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Low Body Fat Percentage and Menstrual Cycle Disorders in Female Elite Adolescent Dancers

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Abstract

Introduction: The menstrual cycle is an important indicator of health in female athletes. Female elite adolescent dancers are expected to control their weight while also training intensely, which can lead to menstrual disorders. This study aimed to investigate the relationship between body composition and menstrual status in female elite adolescent dancers. **Methods**: In total, 131 female elite adolescent dancers (age: 15.9 ± 1.5 years) were enrolled in this study. We measured the height, weight, and body fat percentage (BFP) for each participant and calculated their body mass index (BMI). We gathered information on individual menstruation patterns and the participants' menstrual cycles over the previous year using recall methods. We then compared the differences between dancers with menstrual cycle disorders and those without. Primary amenorrhea was defined as menarche occurring after the age of 15, while secondary amenorrhe was defined as experiencing fewer than 5 or no menstrual periods for at least 3 of the previous 12 months. We conducted a reliability test using the same questionnaire 2 weeks later. Statistical significance was defined as $P < .05$, and we calculated the effect sizes (d) and 95% confidence intervals (95% CI). **Results**: The average BMI and BFP were 22.6 ± 3.0% and 19.4 ± 2.2 kg/m^2, respectively. Low BFP and low BMI were observed in 51 (38.6%) and 47 (35.6%) participants, respectively. Primary amenorrhea in 3 participants (2.3%) and 29 (22.1%) reported experiencing secondary amenorrhea; they had lower BFP than the dancers who did not experience amenorrhea ($P = .041$, 95% CI, −2.51 to −0.05). **Conclusion**: Female elite adolescent dancers in China may have lower BFP and menstrual problems. Given that lower BFP may contribute to the occurrence of menstruation disorders, it is essential to pay an attention to both BFP and the menstruation status in female elite adolescent dancers.

Keywords

female elite adolescent dancer, body fat percentage, body mass index, menstrual disorders

Key Points

- Low body fat percentage (PBF) in female elite adolescent dancers is associated with menstrual disorders, emphasizing the importance of monitoring PBF in this population.
- Primary and secondary amenorrhea rates are notable concerns, indicating the need for comprehensive menstrual health assessment and intervention strategies among young dancers.
- These findings underscore the significance of addressing PBF and menstrual status to promote the overall health and performance of female elite adolescent dancers.

Introduction

Menstruation is often used as a crucial indicator for assessing a women's health. Disorders related to the menstrual cycle may be associated with the central nervous system, such as central premenstrual mood disorders, menstrual migraines, catamenial epilepsy, or infertility.[1-3] Moreover, the menstrual cycle can influence factors such as anterior cruciate ligament laxity,[4] muscle glycogen content,[5] and body temperature elevation.[6] It is used to evaluate athletes' physical condition and plan for training programs.[7,8] During puberty, the onset of menarche marks the development of the reproductive organs and is considered the beginning of

the development of secondary sexual characteristics. Delayed menarche or menstruation cycle disorders may have future implications for ovarian function, fertility, and sexuality.[9] This is particularly relevant in the adolescent athletes who may be at an increased risk of low bone mass[10] and sustain bone stress injuries.[11] However, the typical menstrual cycle may take several years to develop.[12] A previous study reported that the body fat percentage (BFP) recorded at menarche was 17%, while 22% is required to maintain the typical menstrual cycle.[13] Lower BFP may not provide sufficient energy for the menstrual cycle to influence menstruation. The adipose tissue plays a crucial role in maintaining estrogen levels through the aromatization process, which converts androgens to estrogen. The lack of body fat can result in the failure of androgen-to-estrogen conversion, resulting in the dysfunction of the hypothalamic-pituitary-gonadal axis and leading to menstrual disorders.[14] In addition, white adipose tissue produces leptin, which influences kisspeptin expression in the hypothalamus. Kisspeptin, in turn, stimulates the production of gonadotropin-releasing hormone, subsequently triggering the production of peripheral luteinizing and follicular stimulating hormones. These hormones, in a cascade effect, further stimulate the production of androgens and estrogens.[15] Insufficient adipose tissue may reduce the leptin secretion, impacting estrogen levels and the menstrual cycle.[16]

The Female Athlete Triad is a syndrome of interrelated conditions frequently observed in physically active women. It involves low energy availability (with or without eating disorders), menstrual cycle disturbances, and low bone mineral density. Low energy availability can result from eating disorders, such as anorexia nervosa, bulimia nervosa, or dieting behaviors.[17] According to the definition provided by the American College of Sports Medicine, low bone mineral density is characterized by a Z-Score between −1 and −2, which is determined using dual-energy X-ray absorptiometry. Clinical risk factors for fractures, including decreased energy availability, amenorrhea, and a history of stress fractures, play a crucial role in this definition.[18] Among these factors, amenorrhea is the most commonly discussed menstrual cycle disturbance and can be categorized as primary or secondary amenorrhea.[17] Primary amenorrhea refers to the absence of menarche at the age of 15 despite the normal development of secondary sexual characteristics. Secondary amenorrhea refers to the occurrence of menstruation less than 5 times or a lack of menstruation for at least 3 of the past 12 months,[19] and oligomenorrhea associated with the triad is clearly defined as the presence of irregular and inconsistent menstrual cycle intervals of 36 to 90 days.[20] The presence of any one of these conditions in the triad is sufficient for diagnosis.[18] The Female Athlete Triad is particularly harmful in adolescents, as this is the critical period for maximum bone mass accumulation and reproductive system development.[11] Furthermore, a study reported that the Female Athlete Triad may be a risk factor for stress fractures in adolescent athletes.[21] Moreover, studies have shown that amenorrhea or menstrual disturbances may lead to low bone mineral density and delayed development of secondary sexual characteristics during puberty.[22,23] As a combination of art and sports, dancing exerts high pressure on physical ability and weight management.[24] An exceptional dancer, who has received professional training since adolescence engages in high-intensity performances while carefully managing their weight through dietary control.[25] Thus, female elite adolescent dancers may have lower BFP, resulting in a higher incidence of menstrual disturbances. In a study by Grochowska-Niedworok et al, 18% of professional ballet dancers aged 10 to 15 who exercised more than 15 hours per week had a substandard BMI, and 54% had below-normal BFP.[26] In another study regarding BFP among adolescent ballet dancers with a relatively small amount of training, BFP was not found to be low.[27] However, menstrual status was not assessed in these 2 studies. Two subsequent follow-up studies that investigated menstrual status reported irregular menstruation rates of 44% to 69%.[24,28] However, these studies did not screen for or include the overall training time among the studied participants.

To date, no study has discussed the combination of BFP and menstrual status among female elite adolescent dancers undergoing intensive training. Therefore, this study aimed to determine the BFP and menstrual status of female elite adolescent dancers and clarify the relationship between body composition and menstrual status.

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Methods

Study Participants

We initially recruited 163 female elite adolescent dancers (DanceSport and traditional Chinese Dance dancers) from a Chinese pre-professional dance school, all of whom had a fixed class schedule. Before entering the school, all dancers were required to have received at least 1 year of amateur training and pass the entrance examination to apply for professional study. The inclusion criteria for this study required participants to have attended a pre-professional dance school for at least for 1 year. Owing to the school's requlations, the use of contraceptives, and other methods of menstrual period modification was prohibited. Moreover, all students resided on campus, had the same meals, and reported no history of smoking, sexual intercourse, or childbirth.

At the beginning of the study, a simple questionnaire was distributed to each participant, which mainly investigated their learning and living conditions in the previous year and asked whether they would like to participate in this study. Eleven of the recruited dancers were excluded as some personally wished not to participate or they broke training for more than 3 months in the past 6 months before our study. A total of 152 female elite dancers were enrolled.

This study was approved by the ethics committee of Waseda University (No.2022-344). Before the commencement of the study, the participants' parents provided written informed consent for their children's participation. The purpose, content, and significance of the experiment were explained to them in detail.

Procedures

This study aimed to determine the BFP, menstrual status, and the relationship between these factors in female elite adolescent dancers. As the first study of its kind, this research was designed as a cross-sectional study.

This study was divided into 2 phases: (A) design, distribution, and screening of qualified questionnaires and (B) verification of the accuracy of the questionnaire responses.

Design and distribution of the questionnaire. The questionnaire used in this study was designed based on previous studies and answered using the recall method. It included information on current age, age at the beginning of pre-professional training, duration of practice outside the curriculum, age at first menstrual period, number of menstrual cycles in the past year, and average menstrual cycle length (short cycles: $\leq$24 days; normal cycles: 25-31 days; and long cycles: $>$31 days).[29] However, as menstrual cycle disorders are more prevalent during the first year of menstruation, we excluded dancers in their first year of menstruation from this study.[10] Primary amenorrhea was defined as menophania after the age of 15, whereas secondary amenorrhea was defined as experiencing fewer than 5 or no menstrual periods for at least 3 of the previous 12 months. The questionnaire was completed in a face-to-face, allowing participants to seek clarification if they had any questions about its content. A school physician explained the questions to the athletes to ensure accurate responses.

Table 1. Demographic Characteristics of 131 Dancers.

Age (years)	16.0 ± 1.3
Height (cm)	165.0 ± 4.9
Weight (kg)	53.0 ± 7.2
BMI (kg/m^2)	19.4 ± 2.2
BFP (%)	22.6 ± 3.0
Athletic Career (years)	2.9 ± 1.8
Weekly Practice Time (hours)	19.5 ± 10.7

A total of 152 questionnaires were distributed, and all of them were recovered. After reviewing the questionnaires and excluding those with one or more missing answers, a total of 131 dancers (Table 1) aged 12 to 18 were ultimately included (Figure 1).

Verifying the accuracy of the questionnaire. To verify the accuracy of the questionnaire, 112 out of 131 respondents were administered the same questionnaire for the second time 2 weeks later, and Kappa statistics were performed based on the data extracted from the 2 responses. The results showed that the k coefficient of all questions exceeded 0.975, and the k coefficient of 3 questions reached 1.00.

Anthropometric Measurement

All measurements for each participant were conducted on 3 separate testing days between 9 am and 10 am by a school physician. Dancers were instructed to abstain from caffeine and excessive water intake.[30] Anthropometric measurements of all the dancers were taken, including height, weight and BFP, were taken for all participants. Height was determined with a Seca 213 portable stadiometer (Seca GmbH & Co. KG, Hamburg, Germany), with participants positioned in standard anatomical gaze-ahead posture, ensuring their buttocks and the backs of their heads were in contact with the machine. Weight and body fat were measured by electrical bioimpedance using the Vbody HBF-371 body composition analyzer (OMRON, Kyoto, Japan) to control for variable influencing factors. A previous study determined the concordance between low-cost and high-cost bioelectrical impedance analyzers for BFP measurement in dancers, revealing a high level of concordance between the two.[30]

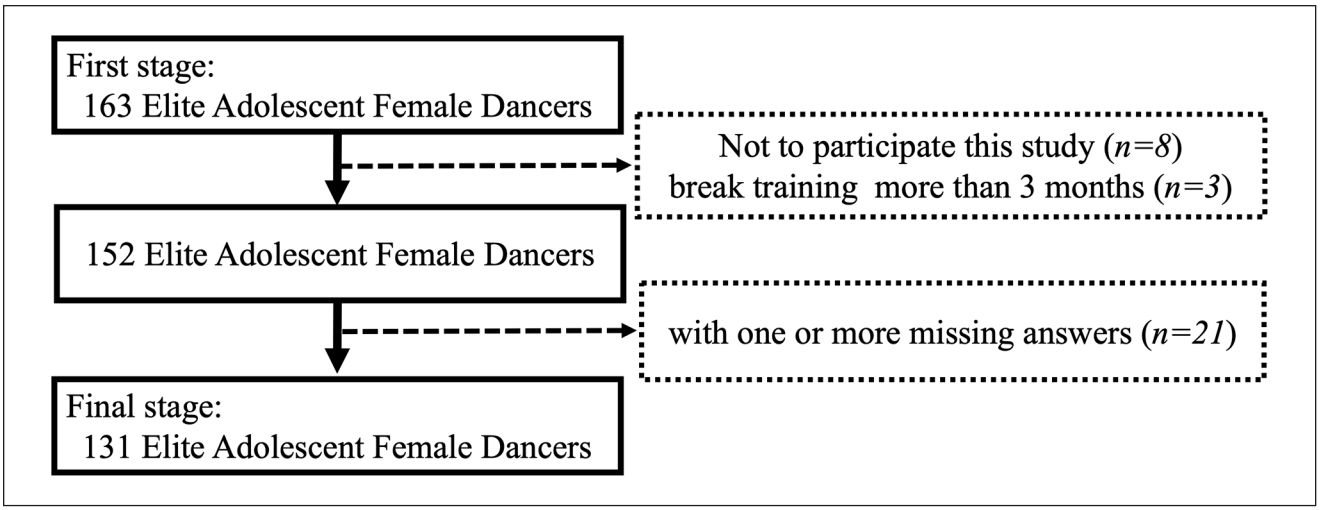

Figure 1. Flowchart for the classification of participants based on the criteria.

The Vbody HBF-371 body composition analyzer features 8 tactile electrodes, 4on the platform and 4 on the handle. It measures the impedance to a small undetectable electrical current applied as it passes through the body. The impedance is directly proportional to the amount of body fat; owing to fat mass having less water and electrolyte content, it does not have good electrical conductivity.[30] Following the instructions provided in the Vbody manual, participants maintained an upright position with their shoulders flexed at 90°, elbows extended, and both hands grasping the tactile electrodes. Participants had to be barefoot to facilitate the connection of the 4 tactile electrodes on the platform. All measurements were performed 3 times, and the averages were calculated.

Their BMI was calculated based on their height and weight. In conformance with previous studies, BMI was defined as underweight, $<18.5\,kg/m^2$; normal weight, 18.5 to $23\,kg/m^2$; and overweight: $>23\,kg/m^2$ [31,32]; low BFP was defined as $<22\%$.[13]

Data Analysis

SPSS software (version 28.0, SPSS Inc., Chicago, Illinois, USA) was used to analyze all the data in this study. The distribution of numerical variables was tested with the Shapiro–Wilk test. The t-tests or one-way analysis of variance was used if the data followed the normal distribution, or a Mann–Whitney U-test or Kruskal–Wallis test was performed. Since all the data followed a normal distribution, we employed t-tests to evaluate the difference in weekly practice time between the group with BFP lower than 22% and the normal group. We compared BFP and BMI between the secondary amenorrhea group and group without secondary amenorrhea group and calculated the effect sizes (d) and 95% confidence intervals (95% CI). One-way analysis of variance was used to compare the difference in weekly practice time among 3 groups with underweight, normal, and overweight BMI, and compare the parameters (BFP or BMI) among the 3 groups (short cycles vs normal cycles vs long cycles). Post-hoc tests with Tukey correction for multiple comparisons were conducted. A P-value of $<.05$ was considered statistically significant for all analyses.

Results

The average BFP was $22.6 \pm 3.0\%$, and 51 dancers (38.6%) showed lower BFP. The average BMI of the dancers was $19.4 \pm 2.2\,kg/m^2$, and 47 (35.6%), 79 (59.8%), and 5 (3.8%) dancers had an underweight, normal, and overweight BMI, respectively. There was no difference in weekly practice time in BFP or BMI.

Among the included 131 adolescent dancers, the average age of menarche was 12.5 ± 1.1 years, and the average number of menstrual cycles per year was 10.5 ± 2.7. Among them, 3 dancers (2.3%) reported menarche that did not begin until the age of 15. Twenty-nine dancers (22.1%) reported secondary amenorrhea. Eight out of 29 dancers reported fewer than 5 periods in the previous year. In the data collected on menstrual cycles, 15 (11.4%) dancers had short cycles, 99 (75.0%) had normal cycles, and 17 (12.9%) had long cycles.

The group with secondary amenorrhea had lower BFP than the normal group (21.6 ± 2.6vs 22.9 ± 3.9; $P=.041$, $t(129)=-2.06$, $|d|=0.433$, 95% CI, -2.51 to -0.05). However, there was no difference when BMI was compared between these 2 groups. (Figure 2) No difference was found in BFP or BMI between these 3 kinds of menstrual cycles.

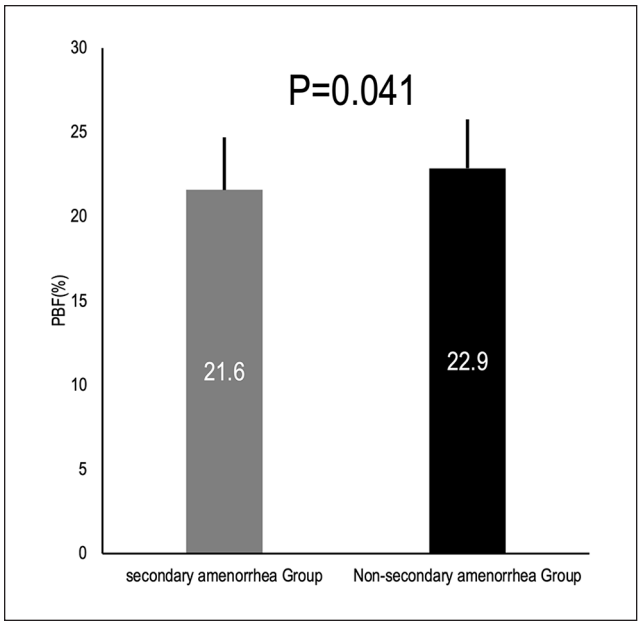

Figure 2. The difference in body fat percentage between the secondary amenorrhea and normal groups in elite adolescent dancers.

Discussion

The menstrual cycle is a complex physiological process influenced by body fat and affected by excessive exertion, especially in sports disciplines that emphasize a lean physique, such as dancers. To our knowledge, this is the first study to investigate the body composition and menstrual status of female elite adolescent dancers, which was analyzed based on the model of elite adolescent dancers in China.

In this study, we investigated the BMI and BFP of female elite adolescent dancers in China, and the results obtained were similar to those of previous studies with a total of 47 female adolescent ballet dancers aged 13 to 18 years (age: 14.2 ± 1.2, BMI: $19.7 \pm 2.4\,kg/m^2$, BFP: $23.5 \pm 4.1\%$).[27] However, a survey of dancers and rhythmic gymnasts aged 9 to 13 years reported lower and more varied results(BMI: $16 \pm 1.6\,kg/m^2$, BFP: 17.4%),[33] as well as those of 150 top-level adolescent ballet dancers in the range of 10 to 18 years old (n: 150, BMI: $16.8 \pm 2.3\,kg/m^2$, BFP:$15.6 \pm 3.7\%$).[26] The participants in these studies were younger than those in our study. Nevertheless, a study has shown that BFP in adolescent women increases with age to accommodate a higher intensity of activity and work.[13] The age range of the respondents in the present study was 12 to 18 years old, which may have led to the differences in results compared to those of previous studies. In another study involving ballet dancers of similar age groups as our participants, the study reported a mean BMI of $17.8 \pm 1.3\,kg/m^2$ was reported for 127 dancers.[34] A previous study reported that as age increases, body fat also increases in adolescents.[35] These studies included girls younger than our study of participants, potentially accounting for the difference results compared to our study. However, the substantial racial diversity in our study (60 Asians and 67 Caucasians) may contribute to the observed variations, as race has been previously linked to differences in body fat composition.[36] Additionally, data on BMI ($19.2 \pm 2.0\,kg/m^2$) and BFP (25.6%; 25th percentile: 21.4, 75th percentile: 29.5) were reported in a survey of body composition in 898 general Chinese adolescents ages of 12 and 18 years (average age: 15.1 ± 2.1).[37] Our study showed that although there might be little a slight difference in BMI ($19.4 \pm 2.2\,kg/m^2$) between elite dancers and general adolescents in China, there may be a higher difference in BFP ($22.6 \pm 3.0\%$). Chinese elite adolescent dancers may have lower BFP than typical Chinese adolescents. The absence of sufficient body fat may contribute to menstrual disorders.[14,15] A previous study reported that the stress fractures group among adolescent athletes had lower BFP than those with non-stress fractures.[21] Therefore, Chinese adolescent dancers may have a higher risk of menstrual disorders or stress fractures than the general adolescent Chinese population. Vigilance should be exercised regarding the potential for injuries, such as stress fractures in dancers with lower BFP.

Consistent with the results of previous studies,[38] we found that the age at which menses began was 12.5 years. A 2019 survey of 27 782 Chinese girls in China reported a median menarche age of 12.07 years in the general population.[39] This indicates may disparities in menarche age between the general population and adolescent dancers in China. In addition, in our study, 3 participants reported menarche at the age $>$ 15 years, 29 (22.1%) reported a history of no periods for more than 3 months in the previous year, and 8 reported fewer than 5 periods in the previous year. Notably, investigations on the menstrual status of underage dancers are less common. In 2 studies on adult dancers, lower results for those with a the lack of menstruation for more than 3 months were reported (13.3% and 16.0%, respectively).[40,41] Furthermore, it is important to note that adults generally have more stable menstrual cycles than adolescents because these studies did not control for smoking, alcohol consumption, sexual history, and other factors; it is possible that the adolescent dancers included in the present study might have more menstrual severe problems than the adult dancers. It is also worth noting that the definition of amenorrhea employed in this study is widely used in the investigation and research of young female athletes in other sports. Our study reported that the prevalence of primary amenorrhea was 2.3%, and that of secondary amenorrhea was 22.1%. Other studies regarding amenorrhea have revealed the following: swimming (n = 78,

primary amenorrhea: 0%, secondary amenorrhea: 0%)[42] and tennis (n = 24, primary amenorrhea: 4%, secondary amenorrhea: 4%)[43] had lower results than our study; cross-country running (n = 93, primary amenorrhea: 3.2%, secondary amenorrhea: 17.2%)[10] was similar to our study; and rhythmic gymnastics (n = 45, secondary amenorrhea: 47.1%)[44] had higher results than our study. In a previous study, dancers had a higher prevalence of the Female Athlete Triad rate than runners and figure skaters.[45] Our study showed similar results and thus supported our hypothesis. Therefore, the prevalence of amenorrhea in Chinese adolescent dancers may be second only to rhythmic gymnastics, but higher than other adolescent athletes such as those participating in swimming and tennis.

Similarly, BMI[46] and low BFP[13] can also affect the menstrual cycle. Menstruation is regulated and controlled by the hypothalamic-pituitary-adrenal (HPA) axis[19] and hypothalamic-pituitary-ovarian (HPO) axis.[46] These 2 axes can be affected by excessive exercise,[47] diet behavior,[47] and malnutrition,[19] thus affecting the menstrual cycle and resulting in delayed menstruation or amenorrhea. Menstrual disturbances in the Female Athlete Triad were defined as women who had fewer than 5 periods or who experienced no periods for at least 3 months in the previous 12 months.[48] Our result revealed a correlation between BFP and the non-menstrual group; therefore, adolescent female dancers with lower BFP may experience menstrual problems and symptoms of the Female Athlete Triad.

Limitations

The current study had some limitations. First, we recruited dancers from a Chinese pre-professional dance school. The result may have been influenced by the unique environmental factors associated with the specific school, such as dietary patterns or school schedules. We made efforts to control for these factors, but variations in school schedules or dietary practices at different schools could have impacted our finding. This study relied on a questionnaire to assess the menstrual cycle in dancers without directly measuring hormones such as luteinizing hormone and leptin, which have been reported to influence the menstrual cycle.[15,16]

To further advance our understanding of the relationship between the BFP and the menstrual cycle in elite adolescent dancers, future research should consider expanding the participant pool to include dancers from various dance schools and incorporating hormone measurements. We were unable to include general adolescents in our study because of its specific focus on elite adolescent dancers. As a potential limitation, we recognize the need to consider recruiting general female adolescents in future research endeavors.

Although some dancers reported short and long menstrual cycles, no association was found between their menstrual cycles and BMI or BFP in our survey. Long and irregular menstrual cycles are common in the first 1 to 2 years after menarche; however, most girls enter a regular cycle pattern (26-35-day intervals) in late puberty.[49] It is also worth noting that a previous study reported short menstrual cycles of 21 to 34 days.[9] In this study, we used the menstrual cycles reported from a study of 360 young women with menstrual cycles of 21 to 31 days.[29] In addition, a previous study reported that the average age at the onset of menstruation in adolescent women was 12 to 13 years, and menstrual disturbances in puberty should be evaluated after the age of 14,[23] which may have influenced our results. Future studies should analyze the menstrual status of adolescent dancers combined with their individual development.

Nonpharmacological interventions in female athletes and ballet dancers with menstrual disorders can restore regular menstrual cycles. However, resumption of regular menstruation may take more than 1 year, and increased BFP may be an important predictor of menstrual recovery.[50] Moreover, there is evidence that malnutrition and heavy physical labor affect the natural fertility of our studied population, as indicated by delayed menarche, prolonged infertility during puberty, longer intervals between births, and earlier menopause.[5] Therefore, future studies should evaluate the relationship between BFP, dietary habits, and appetite.

Conclusion

The menstrual cycle serves as a crucial indicator of the physical well-being of female athletes, and changes in the menstrual cycle may predispose them to physical injury. Our study shows that Chinese female elite adolescent dancers with menstrual disorders tend to have lower BFP, potentially leading to bone, muscle, or developmental problems. Future research employing longitudinal study designs can offer valuable insights into the dynamic changes in body composition and menstrual status.

Additionally, as elite dancers strive to achieve a slim feminine physique, it becomes imperative to incorporate carefully tailored nutritional recommendations based on body fat levels into the treatment approach for menstrual dysfunction among these women.

Declaration of Conflicting Interests

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