J Biochem Technol (2026) 17(1): 67-78
https://doi.org/10.51847/in6tOcSCUc
ISSN: 0974-2328

Cardiovascular and Reproductive Disorders Associated with Relative Energy Deficiency in Adolescent Aesthetic Athletes

Zalina Yuryevna Sozaeva*, Marina Vsevolodovna Atayeva, Yana Vitalievna Rozhkova, Irbek Yurievich Khubezhov, Kamilla Robertovna Bagaeva, Evangelina Soslanbekovna Bdaitsieva, Alena Ibragimovna Khozieva, Alina Olegovna Dzigoeva, Rayana Magomedovna Yashurkaeva, Elima Romazanovna Umarova

Received: 21 November 2025 / Received in revised form: 19 February 2026, Accepted: 21 February 2026, Published online: 15 March 2026

Abstract

Russia has seen a steady increase in children's participation in organized sports. Aesthetic sports, which impose strict requirements on body shape and weight, are particularly popular among young female athletes. Intensive training combined with dietary restrictions creates a risk of relative energy deficiency in sport, a condition that negatively affects the reproductive, cardiovascular, and skeletal systems. This study assessed the prevalence and patterns of health disorders in adolescent girls aged 15–18 years engaged in aesthetic sports using healthcare utilization data from children's polyclinics in Vladikavkaz and in-depth clinical examinations. The study was conducted in two stages. The first analyzed healthcare visit records of 1,840 girls. The second involved a comprehensive examination of 240 aesthetic sport athletes, including questionnaires, anthropometry, bioimpedance analysis, ECG, echocardiography, lipid profile, vitamin D level, and bone mineral density. Among aesthetic sport athletes, 68.3% sought care for menstrual cycle disorders and 26.9% for musculoskeletal pain. Cycle disorders were identified in 47.9%, vitamin D deficiency in 78.3%, and body fat below 18% in 42.1%. Bradycardia was recorded in 22.9%, mitral valve prolapse in 15.8%, and dyslipidemia in 28.3%. Girls with cycle disorders had higher atherogenic lipid levels. Risk factors included low body fat, vitamin D deficiency, early training initiation, and meal skipping. These findings demonstrate a high prevalence of reproductive dysfunction, cardiovascular abnormalities, and deficiency conditions among adolescent girls in aesthetic sports, underscoring the need for RED-S screening in pediatric practice.

Keywords: RED-S, Relative energy deficiency in sport, Aesthetic sports, Adolescent girls, Cardiovascular system, Menstrual cycle disorders

Zalina Yuryevna Sozaeva*, Marina Vsevolodovna Atayeva
Department of Children's Diseases, North Ossetian State Medical Academy, Vladikavkaz, Republic of North Ossetia-Alania, Russia.

Yana Vitalievna Rozhkova, Irbek Yurievich Khubezhov, Kamilla Robertovna Bagaeva, Evangelina Soslanbekovna Bdaitsieva, Alena Ibragimovna Khozieva, Alina Olegovna Dzigoeva, Rayana Magomedovna Yashurkaeva
Faculty of Pediatrics, North Ossetian State Medical Academy, Vladikavkaz, Republic of North Ossetia-Alania, Russia.

Elima Romazanovna Umarova
Faculty of Medicine, North Ossetian State Medical Academy, Vladikavkaz, Republic of North Ossetia-Alania, Russia.

***E-mail:** dr.zayushka@mail.ru

Introduction

In recent years, Russia has seen a steady increase in the participation of children and adolescents in organized sports (Grant & Wallace, 2024; Pawluczyk *et al*., 2025). According to data presented at the meeting of the Council for the Development of Physical Culture and Sport in November 2025, the proportion of children regularly engaged in sports reached 93.8%, an unprecedented figure. Nationwide, this translates to 6.3 million children attending sports sections and over 5.8 million participating in school sports clubs.

Parents increasingly enroll their children in sports sections with good intentions: to strengthen health, develop discipline, and organize leisure time. For 40% of parents, the main motive is health benefits, while 37% are guided by their children's own wishes. Swimming, football, martial arts, gymnastics, and dance are particularly popular, chosen by 8–10% of families. However, behind these outwardly favorable statistics lies a serious problem that few parents or even coaches consider (Campbell *et al*., 2019; Lodge *et al*., 2023; Kunie *et al*., 2025).

Professional sport, particularly when involving early specialization and intense training loads, may not only fail to strengthen health but can cause significant harm (Campbell *et al*., 2019; Osluf *et al*., 2024; Gallant *et al*., 2025). A child's body, in a phase of active growth and development, is especially vulnerable to excessive physical loads (Kruse *et al*., 2021; Morgan & Foster, 2025). This is particularly relevant for aesthetic sports (artistic and rhythmic gymnastics, figure skating, ballet, diving, and competitive dance) where success is directly associated with maintaining low body weight and specific physique parameters (Lisboa *et al*., 2022; Lundqvist *et al*., 2024; Lindstrom *et al*., 2025).

Young female athletes are forced from an early age to restrict their diet, monitor every kilogram, and train to exhaustion, often ignoring their body's signals of overwork, pain, and discomfort

(Kampouri *et al*., 2019; Heikura *et al*., 2022; Anunziata & Cussa, 2024). Coaches and parents, driven by the desire to achieve high results, often encourage such behavior without understanding its true cost (Magee *et al*., 2023; Csep *et al*., 2024). Unlike adults, a child's body lacks sufficient compensatory reserves. The consequences of years of energy deficiency and overload can become irreversible, manifesting in adulthood as infertility, osteoporosis, cardiovascular disease, and chronic musculoskeletal problems (Kruse *et al*., 2021; Grabia *et al*., 2024; Clark & Foster, 2025).

The scientific community has long recognized this issue. In the early 1990s, the so-called "female athlete triad" was described, comprising three interrelated components: low energy availability, menstrual cycle disorders, and decreased bone mineral density (Ganea *et al*., 2024; Nose-Ogura *et al*., 2024; De Souza *et al*., 2026). Over the years, understanding of the problem has deepened. The International Olympic Committee proposed a broader concept - relative energy deficiency in sport, known by the acronym RED-S (Dave & Fisher, 2022; Mountjoy *et al*., 2023; Raza *et al*., 2025).

This condition occurs when an athlete chronically fails to consume enough calories to cover energy expenditure (Melin *et al*., 2019; Ming & Lei, 2025). In an attempt to survive under deficiency conditions, the body sacrifices functions not critical for immediate survival but essential for long-term health (Dipla *et al*., 2021; Angelidi *et al*., 2024). Not only the reproductive system suffers, but also the cardiovascular, endocrine, immune, and skeletal systems (Mountjoy *et al*., 2023; Holtzman *et al*., 2024; Ribeiro *et al*., 2024). Metabolism is disrupted, and mental health deteriorates (Ackerman *et al*., 2019; Cuenca-Martínez *et al*., 2025). In recent years, updated consensus statements have been published, with particular attention paid to adolescence, as this is the period when lifelong health foundations are laid (Gould *et al*., 2023; Torstveit *et al*., 2023; Mickevičius *et al*., 2024).

The relevance of this problem for young female athletes is confirmed by research data: low energy availability is detected in nearly half of female athletes (Besor *et al*., 2024; Jabin & Guthrie, 2025; Kiss *et al*., 2026), and more than 60% are at risk of developing relative energy deficiency syndrome (Stenqvist & Melin, 2023; Hsiao *et al*., 2024; Silvennoinen *et al*., 2025). The consequences can be severe, ranging from menstrual dysfunction and increased risk of stress fractures to cardiovascular disorders, including dyslipidemia, bradycardia, and rhythm disturbances, as well as long-term fertility and bone health issues that may manifest after athletic careers end (Hooper *et al*., 2021; Holtzman *et al*., 2024; Jouhki *et al*., 2024; Wong *et al*., 2025).

Of particular concern is the extremely low awareness of the problem among all participants in the training process (Coelho *et al*., 2021; Magee *et al*., 2023; Alhossan *et al*., 2024). Young athletes often perceive loss of menstruation as normal for sport, not understanding that it signals serious bodily dysfunction (Taim *et al*., 2023; Novak & Dvorak, 2025; Williams *et al*., 2026). Coaches and parents, lacking the necessary knowledge, may overlook warning signs for years or attribute them to the peculiarities of sports activity.

The significance of the problem is recognized at the state level. In November 2025, at a meeting of the Council for the Development of Physical Culture and Sport, the President of Russia, commenting on high rates of children's involvement in sports, emphasized that numbers do not reflect the main outcome - the results of participation. He stressed the importance of understanding how sports affect children's health, education, and physical and general development. To address this task, it was mandated to synchronize the activities of healthcare, sports, and education systems, and to involve the National Center for Sports Medicine in developing relevant guidelines, indicators, and evaluation criteria for all those responsible for children's education, physical training, and health protection. This directly indicates that quantitative participation rates must be complemented by qualitative assessment of sports' impact on the health of the younger generation.

This study aimed to assess the prevalence and patterns of health disorders, including changes in the cardiovascular and reproductive systems, in adolescent girls aged 15–18 years engaged in aesthetic sports, based on healthcare utilization data from children's polyclinics in Vladikavkaz and in-depth clinical and instrumental examinations.

Materials and Methods

The study was conducted at the Department of Pediatrics of the North Ossetian State Medical Academy, in collaboration with children's city polyclinics in Vladikavkaz. The patient enrollment period lasted two years, from January 2024 to December 2025.

The work was carried out in two sequential stages and had the design of a cross-sectional study with elements of retrospective analysis of outpatient medical records.

First stage. Using a continuous sampling method, we analyzed data from 1,840 girls aged 15 to 18 years who sought medical care at children's polyclinics in Vladikavkaz during the study period. We examined the complaints that led patients to consult a physician and the final diagnoses recorded in the primary documentation. Special attention was paid to the frequency of allergic diseases, acute respiratory pathology, menstrual cycle disorders, musculoskeletal complaints, and other conditions common in this age group. Additionally, at this stage, we recorded whether patients engaged in regular sports and adhered to a specialized sports diet, based on anamnestic data.

Second stage. The second stage included 240 girls selected from the overall cohort of first-stage patients. Inclusion criteria were: regular participation in an aesthetic sport for at least two years, with a training load of at least six hours per week, and adherence to a diet aimed at controlling body weight or improving sports performance. Exclusion criteria were: verified chronic diseases in the acute stage, severe somatic pathology, a history of oncological diseases, and use of hormonal medications at the time of examination.

All patients included in the second stage underwent a comprehensive examination. To assess subjective complaints, lifestyle, and eating behavior, we used structured questionnaires covering complaints, menstrual function, dietary habits, and training characteristics (Wasserfurth *et al*., 2025).

Anthropometric measurements included height, body weight, waist, and hip circumference; body mass index was calculated. Bioimpedance analysis was performed to determine body composition, including absolute and relative fat mass, lean mass, and muscle mass (Mathisen *et al*., 2023).

Blood pressure was measured on the right arm three times using a mechanical sphygmomanometer. All girls underwent standard 12-lead electrocardiography at rest and echocardiography to assess structural and functional parameters of the heart (Perone *et al*., 2023; Solmell & Sterner, 2024).

Laboratory methods included complete blood count, biochemical blood analysis with lipid profile assessment, hormone level determination, and measurement of 25-hydroxyvitamin D, calcium, phosphorus, and parathyroid hormone levels (Lozano-Berges *et al*., 2022; Schneider & Krüger, 2025). All second-stage participants underwent dual-energy X-ray absorptiometry of the lumbar spine and proximal femur, with Z-score calculation (Miciak & Jurkiewicz, 2024; Lee *et al*., 2025).

Statistical analysis. Statistical analysis was performed using Statistica 12.0 and SPSS version 26.0. Normality of distribution was assessed using the Shapiro-Wilk test. Data with normal distribution were presented as mean and standard deviation; data with non-normal distribution were presented as median and interquartile range. Categorical data were expressed as absolute and relative frequencies.

For comparisons of quantitative variables, we used Student's t-test, the Mann-Whitney U test, and Pearson's χ^2 test. To identify factors associated with the presence of disorders, we performed logistic regression analysis with calculation of odds ratios and 95% confidence intervals (Burke *et al*., 2023; Rani & Gehrke, 2025). The critical level of statistical significance was set at 0.05.

Results and Discussion

First stage. At the first stage of the study, we analyzed data from 1,840 girls aged 15 to 18 years who sought medical care at children's city polyclinics in Vladikavkaz. The mean age of the patients was 16.4±1.1 years. The structure of healthcare visits, with proportions of athletes and aesthetic sport athletes, is presented in **Table 1**.

Table 1. Structure of healthcare visits among girls aged 15–18 years, with proportions of athletes and aesthetic sport athletes

Reason for visit	Total visits	% of total (n=1,840)	Athletes (any sport) n=420		Aesthetic athletes n=240	
			n	%*	n	%*
Acute respiratory diseases	810	44.0%	162	20.0%	84	10.4%
Back, joint, muscle pain	580	31.5%	210	36.2%	156	26.9%
Allergic diseases	310	16.8%	76	24.5%	42	13.5%
Menstrual cycle disorders	240	13.0%	180	75.0%	164	68.3%
Other reasons	460	25.0%	92	20.0%	38	8.3%

*Note: Percentage calculated per row (proportion of athletes among visits for each reason). The sum in the last column exceeds 240 because one athlete could have visited for multiple reasons.

Table 1 shows that among girls presenting with musculoskeletal pain, 36.2% were athletes, with 26.9% of all visits for this reason attributed to aesthetic sport athletes. In the group of menstrual cycle disorders, 75% of those seeking care were athletes, and 68.3% represented aesthetic disciplines. The overall proportion of athletes in the sample was 420 (22.8% of 1,840), of whom 240 were aesthetic sport athletes. These 240 girls were selected for in-depth examination at the second stage.

Second stage. At the second stage, we examined 240 female athletes aged 15 to 18 years who regularly engaged in aesthetic sports and adhered to a sports diet. The distribution by sport was as follows: the largest group comprised artistic and rhythmic gymnasts - 92 girls (38.3% of the sample). Sports dance was practiced by 68 girls (28.3%), figure skating by 42 (17.5%), ballet by 24 (10.0%), and diving by 14 (5.8%). The mean age of starting sports was 6.2±1.8 years, with a mean training experience of 9.8±2.4 years. Training load varied from 8 to 20 hours per week, averaging 12.4±3.6 hours.

Questionnaire results. Analysis of the questionnaires revealed a high frequency of various complaints among the examined athletes (Alnabulsi *et al*., 2025; Wasserfurth *et al*., 2025). Nearly all participants (97.5%) reported some complaints, with most experiencing a combination of several symptoms. The distribution of subjective complaints is shown in **Figure 1**.

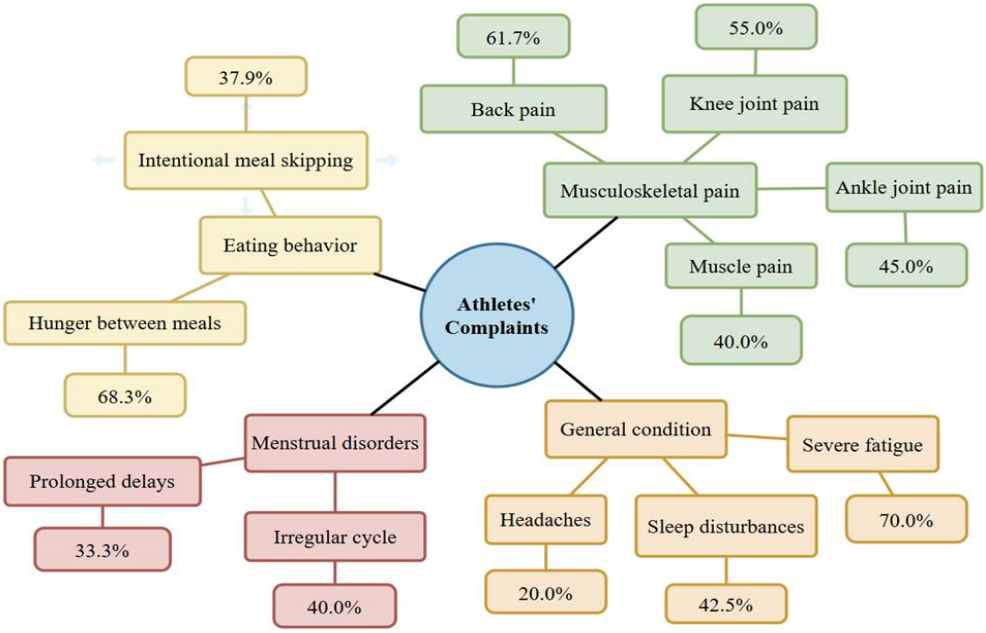

Figure 1. Frequency of subjective complaints among female athletes according to questionnaire data (n=240)

The most common complaints were back pain (61.7%), knee pain (55.0%), and ankle pain (45.0%), as well as severe fatigue after training (70.0%). Every third girl reported irregular menstrual cycles or prolonged delays. Hunger between meals was experienced by 68.3% of girls, while 37.9% intentionally skipped meals to control weight (Heikura *et al*., 2022; Jaafar *et al*., 2024).

Analysis of eating behavior showed that the majority of athletes adhered to restrictive diets. Only 32.1% of girls consumed three meals per day; the remainder ate twice daily or less (Meyer *et al*., 2025; Shen & Bao, 2025). Anthropometric parameters of the examined athletes are presented in **Table 2**.

Table 2. Anthropometric parameters of female athletes (n=240)

Parameter	Mean value	Min-max
Height, cm	162.5±5.8	148–178
Body weight, kg	51.2±6.4	38–72
Body mass index, kg/m²	19.4±2.1	15.8–26.4
Body fat, %	19.6±4.2	11.2–31.5
Muscle mass, %	42.3±3.8	34.1–51.2

Mean body mass index values were within the age norm. In 18.3% of girls, BMI was below the 5th percentile for the corresponding age, indicating underweight. Bioimpedance analysis revealed a reduction in body fat percentage below 18% in 42.1% of the examined athletes, a level considered critical for maintaining regular menstrual cycles (Maya & Misra, 2022; Mathisen *et al*., 2023; Uneno & Morita, 2024).

Menstrual function. Menstrual cycle disorders were detected in a significant proportion of the examined athletes (Heikura *et al*., 2024; Nose-Ogura *et al*., 2024). A regular menstrual cycle with a frequency of 24–35 days was reported by only 125 girls (52.1% of the sample). Oligomenorrhea was diagnosed in 62 girls (25.8%), secondary amenorrhea in 28 (11.7%), and primary amenorrhea in 25 (10.4%). Correlation analysis revealed a statistically significant negative relationship between duration of sports participation and age at menarche. In girls who began training before age 6, menarche occurred on average 1.8 years later than in those who started after age 8 (Indirli *et al*., 2022; Taim *et al*., 2023).

Cardiovascular system. Assessment of the cardiovascular system revealed various abnormalities among the examined athletes (Perone *et al*., 2023; Holtzman *et al*., 2024). Mean blood pressure values were within the age norm, but 22.9% of girls showed a tendency toward bradycardia with heart rates below 55 beats per minute (Hooper *et al*., 2021).

Electrocardiographic changes were recorded in a significant proportion of athletes: sinus bradycardia in 55 girls (22.9%), repolarization disorders in 48 (20.0%), QT interval prolongation in 28 (11.7%), isolated extrasystoles in 15 (6.3%), and pacemaker migration in 12 (5.0%) (Hooper *et al*., 2021; Perone *et al*., 2023).

Echocardiography revealed mitral valve prolapse of varying severity in 38 of 240 examined athletes (15.8%), exceeding population rates for this age. Minor pericardial effusion was diagnosed in 4.2% of girls (Perone *et al*., 2023; Courtney *et al*., 2025).

Lipid profile abnormalities were detected in 28.3% of the examined athletes, mainly in the form of elevated total cholesterol and low-density lipoprotein cholesterol (Grandys *et al*., 2023; Jouhki *et al*., 2024). Lipid profile parameters according to menstrual cycle status are shown in **Table 3**.

Table 3. Lipid profile parameters according to menstrual cycle status

Parameter	Regular cycle (n=125)	Cycle disorders (n=115)	p-value
Total cholesterol, mmol/L	4.2±0.8	4.8±1.1	0.02

LDL cholesterol, mmol/L	2.3±0.7	2.8±0.9	0.03
HDL cholesterol, mmol/L	1.4±0.3	1.2±0.3	0.04
Triglycerides, mmol/L	1.1±0.4	1.2±0.5	0.21

Girls with menstrual cycle disorders had statistically significantly higher levels of atherogenic lipids and lower high-density lipoprotein levels, indicating an unfavorable cardiovascular profile in this group (Grandys *et al*., 2023; Jouhki *et al*., 2024).

Vitamin D and bone mineral density. Vitamin D deficiency was detected in the vast majority of examined athletes (Zheng *et al*., 2021; Lozano-Berges *et al*., 2022). Serum 25-hydroxyvitamin D levels below 30 ng/mL were recorded in 78.3% of girls, with 34.6% having levels below 20 ng/mL, corresponding to severe deficiency (Constantini *et al*., 2010).

Dual-energy X-ray absorptiometry revealed a Z-score below -2.0 in the lumbar spine in 18 of 240 girls (7.5%), meeting the criteria for low bone mass for this age (Bouillon *et al*., 2024; Lee *et al*., 2025). An additional 42 girls (17.5%) had Z-score values between -1.0 and -2.0, which was considered a borderline condition.

Risk factors. Logistic regression analysis identified factors associated with the development of menstrual cycle disorders in the examined athletes (Burke *et al*., 2023). The results of multivariate logistic regression analysis, showing odds ratios with 95% confidence intervals, are presented in **Figure 2**. The most significant predictors were low body fat percentage, vitamin D deficiency, early initiation of training, and intentional meal skipping.

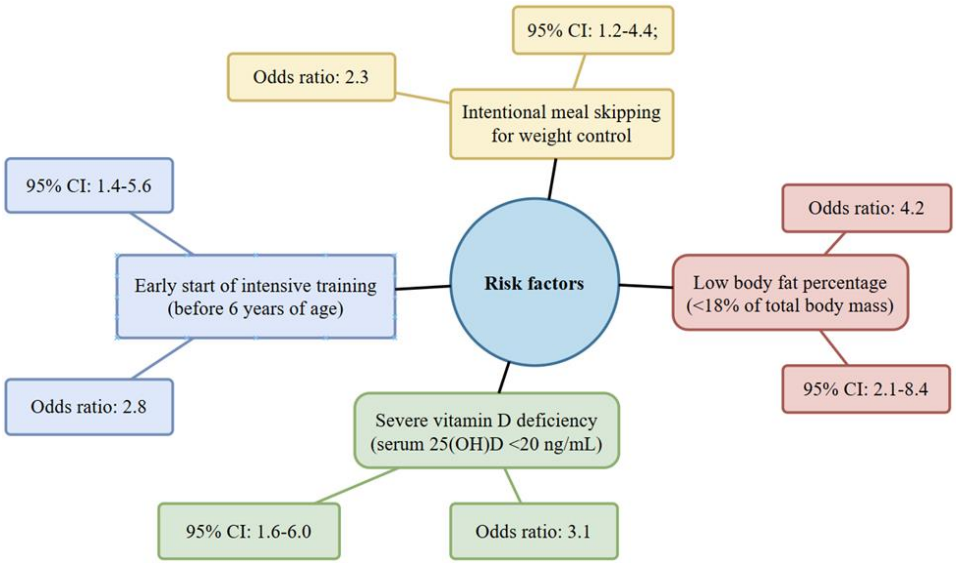

Figure 2. Risk factors for menstrual cycle disorders in adolescent athletes: results of multivariate logistic regression analysis showing odds ratios (OR) with 95% confidence intervals (95% CI)

The greatest contribution came from a reduction in body fat below the critical level, which increased the likelihood of cycle disorders more than fourfold. Vitamin D deficiency increased risk by 3.1 times, early initiation of training before age 6 by 2.8 times, and intentional meal skipping by 2.3 times (Maya & Misra, 2022; Burke *et al*., 2023).

Correlation analysis also revealed a moderate positive correlation between training load duration and LDL cholesterol levels, as well as a negative correlation between duration of sports participation and bone mineral density in the lumbar spine (Grandys *et al*., 2023; Bouillon *et al*., 2024).

This study revealed a high prevalence of health disorders among adolescent girls engaged in aesthetic sports and adhering to dietary restrictions. The findings not only confirm the presence of these problems but also allow us to construct a logical chain of pathogenetic relationships characteristic of relative energy deficiency in sport (Dave & Fisher, 2022; Mountjoy *et al*., 2023).

According to current understanding, the central mechanism underlying the identified disorders is low energy availability, which arises from a mismatch between energy expenditure during intensive training and energy intake from food (Melin *et al*., 2019; Gould *et al*., 2023). In our study, nearly all athletes reported dietary restrictions aimed at weight control, and 37.9% intentionally skipped meals. These findings are consistent with those of other researchers, who have shown that restrictive eating behaviors reach critical levels in aesthetic sports (Heikura *et al*., 2022; Magee *et al*., 2023).

Low energy availability triggers a cascade of endocrine disturbances, the most critical of which is suppression of the hypothalamic-pituitary-gonadal axis, leading to hypoestrogenism (Dipla *et al*., 2021; Angelidi *et al*., 2024). The clinical manifestation of this process is menstrual cycle disorders, which we observed in 47.9% of the examined athletes. The frequency of secondary amenorrhea in our sample was 11.7%, somewhat lower than figures reported in the literature for ballet dancers, but comparable to rates reported among gymnasts (Taim *et al*., 2023;

Williams *et al*., 2026). The association we found between early training initiation and later age at menarche supports the hypothesis that intensive training during the prepubertal period may influence the timing of pubertal development (Brzeziański *et al*., 2022; Indirli *et al*., 2022).

The cardiovascular changes we identified deserve particular attention. Bradycardia, recorded in 22.9% of athletes, may be interpreted as an adaptive response to physical training. However, when combined with repolarization abnormalities and QT interval prolongation, it acquires pathological significance (Hooper *et al*., 2021; Perone *et al*., 2023). Several authors have noted that athletes with relative energy deficiency syndrome are at increased risk for arrhythmias and sudden cardiac death (Holtzman *et al*., 2024; Courtney *et al*., 2025). The mitral valve prolapse we detected in 15.8% of girls significantly exceeds population rates and is likely associated with low body mass index and altered cardiac geometry, a finding also described in the literature (Perone *et al*., 2023; Courtney *et al*., 2025).

The association we found between menstrual cycle disorders and unfavorable lipid profile changes represents a particularly concerning finding (Grandys *et al*., 2023; Jouhki *et al*., 2024). Girls with amenorrhea and oligomenorrhea had statistically significantly higher levels of total cholesterol and low-density lipoprotein cholesterol, along with lower high-density lipoprotein levels. Such dyslipidemia is a well-established risk factor for early atherosclerosis and future cardiovascular disease (Grandys *et al*., 2023; von Brackel *et al*., 2025). Other researchers have also reported adverse metabolic changes in athletes with hypothalamic amenorrhea, though the long-term consequences of these disturbances require further investigation (Nicotra *et al*., 2023; Jouhki *et al*., 2024).

Vitamin D deficiency, detected in 78.3% of the examined athletes, represents an independent problem that exacerbates both skeletal and cardiovascular risks (Zheng *et al*., 2021; Lozano-Berges *et al*., 2022). Reduced bone mineral density in 7.5% of girls and borderline values in an additional 17.5% indicate a real threat of osteoporosis and stress fractures (Bouillon *et al*., 2024; Lee *et al*., 2025). The literature emphasizes that peak bone mass is achieved during adolescence, and energy deficiency during this period may have irreversible consequences (Constantini *et al*., 2010; Dubnov-Raz *et al*., 2015).

To visually represent the pathogenetic relationships among the identified disorders, we developed a diagram of causal relationships **(Figure 3)**.

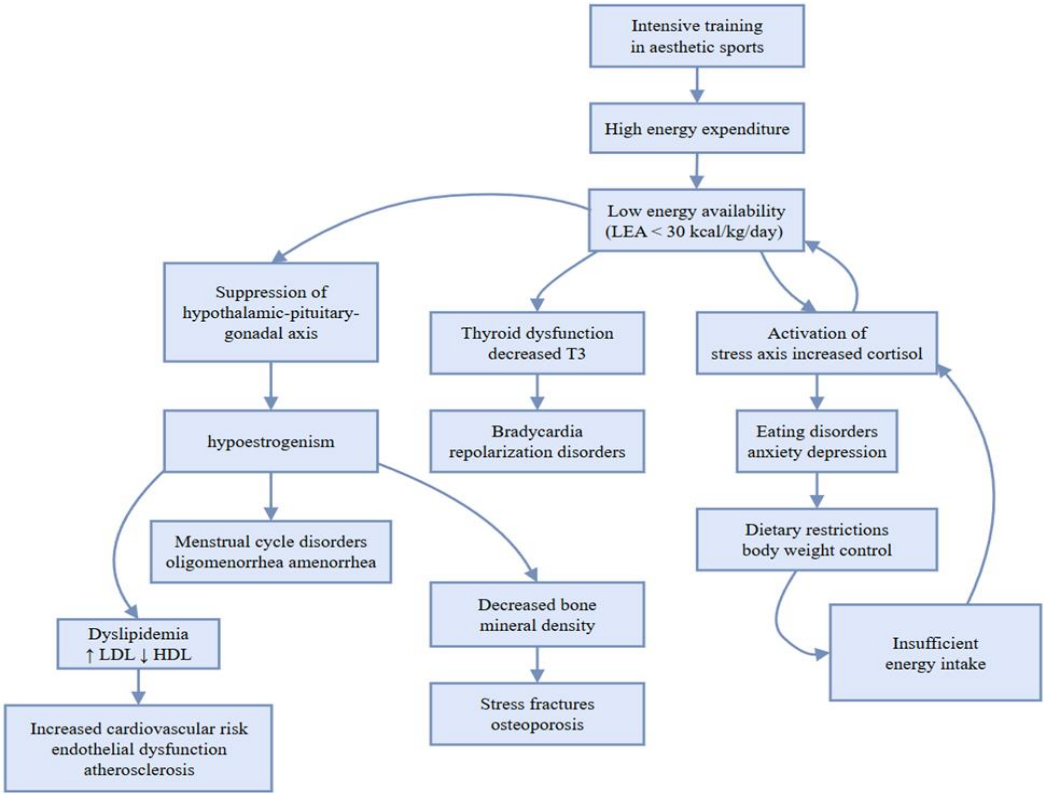

Figure 3. Pathogenetic relationships of health disorders in adolescent girls engaged in aesthetic sports

The diagram clearly demonstrates that low energy availability underlies all identified disorders, triggering multiple pathological cascades. It is important to emphasize that these processes are interconnected and can amplify one another, forming a vicious cycle. For example, hypoestrogenism not only disrupts menstrual function but also exacerbates dyslipidemia, while vitamin D deficiency simultaneously affects both bone metabolism and the cardiovascular system (Dipla *et al*., 2021; Zheng *et al*., 2021).

Logistic regression analysis allowed us to quantitatively assess the contribution of various factors to the development of menstrual cycle disorders. The greatest predictive value was found for

reduced body fat below 18%, which increased risk more than fourfold (Maya & Misra, 2022). This finding is consistent with data from other researchers highlighting the critical role of adipose tissue as an endocrine organ that provides peripheral conversion of androgens to estrogens (Nose-Ogura *et al*., 2024; De Souza *et al*., 2026). Vitamin D deficiency and early initiation of training also emerged as significant predictors, underscoring the need for a comprehensive approach to prevention (Zheng *et al*., 2021; Brzeziański *et al*., 2022).

Our findings indicate that relative energy deficiency in sport is a genuine clinical problem in the population of young female athletes engaged in aesthetic sports (Dave & Fisher, 2022; Mountjoy *et al*., 2023). The high frequency of menstrual cycle disorders, unfavorable lipid profile changes, electrocardiographic abnormalities, and reduced bone density form the basis for long-term risks, including infertility, cardiovascular disease, and osteoporosis in adulthood (Bouillon *et al*., 2024; Holtzman *et al*., 2024; Jouhki *et al*., 2024).

Limitations. The limitations of this study include its cross-sectional design, which does not allow for monitoring of changes over time, and the absence of a control group of athletes not adhering to dietary restrictions. Nevertheless, the results have high practical significance and justify the need to implement screening programs for early detection of RED-S in the population of adolescent girls engaged in aesthetic sports (Coelho *et al*., 2021; Torstveit *et al*., 2023).

Conclusion

This study confirmed a high prevalence of health disorders among adolescent girls engaged in aesthetic sports. Analysis of healthcare visits by 1,840 girls showed that athletes comprised the majority of those seeking care for menstrual cycle disorders and musculoskeletal pain.

In-depth examination of 240 aesthetic sport athletes revealed menstrual cycle disorders in 47.9% of girls, vitamin D deficiency in 78.3%, and critically low body fat percentage in 42.1%. Cardiovascular changes included bradycardia (22.9%), repolarization disorders (20.0%), and mitral valve prolapse (15.8%). Girls with cycle disorders had an unfavorable lipid profile with elevated atherogenic cholesterol fractions.

Statistical analysis showed that the risk of cycle disorders increased 4.2-fold with body fat below 18%, 3.1-fold with vitamin D deficiency, 2.8-fold with early initiation of training, and 2.3-fold with intentional meal skipping. All identified factors are modifiable.

These findings indicate the need to implement RED-S screening in clinical practice with young female athletes, including assessment of menstrual function, eating behavior, body composition, vitamin D levels, and lipid profile. Educational efforts targeting coaches, parents, and athletes regarding the long-term risks of energy deficiency are required. Treatment should begin with restoration of energy balance rather than pharmacological masking of symptoms.

Acknowledgments: None

Conflict of interest: None

Financial support: None

Ethics statement: This study was conducted in accordance with the ethical standards of the institutional research committee of the North Ossetian State Medical Academy and with the principles of the Declaration of Helsinki (2013 revision). The Local Ethics Committee of the North Ossetian State Medical Academy approved the study protocol. All participants and their legal guardians (for minors under 18 years of age) were informed about the purpose and methods of the study, as well as potential risks and benefits. Written informed consent was obtained from all participants and their legal guardians. The study involved prospective data collection and in-depth clinical examination of adolescent athletes, as well as retrospective analysis of medical records. All patient data were processed in compliance with applicable data protection regulations. Patient confidentiality was maintained throughout the study by anonymizing all clinical data, with removal of all personal identifiers before analysis and publication.

References

Ackerman, K. E., Holtzman, B., Cooper, K. M., Flynn, E. F., Bruinvels, G., Tenforde, A. S., Popp, K. L., Simpkin, A. J., Parziale, A. L., et al. (2019). Low energy availability surrogates correlate with health and performance consequences of relative energy deficiency in sport. *British Journal of Sports Medicine, 53*(10), 628–633. doi:10.1136/bjsports-2017-098958

Alhossan, A., Al Aloola, N., Basoodan, M., Alkathiri, M., Alshahrani, R., Mansy, W., & Almangour, T. A. (2024). Assessment of Community Pharmacy Services and Preparedness in Saudi Arabia during the COVID-19 Pandemic: A Cross-Sectional Study. *Annals of Pharmacy Education, Safety, and Public Health Advocacy, 4*, 43-49. doi:10.51847/C52qAb0bZW

Alnabulsi, M., Ali, E. A. A., Alsharif, M. H., Filfilan, N. F., & Fadda, S. H. (2025). Medical students' perceptions, self-confidence, and willingness to handle in-flight medical emergencies: A cross-sectional study. *Bulletin of Pioneer Research in Medical & Clinical Sciences, 5*(2), 63–74. doi:10.51847/EQuNo67MNf

Angelidi, A. M., Stefanakis, K., Chou, S. H., Valenzuela-Vallejo, L., Dipla, K., Boutari, C., Ntoskas, K., Tokmakidis, P., Kokkinos, A., Goulis, D. G., et al. (2024). Relative energy deficiency in sport (REDs): Endocrine manifestations, pathophysiology and treatments. *Endocrine Reviews, 45*(5), 676–708. doi:10.1210/endrev/bnae011

Anunziata, O. A., & Cussa, J. (2024). Development and assessment of cyclophosphamide-loaded microspheres for enhanced topical drug delivery. *Pharmaceutical Science & Drug Design, 4*, 35–42. doi:10.51847/mrkjejeAVc

Besor, O., Redlich, N., Constantini, N., Weiler-Sagie, M., Monsonego Ornan, E., Lieberman, S., Bentur, L., & Bar-Yoseph, R. (2024). Assessment of relative energy deficiency in sport (REDs) risk among adolescent acrobatic

gymnasts. *Journal of Personalized Medicine, 14*(4), 363. doi:10.3390/jpm14040363

Bouillon, R., Antonio, L., & Narinx, N. (2024). Vitamin D status in children. *Journal of Pediatrics (Rio J), 100*(4), 335–339. doi:10.1016/j.jped.2024.04.001

Brzeziański, M., Migdalska-Sęk, M., Stuss, M., Jastrzębski, Z., Radzimiński, Ł., Brzeziańska-Lasota, E., & Sewerynek, E. (2022). Effect of physical training on parathyroid hormone and bone turnover marker profile in relation to vitamin D supplementation in soccer players. *Biology of Sport, 39*(4), 921–932. doi:10.5114/biolsport.2022.109956

Burke, L. M., Ackerman, K. E., Heikura, I. A., Hackney, A. C., & Stellingwerff, T. (2023). Mapping the complexities of relative energy deficiency in sport (REDs): Development of a physiological model by a subgroup of the International Olympic Committee (IOC) consensus on REDs. *British Journal of Sports Medicine, 57*(17), 1098–1108. doi:10.1136/bjsports-2023-107335

Campbell, R. A., Bradshaw, E. J., Ball, N. B., Pease, D. L., & Spratford, W. (2019). Injury epidemiology and risk factors in competitive artistic gymnasts: A systematic review. *British Journal of Sports Medicine, 53*(17), 1056–1069. doi:10.1136/bjsports-2018-099547

Clark, A., & Foster, H. (2025). Network pharmacology integration and experimental verification to elucidate the molecular mechanisms of triptolide in treating membranous nephropathy. *Pharmaceutical Science & Drug Design, 5*, 33–47. doi:10.51847/X9UVmVSJ4E

Coelho, A. R., Cardoso, G., Brito, M. E., Gomes, I. N., & Cascais, M. J. (2021). The female athlete triad/relative energy deficiency in sports (RED-S). *Revista Brasileira de Ginecologia e Obstetrícia, 43*(5), 395–402. doi:10.1055/s-0041-1730289

Constantini, N. W., Dubnov-Raz, G., Chodick, G., Rozen, G. S., Giladi, A., & Ish-Shalom, S. (2010). Physical activity and bone mineral density in adolescents with vitamin D deficiency. *Medicine & Science in Sports & Exercise, 42*(4), 646–650. doi:10.1249/MSS.0b013e3181bb813b

Courtney, A., Wyse, A., Murphy, B., McCarthy, E., Kgosidialwa, O., & Tuthill, A. (2025). Screening for risk of low energy availability in female Gaelic game athletes in Ireland. *Irish Journal of Medical Science, 194*(5), 1617–1624. doi:10.1007/s11845-025-04005-3

Csep, A. N., Voiţă-Mekereş, F., Tudoran, C., & Manole, F. (2024). Understanding and managing polypharmacy in the aging population. *Annals of Pharmacy Practice and Pharmacotherapy, 4*, 17–23. doi:10.51847/VdKr0egSln

Cuenca-Martínez, F., Herranz-Gómez, A., Madroñero-Miguel, B., Reina-Varona, Á., Touche, R. L., Angulo-Díaz-Parreño, S., Pardo-Montero, J., Corral, T. D., & López-de-Uralde-Villanueva, I. (2025). A Systematic Review of the Literature on the Connection Between Cervical Spine Abnormalities and Internal Disorders of the Temporomandibular Join. *Journal of Current Research in Oral Surgery, 5*, 1-10. doi:10.51847/e4CoCM6iSZ

Dave, S. C., & Fisher, M. (2022). Relative energy deficiency in sport (RED-S). *Current Problems in Pediatric and Adolescent Health Care, 52*(8), 101242. doi:10.1016/j.cppeds.2022.101242

De Souza, M. J., Williams, N. I., Misra, M., Nattiv, A., Joy, E., Barrack, M., Ricker, E. A., Gorrell, S., Koltun, K. J., O'Donnell, E., et al. (2025). 2025 update to the female athlete triad coalition consensus statement part 1: State of the science and introduction of a new adolescent model. *Sports Medicine, 56*(2), 327–373. doi:10.1007/s40279-025-02333-z

Dipla, K., Kraemer, R. R., Constantini, N. W., & Hackney, A. C. (2021). Relative energy deficiency in sports (RED-S): Elucidation of endocrine changes affecting the health of males and females. *Hormones (Athens), 20*(1), 35–47. doi:10.1007/s42000-020-00214-w

Dubnov-Raz, G., Azar, M., Reuveny, R., Katz, U., Weintraub, M., & Constantini, N. W. (2015). Changes in fitness are associated with changes in body composition and bone health in children after cancer. *Acta Paediatrica, 104*(10), 1055–1061. doi:10.1111/apa.13052

Gallant, T. L., Ong, L. F., Wong, L., Sparks, M., Wilson, E., Puglisi, J. L., & Gerriets, V. A. (2025). Low energy availability and relative energy deficiency in sport: A systematic review and meta-analysis. *Sports Medicine, 55*(2), 325–339. doi:10.1007/s40279-024-02130-0

Ganea, M., Horvath, T., Nagy, C., Morna, A. A., Pasc, P., Szilagyi, A., Szilagyi, G., Sarac, I., & Cote, A. (2024). Rapid Method for Microencapsulation of *Magnolia officinalis* Oil and Its Medical Applications. *Specialty Journal of Pharmacognosy, Phytochemistry, and Biotechnology, 4*, 29-38. doi:10.51847/UllqQHbfeC

Gould, R. J., Ridout, A. J., & Newton, J. L. (2023). Relative energy deficiency in sport (RED-S) in adolescents - A practical review. *International Journal of Sports Medicine, 44*(4), 236–246. doi:10.1055/a-1947-3174

Grabia, M., Perkowski, J., & Socha, K. (2024). Female athlete triad and relative energy deficiency in sport (REDs): Nutritional management. *Nutrients, 16*(3), 359. doi:10.3390/nu16030359

Grandys, M., Majerczak, J., Frolow, M., Chlopicki, S., & Zoladz, J. A. (2023). Training-induced impairment of endothelial function in track and field female athletes. *Scientific Reports, 13*(1), 3502. doi:10.1038/s41598-023-30165-2

Grant, O., & Wallace, E. (2024). The influence of diversity-focused leadership on employee advocacy in selected Indian Fortune companies: The mediating roles of symmetrical internal communication and work engagement. *Annals of Organizational Culture, Communications and Conflict, 5*, 159–173. doi:10.51847/X2YHdX2Qz7

Heikura, I. A., McCluskey, W. T. P., Tsai, M. C., Johnson, L., Murray, H., Mountjoy, M., Ackerman, K. E., Fliss, M., & Stellingwerff, T. (2024). Application of the IOC Relative Energy Deficiency in Sport (REDs) Clinical Assessment Tool version 2 (CAT2) across 200+ elite athletes. *British Journal of Sports Medicine, 59*(1), 24–35. doi:10.1136/bjsports-2024-108121

Heikura, I. A., Stellingwerff, T., & Areta, J. L. (2022). Low energy availability in female athletes: From the lab to the field. *European Journal of Sport Science, 22*(5), 709–719. doi:10.1080/17461391.2021.1915391

Holtzman, B., Kelly, R. K., Saville, G. H., McCall, L., Adelzedah, K. A., Sarafin, S. R., Nikam, P., Meneguzzi, I., McIntyre,

A., & Kraus, E. K., et al. (2024). Low energy availability surrogates are associated with relative energy deficiency in sport outcomes in male athletes. *British Journal of Sports Medicine, 59*(1), 48–55. doi:10.1136/bjsports-2024-109165

Hooper, D. R., Mallard, J., Wight, J. T., Conway, K. L., Pujalte, G. G. A., Pontius, K. M., Saenz, C., Hackney, A. C., & Tenforde, A. S. (2021). Performance and health decrements associated with relative energy deficiency in sport for Division I women athletes during a collegiate cross-country season: A case series. *Frontiers in Endocrinology, 12*, 524762. doi:10.3389/fendo.2021.524762

Hsiao, F. H., Chen, P. L., Ho, C. C., Ho, R. T. H., Lai, Y. M., & Wu, J. L. (2024). Exploring the impact of cognitive-behavioral therapy on anxiety disorders in children and adolescents. *International Journal of Social Psychological Aspects of Healthcare, 4*, 26–31. doi:10.51847/jcgvRFfQPM

Indirli, R., Lanzi, V., & Mantovani, G., Arosio, M., Ferrante, E. (2022). Bone health in functional hypothalamic amenorrhea: What the endocrinologist needs to know. *Frontiers in Endocrinology (Lausanne), 13*, 946695. doi:10.3389/fendo.2022.946695

Jaafar, N. H., Rahman, I. A., Ter, K. Z., & Ahmad, B. (2024). The impact of non-classroom teaching on musculoskeletal pain in university students amid the COVID-19 pandemic. *Bulletin of Pioneer Research in Medical & Clinical Sciences, 4*(1), 50–57. doi:10.51847/UZ9DyvWUrn

Jabin, A., & Guthrie, A. (2025). Understanding treatment gaps in type 2 diabetes: A qualitative study on why patients stop and restart care. *International Journal of Social Psychological Aspects of Healthcare, 5*, 24–34. doi:10.51847/K4r85uzgEQ

Jouhki, I., Sarin, H. V., Jauhiainen, M., O'Connell, T. M., Isola, V., Ahtiainen, J. P., Hulmi, J. J., & Perola, M. (2024). Effects of fat loss and low energy availability on the serum cardiometabolic profile of physique athletes. *Scandinavian Journal of Medicine & Science in Sports, 34*(1), e14553. doi:10.1111/sms.14553

Kampouri, D., Kotopoulea-Nikolaidi, M., Daskou, S., & Giannopoulou, I. (2019). Prevalence of disordered eating in elite female athletes in team sports in Greece. *European Journal of Sport Science, 19*(9), 1267–1275. doi:10.1080/17461391.2019.1587520

Kiss, J., Critchley, M., Gabel, L., Galarneau, J., Doyle-Baker, P., Ballinger, K., Lun, V., & Emery, C. (2026). Relative energy deficiency in sport (REDs) and site-specific bone mineral density in female adolescent artistic athletes. *Applied Physiology, Nutrition, and Metabolism, 51*, 1–11. doi:10.1139/apnm-2025-0330

Kruse, D. W., Nobe, A. S., & Billimek, J. (2021). Injury incidence and characteristics for elite, male, artistic USA gymnastics competitions from 2008 to 2018. *British Journal of Sports Medicine, 55*(3), 163–168. doi:10.1136/bjsports-2019-101297

Kunie, K., Kawakami, N., Shimazu, A., Yonekura, Y., & Miyamoto, Y. (2025). Examining the impact of managerial communication on the link between nurses' job performance and psychological empowerment. *Annals of Organizational Culture, Communications and Conflict, 6*, 1–7. doi:10.51847/SF5ZX3J4OT

Lee, K. M., Gallucci, A. R., Forsse, J. S., Chapman-Lopez, T. J., Torres, R., de Souza, L. C., Heileson, J. L., & Funderburk, L. K. (2025). The relationship between serum vitamin D, bone mineral density, and injury in collegiate acrobatics and tumbling athletes. *Nutrition and Health, 31*(1), 47–51. doi:10.1177/02601060241292398

Lindstrom, H., Jansson, S., & Lundgren, P. (2025). Hospital pharmacists' knowledge, attitudes, and practices toward clinically significant drug interactions: A multi-center regional survey in Indonesia. *Annals of Pharmacy Practice and Pharmacotherapy, 5*, 13–22. doi:10.51847/AtEgvCNECd

Lisboa, S. C., Vieira, A., Teodoro, J. L., Costa, R., Boeno, F. P., Farinha, J., Bracht, C. G., Reischak-Oliveira, Á., & Dos Santos Cunha, G. (2022). Cardiometabolic health profile of young girls with aesthetic professions. *BMC Women's Health, 22*(1), 15. doi:10.1186/s12905-022-01599-z

Lodge, M. T., Ward-Ritacco, C. L., & Melanson, K. J. (2023). Considerations of low carbohydrate availability (LCA) to relative energy deficiency in sport (RED-S) in female endurance athletes: A narrative review. *Nutrients, 15*(20), 4457. doi:10.3390/nu15204457

Lozano-Berges, G., Matute-Llorente, Á., Gómez-Bruton, A., González-Agüero, A., Vicente-Rodríguez, G., & Casajús, J. A. (2022). Do serum 25-hydroxyvitamin D concentrations affect body composition, physical fitness, bone strength, and bone biomarkers in female children and adolescent football players? A one-season study. *International Journal of Environmental Research and Public Health, 19*(22), 15394. doi:10.3390/ijerph192215394

Lundqvist, C., Kolbeinsson, Ö., Asratian, A., & Wade, T. D. (2024). Untangling the relationships between age, gender, type of sport, perfectionistic self-presentation, and motivation on body satisfaction: A cross-sectional study on aesthetic and non-aesthetic female and male athletes aged 10 to 22 years. *BMJ Open Sport & Exercise Medicine, 10*(3), e001975. doi:10.1136/bmjsem-2024-001975

Magee, M. K., Jones, M. T., Fields, J. B., Kresta, J., Khurelbaatar, C., Dodge, C., Merfeld, B., Ambrosius, A., Carpenter, M., Jagim, A. R., et al. (2023). Body composition, energy availability, risk of eating disorder, and sport nutrition knowledge in young athletes. *Nutrients, 15*(6), 1502. doi:10.3390/nu15061502

Mathisen, T. F., Ackland, T., Burke, L. M., Constantini, N., Haudum, J., Macnaughton, L. S., Meyer, N. L., Mountjoy, M., Slater, G., Sundgot-Borgen, J., et al. (2023). Best practice recommendations for body composition considerations in sport to reduce health and performance risks: A critical review, original survey and expert opinion by a subgroup of the IOC consensus on relative energy deficiency in sport (REDs). *British Journal of Sports Medicine, 57*(17), 1148–1158. doi:10.1136/bjsports-2023-106812

Maya, J., & Misra, M. (2022). The female athlete triad: Review of current literature. *Current Opinion in Endocrinology, Diabetes and Obesity, 29*(1), 44–51. doi:10.1097/MED.0000000000000690

Melin, A. K., Heikura, I. A., Tenforde, A., & Mountjoy, M.

(2019). Energy availability in athletics: Health, performance, and physique. *International Journal of Sport Nutrition and Exercise Metabolism, 29*(2), 152–164. doi:10.1123/ijsnem.2018-0201

Meyer, A., Haigis, D., Klos, B., Zipfel, S., Resmark, G., Rall, K., Dreser, K., Hagmann, D., Nieß, A., Kopp, C., et al. (2025). Relative energy deficiency in sport-multidisciplinary treatment in clinical practice. *Nutrients, 17*(2), 228. doi:10.3390/nu17020228

Miciak, M., & Jurkiewicz, K. (2024). Recent advances in the diagnostics and management of medullary thyroid carcinoma: Emphasis on biomarkers and thyroidectomy in neuroendocrine neoplasms. *Archives of International Journal of Cancer and Allied Sciences, 4*(1), 17–23. doi:10.51847/ar1ylTQfNa

Mickevičius, I., Astramskaitė, E., & Janužis, G. (2024). A systematic review of the implant success rate following immediate implant placement in infected sockets. *Journal of Current Research in Oral Surgery, 4*, 20–31. doi:10.51847/PcPJL1v1XF

Ming, S., Lei, Z., & Jie, W. (2025). Peripheral neuropathy in diabetes patients at Jimma University Medical Center: Magnitude and contributing factors. *Interdisciplinary Research in Medical Sciences Special, 5*(2), 1–9. doi:10.51847/2aT3p1KejS

Morgan, A. L., Foster, D. K., & Collins, I. J. (2025). Disparities in HER2-targeted therapy adoption and survival impact in metastatic HR−/HER2+ breast cancer: NCDB cohort study. *Asian Journal of Current Research in Clinical Cancer, 5*(2), 1–11. doi:10.51847/AZI4JURGlQ

Mountjoy, M., Ackerman, K. E., Bailey, D. M., Burke, L. M., Constantini, N., Hackney, A. C., Heikura, I. A., Melin, A., Pensgaard, A. M., Stellingwerff, T., et al. (2023). 2023 International Olympic Committee's (IOC) consensus statement on relative energy deficiency in sport (RED-S). *British Journal of Sports Medicine, 57*(17), 1073–1097. doi:10.1136/bjsports-2023-106994

Nicotra, D., Arieli, R., Redlich, N., Navot-Mintzer, D., & Constantini, N. W. (2023). Iron deficiency and anemia in male and female adolescent athletes who engage in ball games. *Journal of Clinical Medicine, 12*(3), 970. doi:10.3390/jcm12030970

Nose-Ogura, S., Yoshino, O., Kamoto-Nakamura, H., Kanatani, M., Harada, M., Hiraike, O., Saito, S., Fujii, T., & Osuga, Y. (2024). Age and menstrual cycle may be important in establishing pregnancy in female athletes after retirement from competition. *Physician and Sportsmedicine, 52*(2), 175–180. doi:10.1080/00913847.2023.2199687

Novak, T. J., & Dvorak, P. M. (2025). A spatiotemporal neural network framework for EEG-based emotion recognition in depression assessment. *Journal of Medical Science & Interdisciplinary Research, 5*(2), 24–38. doi:10.51847/A2pBOYHJW1

Osluf, A. S. H., Shoukeer, M., & Almarzoog, N. A. (2024). Case report on persistent fetal vasculature accompanied by congenital hydrocephalus. *Asian Journal of Current Research in Clinical Cancer, 4*(1), 25–30. doi:10.51847/0gjOEudJNr

Pawluczyk, M., Zwoliński, M., Korpalski, M., Pawlikowski, K., Żygłowicz, M., Torbicki, A., Augustyn, D., Gaworek, P., Marciniak, M., Trybuła, A., et al. (2025). The impact of intensive sports training on the development of young girls. *Quality in Sport, 42*, 61190. doi:10.12775/QS.2025.42.61190

Perone, F., Peruzzi, M., Conte, E., Sciarra, L., Frati, G., Cavarretta, E., & Pingitore, A. (2023). An overview of sport participation and exercise prescription in mitral valve disease. *Journal of Cardiovascular Development and Disease, 10*(7), 304. doi:10.3390/jcdd10070304

Rani, N., & Gehrke, P. (2025). Promoting intercultural competence in German medical students via innovative medical ethics education focused on Muslim patients – A pilot study. *Asian Journal of Ethics in Health & Medicine, 5*, 1–12. doi:10.51847/0foncaeXr1

Raza, S., Khan, A., Mehmood, F., & Farooq, U. (2025). Nationwide implementation of essential pharmacogenomic testing in the Netherlands: A decision-analytic model of lives saved and cost-effectiveness. *Special Journal of Pharmacognosy, Phytochemistry & Biotechnology, 5*, 39–49. doi:10.51847/PUWEymkYkk

Ribeiro, A., Martins, S., & Fonseca, T. (2024). Progress and gaps in national medicines policy implementation in SADC member states: A comprehensive desktop review. *Interdisciplinary Research in Medical Sciences Special, 4*(1), 42–56. doi:10.51847/0eVBxAI8y0

Schneider, T. L., & Krüger, B. E. (2025). Breast cancer-specific mortality in stage IV patients with small tumors: Insights from a population-based cohort. *Archives of International Journal of Cancer and Allied Sciences, 5*(2), 1–12. doi:10.51847/b9vFcweAVg

Shen, F., & Bao, L. (2025). Studying the effects of music on the time to gain independent oral feeding in premature infants. *Journal of Integrated Nursing & Palliative Care, 6*, 1–6. doi:10.51847/xBTC4CiH10

Silvennoinen, J. I. K., Sipilä, P. N., Valtonen, M., Mjøsund, K., Kinnula, V., Hirvelä, L., Mierlahti, L., & Ihalainen, J. K. (2025). Association between the risk of relative energy deficiency in sport and cholesterol levels in Finnish endurance athletes. *BMJ Open Sport & Exercise Medicine, 11*(3), e002644. doi:10.1136/bmjsem-2025-002644

Solmell, O., Sterner, P. D., & Berg, S. (2024). MRI of chronic low back pain: Correlation between pain, disability, and disc herniation. *Journal of Medical Science & Interdisciplinary Research, 4*(1), 22–27. doi:10.51847/hTOnlU7PdK

Stenqvist, T. B., Melin, A. K., & Torstveit, M. K. (2023). Relative energy deficiency in sport (REDs) indicators in male adolescent endurance athletes: A 3-year longitudinal study. *Nutrients, 15*(24), 5086. doi:10.3390/nu15245086

Taim, B. C., Ó Catháin, C., Renard, M., Elliott-Sale, K. J., Madigan, S., & Ní Chéilleachair, N. (2023). The prevalence of menstrual cycle disorders and menstrual cycle-related symptoms in female athletes: A systematic literature review. *Sports Medicine, 53*(10), 1963–1984. doi:10.1007/s40279-023-01871-8

Torstveit, M. K., Ackerman, K. E., Constantini, N., Holtzman, B., Koehler, K., Mountjoy, M. L., Sundgot-Borgen, J., & Melin, A. (2023). Primary, secondary, and tertiary prevention of relative energy deficiency in sport (REDs): A narrative

review by a subgroup of the IOC consensus on REDs. *British Journal of Sports Medicine, 57*(17), 1119–1126. doi:10.1136/bjsports-2023-106932

Uneno, Y., Morita, T., Watanabe, Y., Okamoto, S., Kawashima, N., & Muto, M. (2024). Supportive care requirements of elderly patients with cancer refer to Seirei Mikatahara General Hospital in 2023. *Journal of Integrated Nursing & Palliative Care, 5*, 42–47. doi:10.51847/lmadKZ2u1J

von Brackel, F. N., Munzinger, R., Bartosik, M., Simon, A., Barvencik, F., Oheim, R., & Amling, M. (2025). Impact of relative energy deficiency in sport (REDs) on bone health in elite athletes: A retrospective analysis. *Journal of Cachexia, Sarcopenia and Muscle, 16*(5), e70082. doi:10.1002/jcsm.70082

Wasserfurth, P., Halioua, R., Toepffer, D., Lautz, Z., Engel, H., Melin, A. K., Torstveit, M. K., Claussen, M. C., & Koehler, K. (2025). Screening for relative energy deficiency in sport: Detection of clinical indicators in female endurance athletes. *Medicine & Science in Sports & Exercise, 57*(6), 1257–1265. doi:10.1249/MSS.0000000000003644

Williams, N. I., De Souza, M. J., Misra, M., Nattiv, A., Joy, E., Barrack, M., Ricker, E. A., Gorrell, S., Koltun, K. J., O'Donnell, E., et al. (2025). 2025 update to the female athlete triad coalition consensus statement part 2: Clinical guidelines for screening, diagnosis, treatment, and return to play for adolescents and adults. *Sports Medicine, 56*(2), 375–427. doi:10.1007/s40279-025-02332-0

Wong, Y., Lin, S., Cheng, H., Hsieh, T., Hsiue, T., Chung, H., Tsai, M., & Wang, M. (2025). Understanding the Impact of Medical Humanities on Internship Training and Performance. *Annals of Pharmacy Education, Safety, and Public Health Advocacy, 5*, 12-21. doi:10.51847/Z1fogzPksy

Zheng, C., Li, H., Rong, S., Liu, L., Zhen, K., & Li, K. (2021). Vitamin D level and fractures in children and adolescents: A systematic review and meta-analysis. *Journal of Bone and Mineral Metabolism, 39*(5), 851–857. doi:10.1007/s00774-021-01238-x