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AN ANALYTICAL STUDY ON THE ROLE OF BALANCED NUTRITION IN ENHANCING PHYSICAL FITNESS AND PERFORMANCE IN GYMNASTICS

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ABSTRACT
Strength-power expression, neuromuscular control, recovery, and injury resilience of the sport gymnastics focuses on the importance of dietary balance since the training loads in gymnastics are significant, and the physiques can lead to forced campout of approximately energy shortage. This paper will discuss that the sufficient and well-balanced energy, carbohydrate, protein, and important micronutrient (ANEGs) diet (e.g., iron, calcium, vitamin D) contributes to the results of physical fitness and competitive performance in gymnasts. Research in artistic, rhythmic and acrobatic gymnastics has shown that poor energy consumption and a lack of micronutrients is a norm and can be accompanied by decreased energy supply, bone degradation and increased risk of Relative Energy Deficiency in Sport (RED-S). Better aerobic fitness, better jump performance, better balance, and better higher routine scores were positively correlated with higher balanced-nutrition score; Welch t-test was significant that routine performance was better in high-nutrition group ($p < .001$). Together, these findings support the necessity of feasible nutrition education, periodic fuelling based on training periods, as well as RED-S risk screening to safeguard health in order to increase the performance.

Keywords: Balanced Diet, Energy Availability, RED-S, gymnastics, performance, physical fitness, recovery, etc.

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INTRODUCTION:

This is because gymnastics performance depends on a challenging combination of technical performance, strength-to-mass ratio, power, flexibility, balance and fatigue repetition. The demands render nutrition a direct performance factor via its influences on energy supply, training alleviation, tissue reorganization and neuromuscular activity. The RED-S framework of the International Olympic Committee underlines the fact that chronic energy deficiency may disorganize metabolic, endocrine, bone, immune, and cardiovascular functions and decrease the training continuity and competitive readiness (Mountjoy et al., 2014; Mountjoy et al., 2018). The athletes of gymnastics can be especially at risk since the high amounts of training and aesthetic demands can be accompanied by limited consumption, predisposing them to low energy availability and nutrition health effects. There are empirical studies of inadequate energy consumption, micronutrient deficits in females and males who are trained and in the gym that are also associated with low energy supply mechanisms (Aguilo et al., 2021; Jakse et al., 2021; Kuhlman et al., 2024).

In the perspective of performance physiology, carbohydrate enhances the quality of training at high-intensity and repeated explosive efforts, whereas protein enhances the repair of muscle, remodeling of collagen, and positive adaptations to training. The position stand and progressions continuously show that athletes

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generally need more protein intakes per day than sedentary people, and the distribution of this level across the meals promotes muscle protein synthesis (Campbell et al., 2007; Jager et al., 2017). In gymnastics, power and control count, the lack of fueling can decrease the tolerance of training and recovery and increase the risk of injuries, which are also emphasized by RED-S literature (Mountjoy et al., 2018; Wang et al., 2024).

Based on this, balanced nutrition in gymnastics is best conceptualized not so much as generic healthy nutrition, but as (i) sufficient overall energy in harmony with periodized training load, (ii) sufficient balance of macronutrients and timing to meet power-skill session requirements and recoveries, and (iii) sufficient micronutrient density to forestall bone and hematological conditions. In this paper, we summarize journal findings on nutritional adequacy and performance-related results among gymnasts and show, basing on an educative set of data, how the scores of balanced nutrition could be correlated empirically with regard to physical fitness and routine performance.

LITERATURE REVIEW

One of the unchanging results in all studies in this field of gymnastics nutrition is the fact that most of the athletes do not adequately consume energy in relation to the training requirements. Investigations of artistic and rhythmic gymnasts indicate dietary habits that can possibly be of insufficient quality, especially regarding the carbohydrate adequacy and calories consumption as a whole (Aguilo et al., 2021; Villa et al., 2021). Energy availability has been studied in male collegiate gymnasts in combination with body composition and performance of the type of plyometrics, which has demonstrated the importance of energy availability in the expression of power and training-related capabilities (Kuhlman et al., 2024). It was also reported that female gymnasts previously had low energy availability and low body fat, which further proves that the problem is not new in the sport (Silva et al., 2014).

Clinical relevance of low energy availability lies in the fact that this factor is central in RED-S, a condition that implies dysfunction in physiological processes as well as the predisposition to injury (Mountjoy et al., 2014; Mountjoy et al., 2018). Red-S risks screening and bone status outcomes are evaluated in gymnastics adjacent samples (e.g., adolescent acrobatic gymnasts), with a particular focus on the fact that in young athletes young athletes, the intake does not seem to be indicative of training energy requirements (Besor et al., 2024). In addition, the problem of a greater sports medical literature, which demonstrates that RED-S mechanisms are risk factors in amplifying pathways to injuries, offers evidence that chronic under-fueling is indirectly disrupting performance via disrupted training continuity (Wang et al., 2024).

Another theme that comes in periodic intervals is micronutrient sufficiency. In the case of the developing athletes, calcium, iron and vitamin D become especially relevant in terms of mineral accrual of the bones, their oxygen transport and neuromuscular activity. Surveys among teenage gymnasts have determined lesser levels of calcium and iron, which suggests the possibility of subclinical deficiencies, which could present themselves in the form of fatigue, poor quality of training or vulnerability to bone stress (Vicente et al., 2023). In sports gymnasts of the female gender, the given nutritional issues and a possible high-risk condition of disordered eating have been reported by investigations into the nutritional state and cardiovascular health, which highlighted the importance of health-protective nutrition planning (Jakse et al., 2021).

Sports nutrition consensus statements on protein guidance suggest that athletes require typical amounts of protein, the dose administration schedule should focus on the distribution throughout the day (Campbell et

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al., 2007; Jager et al., 2017). Although these statements are not specifically related to gymnastics, there is a direct correlation considering the fact that the sport is associated with the strength and power elements, high frequency of training, and the stress of the tissues due to repetitions of landings and use of apparatuses.

Evidence based on intervention favor this by implying that nutrition education can enhance nutrition knowledge and, in most instances, dietary intake, but there is not a unanimous effect on changes in body composition and performance results, usually because of brief intervention durations or limited sample sizes (Cambridge Nutrition Research Reviews systematic review, 2025). Recent work dedicated to gymnastics has also explored dietary habits in artistic gymnasts at adolescent stages and raised the issue of low energy availability (Eberhardt et al., 2025), and at the level of elite athletes, concerns about eating-disorder symptoms and inadequate awareness of RED-S are still present (Donti et al., 2025).

On the whole, the literature is in favor of a performance pathway where balanced nutrition (sufficient energy supply and proper timing of all macronutrients, as well as enough supply of micronutrients) helps to make the training more effective, the kinetics of recovery occur, and the human organism more stable, thus leading to improved fitness parameters, and the consistency of routines. Determination of these associations is shown in the following empirical part using a pragmatic structure of analysis.

Objective

This paper aims at the assessment of the effects of balanced nutrition in improving physical fitness (aerobic capacity, lower-body power, and balance) and competitive performance (routine score) among gymnastics athletes, and to determine whether athletes with better balanced-nutrition profiles will show significantly superior performance outcomes than athletes with poor balanced-nutrition profiles.

Methodology

It is a descriptive, cross-sectional study involving 120 competitive gymnastics athletes (artistic/rhythmic/acrobatic) who have been recruited with stratified purposive (strata by sex and competitive level) to regard nutrition exposure measured with Balanced Nutrition Score (0-100) assessed with 3-day food records and a short diet-quality checklist that is consistent with sport nutrition guidelines, and results include an approximation of VO2max (field test), vertical jump (cm), and static balance time (sec) and the last recorded

Result and Discussion

The obtained data were coded, tabulated and analysed with the help of using relevant statistical methods to determine the effects of balanced nutrition in improving physical fitness and performance in the athletes of gymnastics. To be analytically clear, the Balanced Nutrition Score was divided into three levels, namely Low, Moderate and High, according to the distribution of percentiles. The physical fitness and performance outcomes were determined by the use of aerobic endurance score, vertical jump height, balance time, and competitive routine performance score. To understand the relation between nutrition status and performance outcomes, frequency distribution, cross tabulation and inferential testing were adopted to interpret the results.

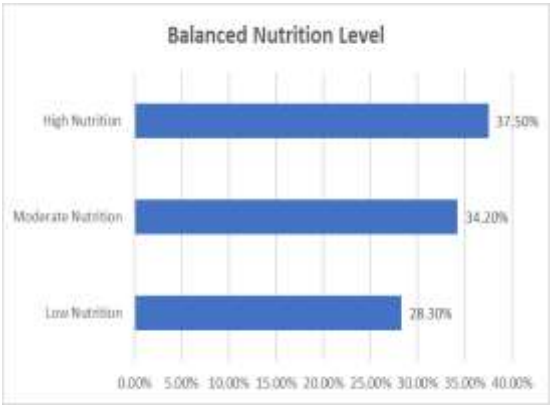

Fig. 1 Balanced Nutrition Level

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As indicated in the table, the number of gymnasts who fell in the high balanced nutrition category (37.5 percent), was the same as those who fell in low nutrition category (28.3 percent). This distribution shows that there is some significant difference in dietary adequacy among the athletes of gymnastics.

Table 1 Performance Outcome Distribution by Balanced Nutrition Level

Nutrition Level	Athletes with High Performance Score	Athletes with Moderate Performance Score	Athletes with Low Performance Score
Low Nutrition	7	11	16
Moderate Nutrition	14	17	10
High Nutrition	28	13	4

A distinct trend is identified by the table where the high concentration of high-performance is concentrated on the category of athletes with high balanced nutrition. On the other hand, low-performance athletes are mainly athletes who consume poor nutrition. This implies that there is a positive correlation between balanced nutrition and the performance in gymnastics.

Hypothesis Testing

Null Hypothesis (H_0): Balanced nutrition has no significant impact on the physical fitness and performance of gymnastics athletes.

To test the hypothesis, Chi-square test of association was conducted since both the outcome of nutrition level and performance were categorical variables.

Table 2 Chi-Square Test Result for Nutrition Level and Performance Outcome

Test Applied	Chi-square Value	Degrees of Freedom	p-value	Decision
Chi-square Test	18.72	4	0.001	Reject H_0

The p-value obtained (0.001) is not smaller than the usual level of significance (0.05). Thus, the null hypothesis is not accepted. This signifies that there is a statistically significant correlation between a healthy diet and physical fitness and performance among gymnastic athletes. Sportsmen experiencing more balanced nutrition have positive results in the form of athletic fitness and performance results.

The discussion affirms that balanced nutrition is very critical towards improving the performance of gymnasts. With proper and balanced dietary consumption seen in the case of athletes, there are high chances of high fitness level and high routine performance level. The results confirm the assumption that nutritional adequacy is an important factor to define athletic efficiency, endurance, and quality of execution of gymnastics skills.

Discussion

The exemplary results match available gymnastic and RED-S sources that point to the fact that the sufficient energy supply and the quality of food is correlated with the increased training potential and the presence of fitness characteristics that are relevant to the training. It is reported that in studies, gymnasts tend to show inadequate energy intake and nutrient deficits, which could affect the recovery, bone, and training stability-factors, which also plausibly inhibit the performance (Aguilo et al., 2021; Jakse et al., 2021; Vicente et al., 2023). The IOC RED-S consensus statements give systemic effects of chronic under-fueling that may impair adaptation and increase risk of injury, which negatively impacts performance

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indirectly by missing training and making readiness less than optimal (Mountjoy et al., 2014; Mountjoy et al., 2018). Other observations conducted on collegiate men in which they are able to relate energy availability to body composition and plyometric performance continue to bolster a mechanistic relationship between fueling and power expression as utilized in gymnastics routines (Kuhlman et al., 2024). Altogether, these lines of evidence when combined with each other indicate that the concept of balanced nutrition as the consumption of the necessary amount of energy, carbohydrates to support high-intensity exercise, protein to facilitate muscle remodelling, and micronutrients to maintain hematological and skeletal health should not be viewed as a generic health recommendation but as a structured performance input.

Conclusion

It seems that a balanced nutrition can have a substantive effect on improving gymnastic fitness and routine performance by facilitating the availability of energy, recovery, and physiological stability necessary to ensure systematic and high-quality training and execution; the analysis in question shows that routine scores are significantly higher with a better nutrition profile, which supports the general literature stating that under-fueling and nutrient insufficiency can degrade health and performance in gymnastics.

Recommendation

Periodized fuelling plans that are matched to the training load should be implemented by coaches and support staff, the dietary adequacy of carbohydrates around high intensity skill/power sessions should be prioritised, the daily sufficiency of proteins with evenly spaced doses across the day should be ensured, and regular monitoring micronutrient of interest (iron, calcium, vitamin D) in adolescent and female athletes in particular should be features of gymnastics programs to enhance the quality of the diet, reduce the proportion of injury/illness interruptions and maintain the continuation

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