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Impact of Short-Term Parental Nutrition Education on the Performance and Body Composition of Young Basketball Players: A Pre-Post Intervention Study

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Research Article

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Abstract

Purpose

This study aimed to investigate the impact of nutrition education provided to parents on the sports performance and body composition of young basketball players.

Methods

This study involved 30 young players, aged 8 to 13 years, who participated in a Basketball team. This questionnaire included socio-demographic data, eating habits, and an assessment of sports nutrition knowledge. Anthropometric measurements of participants were taken before the beginning of sports nutrition education and performance tests. A 3-day food consumption record form was utilized employing the retrospective recall method in pre- and post-education. The players' body compositions were assessed via bioelectrical impedance analysis.

Results

The mean age of the players was 10.2 ± 1.5 years. The mean body fat percentage of the players before and after the education was 9.6% ± 6.1 and 8.9% ± 4.9, respectively ($p < 0.05$). The players' parents mean pre-education nutrition knowledge score was 34.0 ± 17.6, but their post-education nutrition knowledge score mean was 57.5 ± 11.7. Sub-group analysis revealed that participants who achieved a higher increase in protein intake gained significantly more lean body mass compared to the low-change group.

Conclusion

These findings highlight the importance of involving parents in nutritional interventions targeting young players.

Trial Registration:

ClinicalTrials.gov Identifier: NCT07344870. Registered 09 December 2025 - Retrospectively registered.

1. Introduction

Adolescence represents a crucial period characterized by rapid growth and alterations in body composition. Healthy eating during this period is essential for physical health, cognitive development, and the prevention of chronic diseases in later life. Nutrition plays a key role in supporting the performance and health of players not only adults but also during early adolescence (1). Considering the

physiological demands of young players resulting from growth and heightened physical activity, it is crucial to offer recommendations in nutritional guidelines that meet their energy and macro- and micronutrient requirements. Adolescent dietary guidelines should emphasize macronutrient intake, micronutrient adequacy, and the promotion of healthy eating habits. Nutritional guidelines recommend that carbohydrates should constitute 45–60% of daily energy intake, with priority given to whole grains and fiber-rich foods (2). Protein intake is crucial, particularly for individuals involved in physical activity, as it facilitates muscle growth and repair (3). Incorporating healthy fats from sources like fish, nuts, and avocados is essential for promoting overall health and physical development (4).

Adolescent players exhibit elevated energy and nutritional requirements relative to their non-exercising counterparts due to the simultaneous demands of growth, development, and athletic performance (3). Studies indicate that a balanced diet, abundant in macronutrients, particularly carbohydrates, proteins, and healthy fats, is essential for enhancing performance and recovery (4–6). Carbohydrates are essential as they function as the main energy source for high-intensity exercise, with recommendations indicating that players should intake between 6–10 g. Complex carbohydrates provide significant sources of dietary fiber and vitamins that play a role in energy metabolism, such as thiamine, riboflavin, and niacin. Protein consumption is essential for facilitating muscle repair and growth in young players. Current recommendations suggest a protein intake of 1.2–1.7 g/kg (4, 7).

Adolescent players face a risk of micronutrient deficiencies, which can adversely affect their performance and overall health. Adolescents require elevated levels of specific vitamins and minerals, including calcium and iron, to facilitate bone development and mitigate the risk of anemia. Numerous young adolescents have indicated that they fail to meet micronutrient recommendations, particularly regarding fruit and vegetable intake (8). Adolescents should decrease their intake of sugary beverages and fast food while enhancing their consumption of fruits, vegetables, dairy products, and whole grains (9). This is because the vitamins and minerals required by adolescent players are mainly found in milk and dairy products, fruits and vegetables, and whole grains. In addition, sugary beverages have a high energy load that can lead to the accumulation of energy in adipose tissue, which may negatively affect sports performance (3).

Hydration is considered an essential component of nutrition for young players. Maintaining adequate fluid intake before, during, and after exercise is essential for performance and dehydration prevention (5, 6). Players should be advised to consume water consistently, and the inclusion of electrolyte-rich beverages should be contemplated during extended or vigorous exercise periods. Electrolyte-rich beverages facilitate the replacement of electrolytes lost via perspiration, thereby preventing fluid-electrolyte imbalances. Recommended fluid intake ranges from 90–240 mL every 20 minutes for young players to up to 1.0 L per hour for older adolescents, depending on sweat rate and environmental conditions. Monitoring pre- and post-exercise body weight provides a practical estimate of fluid losses, as each 0.45 kg reduction corresponds to approximately 480–600 mL of fluid that should be replaced (3).

Nutritional education is essential for planning balanced meals, understanding the significance of food timing, and recognizing the role of various food groups in enhancing athletic performance (10, 11). Nutritional education is essential for understanding individual requirements for macro and micronutrients, dietary fiber, and daily fluid intake. The impact of optimal nutritional behaviors on physical and mental well-being is evident, as are the negative health risks associated with inadequate and unbalanced nutritional habits. Adolescence is a crucial period for nutrition, characterized by increased physiological requirements. Nutritional education is particularly crucial for young adolescent players, who represent a group at increased risk regarding nutrition, due to increased nutritional requirement, increased risk of eating disorders such as anorexia nervosa, bulimia nervosa, and synthesis of sex hormones. This period represents an exploration of identity, during which negative habits may also emerge. To enhance the effectiveness of nutrition education during adolescence, it is essential to involve parents as caregivers and coaches in the educational process (10–13). Parents or primary caregivers, through various processes and behaviors, instill in their children's certain mechanisms which are important from the health perspective and can be helpful and contribute to the proper development of nutritional practices (14). While parents or primary caregivers undeniably play a crucial role in motivating young players, the manner and extent of their involvement are key (15). In addition, the importance of parents in nutrition education and diet is an indispensable factor. However, according to previous studies, the influence of coaches on players' nutrition cannot be ignored (16). However, limited studies have evaluated the effect of nutrition education given to parents or primary caregivers of young basketball players, highlighting a research gap. Although several studies have addressed the nutritional needs of young players, few have focused on the role of parental nutrition education in shaping the dietary habits and performance outcomes of children engaged in organized sports. Given that children aged 8–13 rely heavily on their parents for food choices, developing and evaluating an evidence-based nutrition education program for parents of basketball players is essential to promote optimal growth, performance, and long-term healthy behaviors. This study aimed to investigate the impact of nutrition education provided to parents of young basketball players' sports performance and body composition. We hypothesized that parental nutrition education would significantly improve players' body composition and performance outcomes.

2. Materials and methods

Participant

This study involved 30 young basketball players, aged 8 to 13 years, who participated in the Burdur Mehmet Akif Ersoy University Basketball team from May to July 2023. A single-group pre-post quasi-experimental design was used. The sample size was determined based on feasibility within the basketball team context. A post-hoc power analysis was performed using G*Power 3.1 software for a two-tailed paired-sample t-test. With an α level of 0.05, a sample of 30 participants, and an observed large effect size (Cohen's d = 0.8), the achieved statistical power (1 - β) was 0.95. Therefore, the study was sufficiently powered to detect medium-to-large differences between pre- and post-education

measurements. This power level is consistent with previous intervention studies in young or adolescent athletes (5, 17, 18).

Ethics approval

The parents of the players involved in the study were informed about the research; the informed consent form was obtained from all of parents. Prior to commencing the study, ethical approval was secured from the Burdur Mehmet Akif Ersoy University Non-Interventional Research Ethics Committee (Approval No: GO 2023/206, Date: April 5, 2023) before beginning of data collection and was registered at ClinicalTrials.gov (Identifier: NCT07344870; registration date: 09 December 2025).

Procedures

Before the start of the study, a questionnaire developed by the researchers was administered to the parents (see additional file 1). This questionnaire included socio-demographic data, eating habits, and an assessment of sports nutrition knowledge for young adolescent players. At the same time, anthropometric measurements of young adolescent players were taken prior to the beginning of sports nutrition education and performance tests. A retrospective 3-day food consumption record form was utilized employing the retrospective recall method. Food consumption was recorded over two weekdays and one weekend day, with the data presented as the average for the three days. The same questionnaire and forms were administered to the parents post-training, and the performance and anthropometric measurements of the players were reassessed education. Training volume was assessed using a self-reported training diary completed by the players and verified by their coaches. Players recorded the duration (minutes per session) and frequency (sessions per week) of their training over the previous four weeks. Weekly training volume was calculated as the product of session duration and frequency (minutes/week). Assessments were repeated 4 weeks after baseline. The Nutrition Knowledge Level Test was utilized to assess the sports nutrition knowledge of parents and evaluate the effectiveness of the education provided on this topic.

Sport Nutrition Knowledge Level Test

The Sports Nutrition Knowledge Level Test (SNKT) was created by Torres-McGehee et al. (19) and then adapted into Turkish by Dener (20). The test consists of 20 questions, with a scoring scale of 100 points. Each question is assigned a value of 5 points for a correct answer and 0 points for an incorrect response. A correct response to 15 questions (greater than 75 points) demonstrates a sufficient level of knowledge. Higher scores indicate a greater level of sport nutrition knowledge.

Dietary Assessment

The players' parents were requested to complete the 3-day food consumption record form in detail, utilizing the retrospective recall method for the young basketball players. Players were instructed to complete a 3-day food consumption record over three consecutive days (Thursday, Friday, Saturday, or Sunday, Monday, Tuesday), ensuring that one of these days fell on the weekend. They were required to

document the foods consumed, including water, along with the quantity (weight, portion), cooking method, and food content. Meal and Food Photograph Catalog (21) and Standard Recipes for Caterings (22) books were used to determine the food quantities and the amounts included in the portions of the meals. The completed food consumption record was subsequently entered into the Nutrition Information System (BEBİS 8.0, Stuttgart, Germany). All 3-day dietary records were analyzed and entered into the Nutrition Information System by the same registered dietitian to ensure consistency in data interpretation and nutrient coding. The Nutrition Information System used in this study has been previously validated for estimating macro- and micronutrient intakes in Turkish populations (23). The mean daily intake levels of energy, macronutrients, and micronutrients for the players were evaluated.

Anthropometric Measurements

Anthropometric measurements such as height, body weight, Body Mass Index (BMI), and body composition were conducted to evaluate nutritional status and monitoring growth. Height was measured with feet positioned side by side and the head in line in the Frankfort plane, ensuring the eye triangle and auricle were at the same level and parallel to the ground. Body weight was recorded with players removing their shoes and wearing light clothing. The device quantifies weight in kg with an accuracy of 0.1 kg. To ensure accurate weight measurement, it was considered that individuals had fasted for a minimum of 4 hours, refrained from fluid intake, and did not experience frequent urination. The calculation of BMI involves dividing an athlete's body weight in kilograms (kg) by the square of their height in meters (m^2). Waist circumference was assessed at the midpoint between the lowest rib and the crista iliac crest using a non-elastic tape measure. Prior to the measurement of waist circumference, individuals were instructed to remove any items and clothing that could obstruct the measurement process. To ensure accurate measurement, the individual stood upright with a relaxed abdomen, arms positioned at their sides, feet together, and faced directly towards the person conducting the measurement. The measurements were documented in centimeters with a precision of 0.1 cm. Hip circumference was assessed with the players in a lateral position, measuring from the highest point parallel to the floor using a non-stretchable plastic measuring tape. The players' body compositions were assessed on a non-training day, in a fasted state, wearing light clothing, utilizing bioelectrical impedance analysis (BIA). Basal metabolic rate was estimated via the BIA device output. To reduce variability, all measurements were taken by the same trained operator at the same time of day (morning) under standard conditions. Participants arrived after fasting for at least four hours, avoided drinking fluids, caffeine, and vigorous exercise for at least 12 hours, emptied their bladders within 30 minutes of the assessment, took off any metal accessories, and were measured barefoot in light clothing in a room temperature (about 22–24°C). The order of the measurements stayed the same for all sessions, and the device checks that the manufacturer suggested were done before each session.

Performance Tests

Physical performance tests were conducted to assess the players’ speed, strength, and endurance. The testing session included a 20-m sprint, vertical jump, handgrip strength, and sit-and-reach flexibility test.

All procedures followed validated protocols recommended by the American College of Sports Medicine (24) and the European College of Sport Science (25). Tests were performed in the following order to minimize fatigue effects: flexibility, handgrip strength, vertical jump, and 20-m sprint. Each participant was allowed one familiarization trial per test and two recorded attempts, with the best score used for analysis. Handgrip strength was measured using a Takei 5401 digital dynamometer, vertical jump performance with a Smart Jump System, and sprint time with photocell timing gates. All tests were supervised by trained researchers to ensure standardization and reliability.

Nutrition Education Module

The nutrition education presentation was carried out by the researchers in a single 90-minute session online (via Zoom) following the initial questionnaire, performance tests, and anthropometric measurements. The session involved young basketball players, their parents (e.g. mother, father and/or other primary caregivers), and team coaches to ensure a consistent nutrition message across family and sports settings. The nutrition education encompassed the macro and micronutrients essential for adolescents during their growth and development, detailing their required quantities and significance in sports nutrition, healthy meal choices, and guidelines for consumption before, during, and after competitions and training sessions. The importance of water intake was elucidated, and guidance was offered regarding the adequate fluid consumption throughout training and competition. The session concluded with a Q&A segment of young players and their parents regarding nutritional management.

Statistical Analysis

The data obtained from the study were analyzed using IBM SPSS (Statistical Package for Social Sciences) version 27.0. Descriptive statistical methods used for the data evaluation included mean ± standard deviation ($\bar{x}$ ± SD), count (n), and percentage (%). In analyzing the differences between the groups, a paired sample t-test was used for variables that conformed to normal distribution as determined by the Shapiro-Wilk test, while the Wilcoxon t-test was used for variables that did not comply with normal distribution. The effect sizes were calculated using Cohen's d for repeated measures (drm), which accounts for the correlation between the paired observations. The drm was computed by dividing the mean difference between pre- and post-test scores by the pooled standard deviation multiplied by the square root of 2(1–r). The drm were adjusted for the pre–post correlation. Effect sizes were interpreted according to Cohen's benchmarks $0.2 < d < 0.5$ were classified as a small effect, $0.5 < d < 0.8$ as a medium effect, and $d > 0.8$ as a large effect (26). To evaluate the dose-response relationship, participants were divided into two groups according to the median change in dietary protein intake, and differences in lean body mass and performance tests were examined using the Mann-Whitney U test. In the analysis of hypothesis testing, a p value of less than 0.05 was regarded as statistically significant.

3. Results

Table 1 shows the socio-demographic characteristics of the players. Among the 30 young players who participated in the study, 10 were girls (33.3%) and 20 were boys (66.7%). The mean age of the players

was 10.2 ± 1.5 years. The players have been playing basketball for an average of 1.8 ± 1.1 years and engaged in an average of 10.2 ± 8.4 hours of training weekly. 63.3% of the players were elementary school students, while 36.7% were secondary school students.

Table 1
Socio-demographic characteristics of early adolescent players

	$\bar{x}$ ± SD (min-max)
Age (years)	10.2 ± 1.5 (8–13)
Family sizes	4.1 ± 0.7 (3–6)
Duration of playing basketball (years)	1.8 ± 1.1 (1–4)
Training time (hours/week)	10.2 ± 8.4 (2–36)
	n (%)
Gender	
Girl	10 (33.3)
Boy	20 (66.0)
Educational status	
Primary school	19 (63.3)
Middle school	11 (36.7)
Mother's occupation	
Housewife	11 (36.7)
Civil servant	14 (46.7)
Other	5 (16.6)
Father's occupation	
Civil servant	12 (40.0)
Tradesman	16 (53.3)
Worker	2 (6.7)

Table 2 shows the differences in anthropometric measurements of the players before and after the nutrition education. The mean BMI of the players before the education was 18.6 ± 3.8 kg/m², whereas the mean BMI after education was 18.1 ± 3.4 kg/m². The difference in mean BMI before and after the education was not statistically significant ($p > 0.05$). The average waist circumference of the players before and after the education was 70.5 ± 10.7 cm and 68.7 ± 9.1 cm, respectively ($p < 0.05$). The average

body fat percentage of the players before and after the education was 9.6% ± 6.1 and 8.9% ± 4.9, respectively ($p < 0.05$). The average basal metabolic rate of the players was 1279.1 ± 187.5 kcal and 1316.2 ± 178.2 kcal, respectively ($p < 0.05$). The changes in players' Lean body mass (LBM) and body water percentage post-education indicate a large effect size.

Table 2
Anthropometric measurements of young players before and after education

	Before education	After education	p	Effect size, magnitude
	$\bar{x}$ ± SD	$\bar{x}$ ± SD		
Body weight (kg)	40.2 ± 12.6	41.4 ± 12.0	**0.009**	-0.21, small
Height (cm)	145.5 ± 10.9	149.7 ± 10.7	**< 0.001**	0.03, small
BMI (kg/m^2)	18.6 ± 3.8	18.1 ± 3.4	0.069*	-0.35, small
Waist (cm)	70.5 ± 10.7	68.7 ± 9.1	**0.018***	-0.44, small
Hip (cm)	82.0 ± 10.1	81.6 ± 8.9	0.600	-0.10, small
Body fat (%)	9.6 ± 6.1	8.9 ± 4.9	**0.027***	-0.37, small
Lean body mass (kg)	30.6 ± 7.5	32.6 ± 7.9	**< 0.001**	1.17, large
Body fluid (%)	21.9 ± 5.3	23.7 ± 6.0	**< 0.001**	0.96, large
BMR (kcal)	1279.1 ± 187.5	1316.2 ± 178.2	**< 0.001***	0.39, small

* Wilcoxon sign test was used. **BMI**: Body Mass Index, **BMR**: Basal Metabolic Rate. Effect size (drm) values were calculated using Cohen's formula for repeated measures, adjusted for pre–post correlation. Values of $0.2 \le d \le 0.5$ were classified as a small effect, $0.5 \le d \le 0.8$ as a medium effect, and $d \ge 0.8$ as a large effect.

Table 3 shows the parents' knowledge levels on sports nutrition. The players' parents average pre-education nutrition knowledge score was 34.0 ± 17.6, but their average post-education nutrition knowledge score was 57.5 ± 11.7. The total possible score was 100, with higher scores indicating greater sport nutrition knowledge. A change of statistical significance was found in the post-education nutritional knowledge level ($p < 0.05$).

Table 3
Sports nutrition knowledge levels of young players' parents' before and after education

	Before education	After education	Z	p	Effect size, magnitude
	$\bar{x}$ ± SD (min-max)	$\bar{x}$ ± SD (min-max)			
SNKT	34.0 ± 17.6 (0.0–60.0)	57.5 ± 11.7 (35.0–80.0)	-4.794	**< 0.001**	2.08, large

* Wilcoxon sign test was used. **SNKT**: Sports nutrition knowledge test. Effect size (drm) values were calculated using Cohen's formula for repeated measures, adjusted for pre–post correlation. Values of $0.2 \leq d \leq 0.5$ were classified as a small effect, $0.5 \leq d \leq 0.8$ as a medium effect, and $d \geq 0.8$ as a large effect.

Table 4 shows the performance test results of the players before and after the education. Significant differences were observed in the performance tests following the education ($p < 0.05$). An increase was observed in flexibility, balance, right hand-claw strength, left hand-claw strength, push-ups, sit-ups, vertical jump, and standing long jump, while a decrease was observed in reaction time and T-test time. The effect size of the change in performance tests indicates that the relationship is large in all results.

Table 4
Performance test scores of young players before and after education

	Before education	After education	p*	Effect size, magnitude
	$\bar{x} \pm SD$	$\bar{x} \pm SD$		
Flexibility (cm)	26.3 ± 8.7	29.6 ± 9.2	< 0.001	1.00, large
Balance (sec)	9.4 ± 5.0	12.3 ± 5.1	< 0.001	1.19, large
Right hand-claw strength (kg)	16.6 ± 5.7	19.2 ± 6.1	< 0.001	2.39, large
Left hand-claw strength (kg)	15.2 ± 5.6	17.9 ± 6.3	< 0.001	1.17, large
Reaction (cm)	16.1 ± 9.9	14.0 ± 6.9	< 0.001	-0.49, small
T test (sec)	15.6 ± 2.3	13.9 ± 2.3	< 0.001	-1.79, large
Push-ups (number)	16.4 ± 7.5	20.3 ± 8.3	< 0.001	2.41, large
Sit-ups (number)	14.8 ± 4.2	20.3 ± 5.6	< 0.001	2.21, large
Ten meters speed (sec)	2.9 ± 1.6	2.7 ± 1.6	< 0.001	-1.72, large
Vertical jump (cm)	24.7 ± 6.4	29.2 ± 6.7	< 0.001	2.28, large
Standing long jump (cm)	127.1 ± 22.8	140.4 ± 21.8	< 0.001	2.28, large

Table 5 shows the food consumption records of the players before and after the nutrition education. The players consumed an average of 1416.1 ± 372.3 kcal/d of energy before beginning nutrition education, which increased to an average of 1637.3 ± 357.5 kcal/d post-education ($p < 0.05$). The average carbohydrate consumption increased from 162.5 ± 59.5 g/d before nutrition education to 211.2 ± 60.0 g/d after the education. The players who consumed an average of 53.8 ± 17.2 g/d of protein before the nutrition education increased their intake to an average of 64.0 ± 15.3 g/d after the education ($p < 0.05$). The dietary fiber and fluid intakes of the players before and after the nutrition education show a statistically significant difference ($p < 0.05$).

Table 5
Food consumption records of young players before and after education

	Before education	After education	Reference Values*		p	Effect size, magnitude
	$\bar{x} \pm SD$	$\bar{x} \pm SD$	Girl	Boy		
Energy (kcal/d)	1416.1 ± 372.3	1637.3 ± 357.5	1630–2064	1752–2257	**0.001**	0.64, medium
Carbohydrate (g/day)	162.5 ± 59.5	211.2 ± 60.0	45–60% of energy		**< 0.001**	0.79, medium
Carbohydrate (%)	45.5 ± 8.6	51.1 ± 6.3			**< 0.001**	0.69, medium
Protein (g/day)	53.8 ± 17.2	64.0 ± 15.3	10–20% of energy		**< 0.001**	0.61, medium
Protein (%)	15.2 ± 2.7	15.8 ± 2.6			0.393	0.21, small
Protein (g/kg/day)	1.4 ± 0.6	1.6 ± 0.5	1.2–1.6 g/kg/day[+]		**0.028**	0.35, small
Fat (g/day)	57.8 ± 15.0	57.3 ± 14.3	20–35% of energy		0.992	-0.04, small
Fat (%)	37.2 ± 6.4	31.8 ± 5.4			**< 0.001**	-1.02, large
Dietary fiber (g/day)	13.7 ± 4.9	17.8 ± 5.5	16–19	16–19	**< 0.001**	0.83, large
Water (mL)	1308.3 ± 545.9	1715.0 ± 416.3	1900	2100	**< 0.001**	1.35, large
Vitamins						
Vitamin A (mcg/day)	861.2 ± 547.5	750.4 ± 497.4	400–600	400–600	0.141	-0.36, small
Vitamin D (mcg/day)	3.7 ± 3.2	3.8 ± 3.2	15	15	0.692	0.02, small
Vitamin E (mg/day)	8.4 ± 3.1	9.8 ± 3.9	9–11	9–13	0.148	0.35, small
Thiamine (mg/1000 kcal)	0.6 ± 0.2	0.7 ± 0.2	0.4/1000 kcal		**0.002**	0.56, medium
Riboflavin (mg/day)	1.1 ± 0.4	1.2 ± 0.4	1-1.4	1-1.4	0.174	0.23, small

* Türkiye Dietary Guidelines (2022). [+]: Nemet and Eliakim, (2009). Wilcoxon sign test was used. Effect size (drm) values were calculated using Cohen's formula for repeated measures, adjusted for pre–post correlation. Values of $0.2 \leq d \leq 0.5$ were classified as a small effect, $0.5 \leq d \leq 0.8$ as a medium effect, and $d \geq 0.8$ as a large effect.

	Before education	After education	Reference Values*		p	Effect size, magnitude
	$\bar{x}$ ± SD	$\bar{x}$ ± SD	Girl	Boy		
Pyridoxine (mg/day)	0.9 ± 0.3	1.1 ± 0.4	1-1.4	1-1.4	**0.034**	0.37, small
Cobalamin (mcg/day)	4.0 ± 1.7	4.1 ± 1.6	2.5–3.5	2.5–3.5	0.819	0.08, small
Minerals						
Calcium (mg/day)	625.4 ± 228.7	671.3 ± 208.3	800–1150	800–1150	0.131	0.28, small
Phosphorus (mg/day)	872.6 ± 249.7	1044.8 ± 262.8	440–640	440–640	**0.001**	0.68, medium
Iron (mg/day)	7.2 ± 2.5	8.2 ± 2.5	11–13	11	**0.046**	0.35, small
Magnesium (mg/day)	189.2 ± 51.5	222.8 ± 60.0	230–250	230–300	**0.001**	0.52, medium
Zinc (mg/day)	8.0 ± 2.8	9.5 ± 3.1	7.4–10.7	7.4–10.7	**0.010**	0.48, small
Sodium (mg/day)	2823.0 ± 881.4	3328.4 ± 1233.9	1700–2000	1700–2000	**0.015**	0.45, small

* Türkiye Dietary Guidelines (2022). [+]: Nemet and Eliakim, (2009). Wilcoxon sign test was used. Effect size (drm) values were calculated using Cohen's formula for repeated measures, adjusted for pre–post correlation. Values of $0.2 \leq d \leq 0.5$ were classified as a small effect, $0.5 \leq d \leq 0.8$ as a medium effect, and $d \geq 0.8$ as a large effect.

When participants were divided into two groups based on how much their protein intake changed, there was a significant variance in how much LBM they gained. The "High Change" group gained significantly more LBM ($\Delta = 2.6 \pm 0.5$ kg) than the "Low Change" group ($\Delta = 1.3 \pm 0.3$ kg) ($p = 0.032$), with a large effect size ($d = 0.826$). There was no statistically significant difference in sit-up performance ($p = 0.284$), but a medium effect size ($d = 0.528$) was seen, favoring the group that ate more protein. No significantly differences were observed in vertical jump or push-up performance ($p > 0.05$) (Table 6).

Table 6
Comparison of lean body mass and resistance performance measurements according to nutritional change status

	Δ Protein intake (g/kg/day)			
	Low change group	High change group	p	Effect size, magnitude
$\bar{x} \pm SE$	$\bar{x} \pm SE$			
Δ Lean body mass (kg)	1.3 ± 0.3	2.6 ± 0.5	**0.032**	**0.826, Large**
Δ Vertical jump (cm)	4.5 ± 0.5	4.4 ± 2.0	0.962	0.018, Negligible
Δ Push-ups (number)	4.4 ± 0.5	4.4 ± 0.4	0.159	0.399, Small
Δ Sit-ups (number)	5.0 ± 0.7	6.1 ± 0.8	0.284	**0.528, Medium**

* Values are presented as mean ± standard error. Groups were stratified based on the median change in daily protein intake relative to body weight (g/kg/day) **Δ**: Changes with pre-post education

4. Discussion

This study aimed to examine the effect of nutritional education given to parents and coaches of young basketball players' eating habits, body composition, and performance tests. Nutritional education is crucial for players of all ages and genders. However, adequate nutrition during adolescence plays a crucial role in supporting physical growth, cognitive development, and athletic performance (27). Players during this period are unable to regulate their own nutritional practices due to underdeveloped self-management skills, adolescents rely on parents or primary caregivers to manage their nutritional requirements (28). Consequently, nutritional education was provided to young players, as well as their parents or primary caregivers and coaches, in the study. Getting from nutritional education to nutritional behavior may take longer and depend on many things, such as the educational level of the parents, the number of children in the family, the length of weekly training, and the coach's perception on nutritional education (29). Thus, the questionnaire form in the study inquired about the parents' job status and the total number of individuals living in their home.

Physical characteristics and physiological performance measurements are important for optimal athletic performance (30). Anthropometric measurements are widely researched in basketball, as in all sports, to determine the somatic characteristics of players and their particular playing positions (31). The improvement of anthropometric measurements largely enhances players' self-confidence and therefore improves physical performance (32). This study presents the alterations in the anthropometric measurements of players receiving nutritional education, as shown in Table 2. To assess potential gender-based differences in anthropometric responses, supplementary analyses were conducted separately for girl and boy players (see additional file 2). Both groups showed significant improvements in body composition and metabolic parameters following the education. After the nutritional education

of the players, their body fat percentage decreased while their LBM increased. Consequently, their body water percentage and basal metabolic rate increased. Although previous studies were conducted in different populations, their findings similarly demonstrate that nutrition education can lead to improvements in LBM (33, 34). The literature has limited studies demonstrating changes in anthropometric measurements as a result of nutrition education. Results from additional research on young basketball players corroborate the enhancement of anthropometric measurements following nutrition education in this study (17).

The Sports Nutrition Knowledge Test, developed by Torres-McGehee et al., (19) and then adapted into Turkish by Dener (20), evaluates the sports nutrition knowledge of players and parents of young adolescents. It covers topics such as macro and micronutrients, ergogenic aids and performance, weight management and eating disorders, as well as hydration. Scores of 75 or higher on the test demonstrate adequate knowledge of sports nutrition. The present study revealed that the total nutritional education scores among families of young players are inadequate. The average scores increased significantly after the educational program; however, they failed to reach the necessary level according to the test scoring (Table 3). However, it is believed that there are clinically significant improvements when compared to the change in the players' food intake records (Table 5). No studies exist in the literature that incorporate a nutrition education program for parents of basketball players aged 8–13 and evaluate the nutritional program's effectiveness. This study contributes to the existing literature by focusing on young basketball players and combining objective anthropometric and performance measurements with a novel parental nutrition education approach. Similar studies emphasize the inadequacy of players' nutritional knowledge and highlight the importance of nutritional education for achieving athletic success (18, 27, 35).

In basketball, the continuous movement at varying tempos engages multiple energy systems concurrently. The integration and effective use of anaerobic and aerobic energy systems are critical factors contributing to success in basketball (36). The efficiency of these two systems can be evaluated by using different performance tests. Speed and velocity tests, jump tests, and strength and flexibility tests effectively measure anaerobic capacity. These evaluations, in conjunction with anthropometric measurements, facilitate the monitoring of basketball players’ development, performance evaluation, injury prevention, and training program optimization (37). The improvement in athlete performance tests can serve as a source of motivation, encouraging players to pursue new goals. The current study observed significant improvements in performance test results after nutrition education. Performance tests demonstrated statistically significant changes, encompassing anaerobic and mixed energy systems (Table 4). And, gender-based sub-group analyses indicated consistent improvements in all performance parameters for both girls and boys (see additional file 3).

The anaerobic energy system includes the phosphocreatine system, which is directly related to adequate dietary protein and phosphorus intake. Dietary protein contributes to this system through its amino acid precursors (arginine, glycine, and methionine) which are required for endogenous creatine synthesis in the liver and kidneys (38). The results from the 3-day food consumption records obtained from the

players after nutritional education highlight notable changes in protein and phosphorus intake levels (Table 5). Another significant finding that supports anaerobic performance tests is the increase in players' LBM or the reduction in their body fat percentage. The enhancement of glycogen stores in players may facilitate improvements in anaerobic capacity and the efficiency of anaerobic performance tests (39, 40). Adequate dietary carbohydrate intake is essential for maintaining energy availability and supporting glycogen resynthesis during training periods. However, since the present measurements were conducted following a minimum 4-hour fast, acute glycogen replenishment is unlikely to have influenced the observed performance outcomes. Rather, the increase in carbohydrate intake may reflect a general improvement in nutritional practices that support recovery and training adaptation over time. Table 5 indicates a significant increase in the average daily carbohydrate intake and the percentage of total energy among the players after the nutrition education. Although glycogen levels were not directly measured in the present study, the observed increase in carbohydrate intake suggests a nutritional profile conducive to optimal energy metabolism. The notable alteration in the speed-velocity tests can be attributed to flexibility, enhanced energy availability, and the advancement of glycogen stores. Ramos et al. (41) conducted a study on under 14 (U14) basketball players, resulting in significant findings that support the results of the current study. In accordance with Ramos et al., (41) the finalist team demonstrated greater speed, agility, and a lower body fat percentage relative to the other teams, as indicated by anthropometric measurements and physiological performance tests. Consistent with these findings, Torres-Unda et al. (42) and Torres-Unda et al. (43) reported that youth basketball players with higher LBM and lower body-fat percentages achieved better sprint and agility performance, highlighting the link between body composition and speed development in adolescent players. Currently, Čaušević et al., (44) found that body fat percentage significantly predicts performance in speed and agility tests among U14, U15, and U16 male basketball players, suggesting that performance assessments should incorporate body fat percentage evaluations. Detailed energy and macronutrient changes by gender are presented in additional file 4, showing significant improvements in carbohydrate, protein, fiber, and water intake following the intervention.

Low energy availability is identified at 30 kcal/kg/FFM/d; however, adjusting for individual variability, optimal energy availability is estimated to be 45 kcal/kg/FFM/d (45). Low energy availability leads to injuries, the female athlete triad, stress, and reduced physical performance (46). Low energy availability, insufficient intake of energy and macronutrients, and inadequate micronutrient consumption, referred to as hidden hunger, negatively impact athlete performance (47). Dehydration is linked to not getting enough fluids and electrolytes. Similarly, players' health is hurt by not getting enough vitamins and minerals, like riboflavin and niacin for energy metabolism, calcium, magnesium, and phosphorus for skeletal muscle function, and iron for oxygen transport (48). The nutritional education given by the researchers includes the previously stated points, specific recommendations for basketball, and addresses misinformation about nutrition. Table 5 shows the food consumption records of the players before and after the nutrition education. Significant improvements in macro and micronutrient intake levels are observed after nutrition education. The average intake recommendations for macro and micronutrients following nutrition education are provided in the Türkiye Dietary Guidelines 2022. The

Türkiye Dietary Guidelines 2022 do not provide specific recommendations for young players. The sodium requirement may be 1.5 times higher than the reference value to compensate for increased losses due to sweating (2). Table 5 also shows the average daily iron intake of the players falls short of the recommended levels. Iron requirements are elevated in female players due to losses associated with the menstrual cycle. Iron supplements may be recommended in conjunction with iron-rich foods (49). Average phosphorus intake exceeds the recommended levels outlined in the Türkiye Dietary Guidelines 2022 (2). The calcium to phosphorus ratio in the diet significantly influences the bioavailability of these minerals, with a recommended intake ratio of 1:1 to especially 2:1 (50). The unknown bioavailability ratio of ingested phosphorus complicates reliable interpretation. The absence of evaluation of blood biochemical parameters in players before and after the nutrition education represents a limitation of the study. Nonetheless, the changes in micronutrients are considered valuable. The players' average daily fluid intake significantly increased after the nutrition education. This level is estimated to be even higher on training days. Improvements can be discussed when changes in macronutrient intake levels are compared with reference values. The balanced distribution of macronutrients in meals is a critical consideration. The data regarding players' meal consumption are not presented in the tables; however, it can be concluded that the negative eating habits before nutrition education remained unchanged. The rationale behind this conclusion is believed to be the duration needed for education to change into routine behavior. Periodic repetition of education will alter these behaviors.

This study's findings have implications for both performance and health in young players. Enhancements in nutritional understanding and dietary consumption resulting from the parental education program correlated with positive changes in body composition and physical performance. The results indicate that enhancing nutrition awareness in the family context can improve players' energy and nutrient consumption, promote muscle development and recovery, and increase exercise performance. From a health perspective, establishing a balanced distribution of macronutrients and adequate hydration during this developmental stage contributes to healthy growth, reduced injury risk, and enhanced overall well-being. These results highlight the significance of early, evidence-based nutrition education within youth athletic development programs. Early exposure to healthy nutrition practices is crucial for influencing long-term dietary behaviors. Studies demonstrate that dietary patterns established during childhood and adolescence frequently continue into adulthood, correlating with a decreased risk of obesity, cardiovascular disease, and metabolic disorders in later life. In this context, engaging parents in nutrition education may yield dual benefits, enhancing players' current nutritional status and fostering their ability to sustain healthy eating behaviors over time. Consequently, interventions centered on nutrition that engage both adolescents and their caregivers may serve as a cost-effective approach to fostering long-term health and performance.

A significant finding of our study is the dose-response relationship between protein intake and muscle mass development. Even without a control group, our sub-group analysis showed that young players who ate more protein gained twice as much LBM as those who ate less protein. This substantial effect size ($d = 0.826$) fully substantiates the biological efficacy of the nutritional education provided. Additionally, although statistical significance was not achieved for sit-ups, the observed medium effect

size indicates that enhanced protein intake may also provide benefits for muscular endurance, needing further examination with larger sample sizes.

The study also has additional limitations. First of all, the most important limitation of the study is the lack of a control group in its experimental design. Nonetheless, our responder analysis revealed an internal control mechanism. The discovery that adhering to protein guidelines resulted in double the increase in muscle mass indicates that the noted changes are primarily influenced by the nutritional intervention rather than just by biological development. Attributing changes in body composition and performance assessments in players directly to dietary education is difficult. The present study used a single-group pre-post design, which limits the ability to establish causality. Although significant improvements were observed in both performance and nutritional knowledge, part of these changes may have resulted from test familiarization or learning effects rather than the intervention itself. The absence of a control group that did not receive nutritional education in the methodological design constitutes a limitation. Nonetheless, it remains crucial that the short-term changes in body composition and performance tests have yielded statistically significant outcomes. Another limitation of the present study is that all participants were recruited from a single basketball team (one localization sample). This homogeneity may have reduced variability due to environmental and lifestyle differences, thereby improving internal consistency, but it limits the generalizability of the results to players from other regions or sports. Future studies should include participants from multiple institutions and geographical locations to enhance external validity.

Conclusion

Enhancements that improve athletic performance are important. The impact of adequate and balanced diet on athletic performance is unequivocal, despite the influence of other circumstances. Adequate and balanced nutrition improves sports health and physical performance by optimizing body composition. The findings from this study demonstrate the effectiveness of nutritional education in players. Intervention’s nutrition education to young players, particularly those in at-risk groups, can enhance body composition and physical performance. As young adolescents are unable to control their own nutrition, providing sports nutrition education for families or caregivers yields effective outcomes. Early nutrition education for potential professional players ensures long-term achievement by positively affecting their nutritional patterns. The current literature emphasizes the significance of this education; however, there is a limited availability of cross-sectional or case-control studies that incorporate various education models. Neglecting the players' competition periods represents a significant limitation. Future researchers should consider these limitations, and it is recommended that the education be conducted at various periods, with results from different times presented collectively, and further studies with larger and more diverse samples are warranted. In conclusion, this short-term parental nutrition education program significantly improved parental knowledge, dietary adequacy, and athletic performance indicators among young basketball players. The findings underscore the importance of family-based approaches in youth players’ nutrition education programs.

Declarations

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Author contributions

All authors have made substantial contributions in accordance with the ICMJE authorship criteria. MÖ contributed to the conception and design of the study, supervision of data collection, statistical analysis, interpretation of results, and drafting and critical revision of the manuscript. SK contributed to the data collection, organization of intervention sessions, literature review, and initial drafting of the manuscript. Both authors read and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

Ethical approval and consent to participate

The parents of the players involved in the study were informed about the research; the informed consent form was obtained from all of parents. Ethical approval was secured from the Burdur Mehmet Akif Ersoy University Non-Interventional Research Ethics Committee (Approval No: GO 2023/206, Date: April 5, 2023) before beginning of data collection. Informed consent forms were acquired from the families of the young players' who participated in the study, and all procedures followed were by the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration.

Consent for publication

Not applicable

Declaration of conflicting interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Data availability

The datasets generated and/or analyzed during the current study are available in the ClinicalTrials.gov repository, (NCT07344870),

(https://clinicaltrials.gov/ct2/show/NCT07344870).

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