalence of primary amenorrhea (χ^2(3) = 2.364, p = 0.500), secondary amenorrhea (χ^2(3) = 3.815, p = 0.282), or duration of secondary amenorrhea (F(3) = 1.574, p = 0.207). No significant difference was found in the frequency of constant duration of menstrual bleeding between athletes from different countries (χ^2(3) = 7.209, p = 0.066). However, a significant difference was observed in menstrual bleeding duration (F (3) = 4.123, p = 0.007), with Croatian athletes having the longest mean duration of menstrual bleeding (5.5 ± 1.1 days) and Spanish athletes the shortest (4.8 ± 1.3 days). Menstrual bleeding intensity did not significantly differ across countries (F (3) = 0.610, p = 0.609), whereas pain intensity did show a statistically significant difference (F(3) = 15.327, p = 0.026), particularly between Spain (3.65/6) and Singapore (2.94/6) (p=0.015).

DISCUSSION

Age of menarche

The results of this study indicate that female athletes experience menarche significantly later than non-athletes. The age of menarche reported among athletes is consistent with previous studies, such as the one by Krawczyk et al.,[32] which reported an average age of 12.9 years, and Tatarczuk et al.,[57] who reported an average age of 12.3 years. In contrast, the age of menarche among non-athletes in this study is lower than in earlier studies, such as those by Anderson et al.[3] and Parent et al.[40] These lower values align with the global trend of earlier menarche. For example, Wang et al.[61] reported that the average age of menarche dropped from 12.9 years in women born in 1950 to 11.9 years in those born in 2005. This trend is attributed to various factors, most notably an increasingly sedentary lifestyle and higher body mass index (BMI), i.e., obesity.[12] Frisch's 1985 theory estimates that 17% body fat is required for the onset of menarche and 22% for the maintenance of regular menstruation.[20] Female athletes generally have lower body weight and lower body fat percentage than non-athletes, often due to high energy expenditure and eating disorders, which are more common in athletes than in the general population.[51,55] In addition to high training demands, female athletes are more exposed to psychosocial stressors and intense pressure, which can increase the prevalence of disordered eating, desire for weight loss, and dietary restriction.[11] Consequently, metabolic and psychological stress suppress the hypothalamic-pituitary-ovarian (HPO) axis, leading to reproductive function suppression, such as delayed menarche.[31] Unlike non-athletes, the age of menarche in athletes has not significantly decreased over time, further supporting the association between sustained intense physical activity and lower BMI with later menarche.

In terms of sport-specific differences, the latest menarche was recorded among gymnasts, while other sports showed smaller differences. All values, except for water polo players, were comparable to previous studies such as those by T. Dušek[17] and Baxter-Jones et al.[5] Due to limited research on the age of menarche in water polo athletes, comparisons with other studies are difficult. Nonetheless, the results suggest that individual sport athletes tend to experience later menarche compared to team sport athletes. Possible contributing factors include higher stress levels, greater training volume, and increased self-criticism, all of which raise the risk of mental health disorders, including eating disorders.[45, 46]

Furthermore, this study did not find a significant effect of training country on the age of menarche in athletes. Compared to earlier literature, the menarcheal age of Croatian and Spanish athletes is similar to previous findings, whereas Singaporean athletes showed higher and American athletes lower values.[17,34,56] These differences may be related to the inclusion of sports not observed in this study (e.g., figure skating, squash, skiing) in earlier research, which can substantially affect menarcheal age results.

Primary amenorrhea

Although this study confirms delayed menarche among athletes, there was no statistically significant difference in the prevalence of primary amenorrhea. All non-athletes experienced menarche by age 16, whereas 4.7% of athletes had not. The findings for non-athletes are consistent with previous studies reporting a prevalence of primary amenorrhea below 1%.[21] Among athletes, the prevalence of primary amenorrhea was considerably lower than in previous studies. For instance, M. Gimunová et al.[24] reported a prevalence ranging from 0% in water polo players (in line with this study) and basketball players (lower than in this study), up to 58% in gymnasts (significantly higher than observed here). Similarly, the prevalence among swimmers ranged from 0% to 28%, and among track and field athletes from 0% to 20%. Based on this, it can be concluded that the reported prevalence of primary amenorrhea is largely dependent on the type of sport, as well as the specific sample studied.

Despite the lack of a statistically significant difference between non-athletes and athletes, primary amenorrhea was most frequent in gymnasts and least common in water polo players, which may be linked to the delayed menarche observed in gymnasts. These findings could be explained by differences in training processes between sports, particularly the volume of intense effort and negative energy balance characteristic of gymnastics. Such factors may delay pubertal development, suppressing the HPO axis and reducing estrogen production.[49,59] No significant differences were found regarding the prevalence of primary amenorrhea between countries, suggesting that individual factors and training processes have a greater influence than nationality or training environment.

In general, late menarche is associated with complications. It is linked to reduced bone mineral density, increasing the risk of osteoporosis and fractures.[19] Moreover, girls with primary amenorrhea may require 8 to 12 years for all cycles to become ovulatory, compared to 1 to 5 years in girls with early menarche (at age 10 or earlier).[30]

Secondary amenorrhea

This study confirms prior findings that secondary amenorrhea is more common in athletes than in non-athletes. In athletes, it is most often due to functional hypothalamic amenorrhea, typically occurring in the absence of anatomical pathology, caused by reduced or absent secretion of gonadotropin-releasing hormone. The main causes are stress, excessive physical activity, eating disorders, low body weight, or rapid weight loss.[25] Among non-athletes, the prevalence of secondary amenorrhea in the general population was higher in this study (13%) compared to previous literature (3–5%).[43] Among athletes, secondary amenorrhea occurred in 46.3% of track and field athletes, 40.2% of swimmers, 36.8% of basketball players, 30.7% of gymnasts, and 29% of water polo players. Although not statistically significant, it was most common in track and field athletes, and all prevalence values were higher than in previous studies.[24] The increased frequency of secondary amenorrhea may also be linked to rising stress levels among young people.[50]

In some cases, BMI may be within normal limits, but athletes with high training demands may still experience LEA, now recognized as the key mechanism in the development of REDs syndrome and secondary amenorrhea.[18] Despite growing awareness of REDs, its prevalence remains concerning. The syndrome has serious health consequences, affecting the cardiovascular, gastrointestinal, endocrine, reproductive, skeletal, and nervous systems. In addition to increased susceptibility to infections and illness, REDs raises the risk of impaired bone health, fractures, and osteoporosis, which can ultimately affect athletic performance, emphasizing the importance of diagnosis and treatment.[6]

Regularity, duration and intensity of menstrual bleeding

Regarding the influence of sport on menstrual bleeding, statistically significant differences were found based on athletic status (athletes have less intense and shorter duration of menstrual bleeding than non-athletes), and country of training (athletes from Spain had significantly shorter menstrual bleeding than other from other countries). Previous studies show that Asian women have menstrual cycles approximately 1.6 days longer than non-Hispanic white women, and Bull et al.[8] found that women with longer cycles tend to have longer periods, and vice versa.[33] These findings correspond with this study, where Singaporean athletes reported the longer menstrual bleeding than American and Spanish athletes. Such differences may reflect cultural and environmental influences.[8]

Athletes also reported lighter menstrual bleeding than non-athletes, although no statistically significant difference in bleeding intensity was observed across sports or countries.

The general causes of variability in duration and intensity of menstrual bleeding include HPO axis disorders, ovulatory dysfunctions (such as the Polycystic ovary syndrome), excessive stress, disordered eating, low body fat, and excessive exercise—most of which are closely associated with competitive sports.[14] Lighter menstrual bleeding results from changes to the endometrium—the uterine lining that sheds each cycle and whose role is to nourish the early embryo. The endometrium responds to sex steroid hormones, thickens throughout the cycle, and sheds at the end of the luteal phase when estrogen and progesterone levels fall.[38] While limited information exists on the hormonal mechanisms regulating bleeding duration, Small et al.[53] propose that short bleeding may result from a rapid drop in estrogen in the preceding cycle due to a lack of estrogen-producing follicles. They also suggest that short and light bleeding may indicate insufficient endometrial development. Moreover, athletes may experience short or no bleeding due to anovulation, which is more frequent among those engaging in intense physical activity.[27] Prior studies support these theories, reporting more frequent follicular dysfunction in athletes, lower estrogen levels, and shorter luteal phases.[15] Later research points to a thinner endometrial layer in athletes, resulting in lighter bleeding.[60]

Unfortunately, shorter bleeding is also associated with negative consequences. Although a 2–8 day menstrual duration is considered "normal," studies show that women with periods lasting less than 5 days have reduced fecundity.[53] While most median values in this study fall within this range, more athletes (28.6%) than non-athletes (17.2%) had periods shorter than 5 days, which may negatively impact future reproductive health.

Intensity of menstrual pain

In this study, no statistically significant difference was observed in the intensity of menstrual pain between athletes and non-athletes. Literature often notes that exercise increases endorphin levels and reduces prostaglandin levels, leading to lower perception of menstrual pain.[47] However, the perception of menstrual pain varies widely across studies (2.8% to 100% reporting a negative effect on performance), possibly explaining this study's results.[39] Moreover, there is a lack of research conclusively demonstrating that sport reduces menstrual pain.[13] Nevertheless, a difference was observed between athletes from different countries: Singaporean athletes reported the least intense pain, and Spanish athletes the most. This aligns with previous research showing that Asians experience less menstrual pain than Caucasians, while Hispanics have the lowest pain tolerance.

Tolerance[61,62]. This may be linked to cultural and genetic differences, such as the prevalence of menstrual stigma in South Asian countries. For example, a study among Singaporean adolescents found that only about 6% of girls with menstrual problems seek medical help.[2]

Although this study did not find a clear effect of sports participation on menstrual pain, numerous studies have shown that menstrual pain can negatively affect both training and competition performance.[9] Future studies should include psychometric tools to objectively measure attitudes and stigma related to menstruation to enable a deeper understanding of perceptions and reporting of menstrual issues among athletes from different countries.

Limitations

This study has several limitations. First, the relatively small sample size across countries and sports, especially within specific sports, limits the ability to generalize the findings. Second, the small number of participants in the control group (non-athletes) further weakens the comparison between athletes and non-athletes, making it harder to draw robust conclusions. Furthermore, potential selection bias is present, as participants active on social media and willing to take part may represent a specific subgroup that is not fully representative of the broader population of female athletes or non-athletes. Additionally, the cross-sectional design of this study prevents the establishment of causal relationships between sport and menstrual changes, which could be better assessed using a longitudinal research design. Finally, this study did not collect data on body composition, including BMI, body fat percentage, or energy intake, which would allow for a more comprehensive understanding of the relationship between energy availability and the prevalence of menstrual disorders and cycle characteristics.

CONCLUSIONS

The results of this study confirm that, despite numerous positive effects on physical and psychological health, intensive participation in competitive sports can have detrimental effects on the menstrual, reproductive, and overall health of female athletes. Furthermore, the findings indicate that the type of sport and the country in which the athletes train may additionally influence these effects. This research highlights the need to educate both athletes and coaches about the impact of sports on female reproductive health, with the aim of preventing menstrual disorders. Such an approach would allow for the preservation of athletes' health and the achievement of optimal sports performance without compromising their long-term well-being.

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