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Differences in nutritional intake and physique according to dietary behaviors in middle school male athletes

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Although various dietary behavioral issues affecting healthy development of adolescents have been studied, research on dietary behaviors of adolescent athletes is still limited. This study investigated the relationship between dietary behaviors and body size, energy intake, and nutrient intake in 66 first-year male middle school athletes (12.6–13.8 years old). Dietary behaviors were assessed using the nutritional quotient for adolescents (NQ-A), and energy and nutrient intakes were derived from 3-day food records including 2 weekdays and 1 weekend day. Dietary data were analyzed using CAN-pro 6.0 (Korean Nutrition Society). The results showed that the mean energy intake was 2,301.27 ± 643.57 kcal, which was lower than the estimated energy requirement for this age group. In addition, the intake levels of dietary fiber, vitamin A, vitamin C, calcium, and magnesium were less than 70% of the Korean Dietary Reference Intake. In particular, calcium ($r=0.31$, $P=0.021$) and dietary fiber ($r=0.28$, $P=0.038$) showed a weak but positive correlation with the NQ-A score. Calcium ($F=3.201$, $P=0.049$) and dietary fiber ($F=3.376$, $P=0.042$) intake levels were significantly higher in athletes with higher NQ-A grades than in middle or low-grade athletes. However, no significant correlation was observed between NQ-A and physique. In conclusion, when evaluating the dietary behavior of middle school male athletes using NQ-A, athletes with better dietary behaviors were found to consume relatively more calcium and dietary fiber. However, it is important to note that a high NQ-A grade does not necessarily indicate sufficient nutrient intake.

Keywords: Dietary behavior, Nutrition, Nutrition quotient, Adolescence, Athlete

INTRODUCTION

Adolescents generally have limited interest in health and nutrition, and large-scale surveys of adolescents have frequently reported problems such as skipping breakfast, increased consumption of fast food and sugary drinks, and decreased fruit consumption (Norris et al., 2022). Fast food and convenience foods are often high in saturated fat, sugar, and sodium, and low in vitamins, minerals, and dietary fiber. When fruit and vegetable consumption is low, these eating habits may contribute to nutritional deficiencies and imbalances (Beal et al., 2019; Norris et al., 2022).

Given the relationship between dietary behaviors and nutrient intake and the significant impact on diet quality, health status, and overall lifestyle (Liberali et al., 2020; Maneschy et al., 2024), numerous studies have assessed dietary behaviors and proposed intervention strategies. The nutritional quotient for adolescents (NQ-A), developed by the Korean Nutrition Society, is a useful tool for assessing dietary behaviors in adolescents. It is a validated and brief checklist designed to comprehensively assess nutritional status and diet quality at the individual and group levels (Kim et al., 2017). The recently updated NQ-A 2021 reflects changes in adolescents' dietary habits and consists of 20 items categorized into three domains: balance, moderation, and practice. This tool provides insight into adolescents' dietary behaviors and diet quality to help identify areas for improvement.

However, studies analyzing dietary behaviors using the NQ-A

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in adolescent athletes are still lacking. Compared to their nonathlete peers, adolescent athletes have higher energy and nutrient requirements. Adequate nutrient intake is essential for physiological needs such as muscle recovery, energy supply, and immune function. On the other hand, inadequate intake can lead to problems such as relative energy deficiency (RED) in sports, which is mainly caused by low energy availability. RED occurs when the remaining energy after exercise is insufficient to maintain essential physiological functions, including metabolism, immune response, and reproductive health. This condition can negatively affect growth and development (Gould et al., 2023; Logue et al., 2020; Rogers et al., 2021). Therefore, monitoring and analyzing dietary behaviors, energy availability, and nutrient intake in adolescent athletes is crucial for effective athlete management.

Based on these research results, this study aims to evaluate the eating behavior of male middle school athletes using NQ-A and to find out the differences in nutrient intake and physique according to eating behavior. This study aims to contribute to the development of practical measures to improve the health and athletic performance of youth athletes by identifying the specific effects of eating behavior on energy and nutrient intake and physique.

MATERIALS AND METHODS

Participants

The study participants were 66 adolescent male athletes aged 12.6–13.8 years from middle school basketball (n = 15), soccer (n = 30), and taekwondo (n = 21). They were all first-year middle school athletes registered with the Korean Sport and Olympic Committee. Athletes who could not maintain their usual dietary patterns due to sports games or special events during the diet recording period were excluded from the study. The physical characteristics of the subjects are shown in Table 1. The Chungnam National University Ethics Committee (2023-01-SB-010-01, 2024-03-SB-027-01) approved this study. Prior to the investigation, the athletes and their guardians were thoroughly informed of the background, purpose, and procedures of the study, and they voluntarily provided written consent for participation.

Table 1. Characteristics of study participants (n = 66)

Variable	Value
Age (yr)	13.26 ± 0.32
Height (cm)	164.33 ± 8.28
Height percentile	65.37 ± 33.03
Weight (kg)	53.99 ± 11.69
Weight percentile	53.06 ± 31.14
BMI (kg/m^2)	19.67 ± 3.58
BMI percentile	41.00 ± 30.35
% body fat (%)	13.60 ± 6.10
Types of sport	
Basketball	15 (22.7)
Taekwondo	21 (31.8)
Soccer	30 (45.5)

Values are presented as mean ± standard deviation or number (%).
BMI, body mass index.

Evaluation of dietary behaviors

To assess the participants' dietary behavior, we utilized the NQ-A (Kim et al., 2023), developed by the Ministry of Food and Drug Safety and the Korean Nutrition Society and revised in 2021. The NQ-A is a comprehensive tool that uses 20 questions to assess the dietary behavior, dietary quality, and nutritional status of individuals or groups. It consists of three subdomains: balance, moderation, and practice. Balance assesses whether individuals consume a variety of essential foods, moderation assesses the extent to which they consume unhealthy foods sparingly, and practice investigates whether they adhere to healthy and safe eating habits. The NQ-A consists of a total of 20 items, including 8 items for balance, 9 items for moderation, and 3 items for practice, and the responses are measured on a 5-point Likert scale. Specifically, the balance subdomain investigates the frequency of consuming vegetables, fruits, milk and dairy products, fish or shellfish, eggs, beans or tofu, nuts, whole grains, or mixed grains. The temperance subdomain examines distractions such as sugary foods and drinks, fatty snacks, instant noodles, salty soups or stews, caffeinated drinks, overeating, eating late at night, eating near school or academy, using smartphones during meals, playing games, and watching TV. The practice subdomain assesses behaviors such as eating breakfast, checking food labels when purchasing food, and washing hands before eating.

The NQ-A score was calculated by multiplying the path coefficient of each of the 20 items by its corresponding weight, adding up the results, and converting the total to 100 points. Based on this score, the participants were classified into three stages (high, middle, low) according to the criteria suggested by Kim et al. (2023). This criterion standardized the NQ-A scores into percentile ranges and divided them into quartiles. The upper 25th percentile was classified as high, the 25th to 74.9th percentile as middle, and the lower 25th percentile as low. In this study, the participants were classified into groups according to the integrated NQ-A evaluation criteria.

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Evaluation of energy and nutrients intake

Dietary intake was assessed using a 3-day food record method. Participants were trained to record the name, ingredients, and portions of all food consumed during the day. Data recorded on the first day were submitted to the researcher via social media, allowing participants to receive feedback on the recording method. If further clarification was required for the final submission, participants were contacted individually to ensure accurate and complete records. Incomplete or unreasonable records that could not be supplemented through this process were excluded from the data analysis.

All dietary records were analyzed using the Computer Aided Nutritional Analysis Program (CAN-Pro 6.0, Korean Nutrition Society, Seoul, Korea). Data included daily energy intake, macronutrients (carbohydrates, fats, and proteins), vitamins (vitamin A, vitamin E, vitamin C, vitamin B_1, vitamin B_2, and niacin), minerals (calcium, phosphorus, iron, magnesium, and zinc), and dietary fiber. These variables were used in statistical analysis.

To assess the adequacy of daily energy and nutrient intake, the ratio of actual intake to the dietary reference intake (DRI) by age and sex was calculated. For daily energy intake, the estimated energy requirement (EER) was used as the standard. The EER value was calculated based on the coefficient for the general physical activity level of Koreans ('low activity') with a coefficient of 1.13, and the coefficient for the activity level (1.26) and the very active level (1.42). The ratio of intake to these EER values was presented in the analysis (Ministry of Health and Welfare, 2020).

The formula for calculating EER for male adolescents is as follows: EER for male adolescents = 88.5 − 61.9 × age (years) + PA (26.7 × weight [kg] + 903 × height [m]) + 25 kcal/day (PA, physical activity coefficient)

Carbohydrates, fat, and protein were evaluated based on the acceptable macronutrient distribution range (AMDR) set by the 2020 Korean dietary reference intakes (KDRI) (Ministry of Health and Welfare, 2020). In addition, the prevalence of nutrient deficiencies was evaluated by presenting the proportion of athletes whose nutrient intake was less than the estimated average requirements (EARs).

Physique measurements

In order to evaluate the physique of the players, height and weight were measured, and these values were used to calculate the body mass index (BMI). BMI was calculated by dividing weight (kg) by the square of height (m) (kg/m^2). In order to evaluate the physique considering age and gender, the percentile for each measurement was calculated using the 2017 growth chart published by the Korea Centers for Disease Control and Prevention (https://knhanes.cdc.go.kr/knhanes/eng). In addition, body composition was evaluated using a bioelectrical impedance analyzer (InBody 770, InBody Seoul, Korea), and the body fat percentage was specifically presented as a result.

Data analysis

Descriptive statistics were performed on data on physique, NQ-A, energy and nutrient intake. For continuous variables, means and standard deviations were presented, and for distributions, sample sizes (n) and percentages were reported. Pearson correlation analyses were performed to examine associations between NQ-A scores and energy and nutrient intake. One-way analysis of variance was used to compare physique and nutrient intake between groups according to NQ-A ratings. All statistical analyses were performed using IBM SPSS Statistics ver. 29.0 (IBM Co., Armonk, NY, USA), and $P < 0.05$ was considered significant.

RESULTS

Dietary behavior

The NQ-A was used to assess the eating behaviors of first-year middle school male athletes. The scores for the balance, control, and practice domains were 48.1, 56, and 50, respectively, and the overall NQ-A score was 51.5. All of these scores correspond to middle school grades. Looking at the distribution of grades, the upper and middle grades were similarly distributed in balance, while the lower grades were significantly less frequent. In control, the upper and lower grades were similar, while the middle grades were prevalent. In contrast, the lower grades were the most prevalent in practice (Table 2).

The most frequent responses for each item were that vegetable side dishes were usually consumed 3 times per meal (34.8%), while milk or dairy products were consumed 2 or more times per day

Table 2. NQ-A score and distribution by NQ-A grade in middle school male athletes (n = 66)

NQ-A component	Score	High	Middle	Low
Balance	48.14 ± 14.62	28 (42.4)	30 (45.5)	8 (12.1)
Moderation	55.95 ± 14.18	16 (24.3)	35 (53.0)	15 (22.7)
Practice	49.99 ± 18.95	17 (25.8)	23 (34.8)	26 (39.4)
NQ	51.49 ± 13.18	18 (27.3)	31 (47.0)	17 (25.7)

Variables are presented mean ± standard deviation or number (%).
NQ-A, nutritional quotient for adolescents.

(28.8%). Fruits (47.0%), fish or shellfish (40.9%), eggs (47.0%), beans or tofu (37.9%), and whole or mixed grains (28.8%) were most commonly consumed 1 to 3 times per week. Nuts, on the other hand, were rarely consumed (42.4%).

In the moderation area, the most common intake was of simple foods or drinks 4–6 times a week (37.9%), while oily snacks or fried foods (60.6%), ramen (53.0%), salty soups or stews (57.6%), and food near schools or academies (33.3%) were frequently consumed 1–3 times a week. On the other hand, caffeinated foods (63.6%) and late-night snacks (33.3%) were rarely consumed, and overeating was rare (45.5%). Smartphone use, games, and TV watching during meals were occasionally (36.4%).

In the exercise area, more than half of the participants reported eating breakfast every day (60.6%), but almost half of the athletes (48.5%) did not read food labels when buying processed foods. Additionally, 40.9% said they washed their hands before eating.

Table 3. Energy and energy nutrient intakes in middle school male athletes (n=56)

Variable	Mean±SD
Energy intake (kcal/day)	2,301.27±643.57
Energy intake/EER_1 (%)	89.49±27.75
Energy intake/EER_2 (%)	78.00±24.01
Energy intake/EER_3 (%)	67.35±20.60
Energy taken by carbohydrate/daily energy intake (%)	56.46±6.00
Energy taken by fat/daily energy intake (%)	28.09±4.94
Energy taken by protein/daily energy intake (%)	15.46±2.66

SD, standard deviation; EER_1, estimated energy requirements derived with the coefficient for the low level of physical activity; EER_2, estimated energy requirements derived with the coefficient for the active level of physical activity; EER_3, estimated energy requirements derived with the coefficient for the very active level of physical activity.

Energy and nutrient intake

The daily energy intake of the first-year middle school male athlete was 2,301 kcal, which was lower than the EER of 2,500 kcal set by the KDRI for males aged 12–14 years. The KDRI value assumes a standard body composition and a 'low activity' lifestyle for this age group. The ratios of actual energy intake to EER calculated based on the individual's body composition and adjustment factors for low activity, active, and very active lifestyles are presented in Table 3. These ratios were 89.5%, 78.0%, and 67.4%, respectively. The macronutrient distribution of energy intake was as follows: carbohydrates 56.5%, fat 28.1%, and protein 15.5%, which belong to the AMDR (Table 3).

Analysis of the nutrient intakes of athletes showed that only vitamin B_1, iron, and zinc were consumed at levels that met or exceeded the DRI. All other nutrients were consumed below the recommended levels. In particular, calcium intake was the lowest, at only 50.2% of the recommended intake. Vitamin A, vitamin C, magnesium, and dietary fiber were also consumed at less than 70% of the recommended levels. Among the nutrients with low intake rates, the percentage of athletes consuming less than the EAR exceeded 60% for all nutrients except dietary fiber. For dietary fiber, the intake recommendations are based on the adequate intake (AI) rather than the EAR (Table 4).

Table 4. Nutrient intakes and frequencies of intakes under the estimated average requirement (n=56)

Nutrients	Reference	EAR	Intakes	Intake ratio (%)[a]	n (%) under EAR
Vitamin A (μg RAE/day)	RNI	530	395.61±196.84	52.75±26.25	44 (66.7)
Vitamin E (mg α-TE/day)	AI	-	8.26±6.95	75.08±63.17	-
Vitamin C (mg/day)	RNI	70	55.05±43.25	61.17±48.06	42 (63.6)
Vitamin B_1 (mg/day)	RNI	0.9	1.83±1.90	166.37±172.02	4 (6.1)
Vitamin B_2 (mg/day)	RNI	1.2	1.46±0.53	97.57±35.22	17 (25.6)
Niacin (mg NE/day)	RNI	11	12.99±5.27	86.61±35.13	23 (34.8)
Ca (mg/day)	RNI	800	502.01±380.94	50.20±38.10	51 (77.3)
P (mg/day)	RNI	1,000	1,062.45±399.44	88.54±33.29	23 (34.8)
Fe (mg/day)	RNI	11	14.36±9.71	102.56±69.34	17 (25.8)
Mg (mg/day)	RNI	260	173.88±89.37	54.34±27.93	50 (75.8)
Zn (mg/day)	RNI	7	9.10±3.52	113.69±44.03	14 (21.2)
Fiber (g/day)	AI	-	17.64±7.0	58.82±23.24	-

Values are presented as mean±standard deviation or number (%).
EAR, estimated average requirement; RAE, retinol activity equivalents; α-TE, α-tocopherol equivalent; NE, niacin equivalent; RNI, recommended nutrient intake; AI, adequate intake.
[a]Percentage compared to the dietary reference intakes for Koreans (Ministry of Health and Welfare, 2020).

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Table 5. Correlation between NQ-A score and the physique in middle school male athletes (n=66)

Variable	NQ-balance	NQ-control	NQ-practice	NQ-index
Height	-0.16	0.17	0.09	0.10
Weight	-0.20	0.16	0.03	0.04
BMI	-0.12	0.08	0.01	0.01
% body fat	-0.16	0.07	0.11	0.09

NQ-A, nutrition quotient for adolescents; BMI, body mass index.

Table 6. Correlation between NQ-A score and the intake of energy and nutrients (n=56)

Variable	NQ-balance	NQ-control	NQ-practice	NQ-index
Energy intake	-0.09	-0.03	0.08	0.04
Carbohydrate intake rate[a]	0.19	0.17	0.04	0.12
Fat intake rate[b]	-0.30*	-0.08	-0.06	-0.12
Protein intake rate[c]	0.13	-0.23	0.02	-0.04
Vitamin A	0.04	-0.18	-0.07	-0.10
Vitamin E	0.01	-0.01	0.00	0.00
Vitamin C	0.18	0.12	0.13	0.18
Vitamin B_1	-0.14	-0.07	-0.02	-0.06
Vitamin B_2	0.03	-0.07	0.15	0.1
Niacin	0.03	-0.15	0.15	0.08
Ca	0.20	0.19	0.27*	0.31*
P	-0.03	0.00	0.18	0.14
Fe	-0.02	-0.09	-0.03	-0.06
Mg	0.19	0.08	0.25	0.26
Zn	0.026	-0.052	0.21	0.16
Fiber	0.13	0.15	0.26	0.28*

NQ-A, nutrition quotient for adolescents.
*$P<0.05$. [a]Energy taken by carbohydrate/daily energy intake (%). [b]Energy taken by fat/daily energy intake (%). [c]Energy taken by protein/daily energy intake (%).

Relationship between NQ-A and physique, energy and nutrient Intake

Correlation analysis between NQ-A scores and physique variables did not reveal significant associations (Table 5). However, some significant correlations were observed between NQ-A scores and energy or nutrient intake (Table 6). Specifically, the balance score was negatively correlated with the percentage of energy intake from fat ($r=-0.30$, $P=0.023$). The exercise score was positively correlated with calcium intake ($r=0.27$, $P=0.046$). In addition, the total NQ-A score was positively correlated with calcium ($r=0.31$, $P=0.021$) and dietary fiber ($r=0.28$, $P=0.038$) intake. Despite these results, the correlation coefficients between NQ-A scores and nutrient intake were generally low, indicating very weak associations.

Table 7. Difference of physique according to NQ-A grade in middle school male athletes (n=66)

Variable	NQ-A grade			*F*-value	*P*-value
	High (n=18)	Middle (n=31)	Low (n=17)		
Height (cm)	165.41±8.43	164.20±7.89	163.43±9.18	0.252	0.778
Weight (kg)	55.72±11.21	52.48±9.53	54.92±15.58	0.501	0.609
BMI (kg/m^2)	20.3±3.29	19.0±3.31	20.23±4.29	1.026	0.364
% body fat	14.5±6.59	13.57±5.57	12.69±6.70	0.377	0.688

Values are presented as mean±standard deviation.
NQ-A, nutrition quotient for adolescents; BMI, body mass index.

Differences in physique and nutrient intake by NQ-A grade

The results of the analysis of differences in physique by NQ-A grade showed no statistically significant differences (Table 7). However, significant differences were observed in nutrient intake, and calcium ($F=3.201$, $P=0.049$) and dietary fiber ($F=3.376$, $P=0.042$) were statistically significant. The results of the post-analysis showed that the intake of both nutrients was significantly higher in the high NQ grade group than in the middle and low NQ grade groups (Table 8).

DISCUSSION

This study investigated the dietary behavior, nutrient intake, and physique of middle school male athletes and analyzed the differences in nutrient intake and physique according to the NQ-A grade used to evaluate dietary behavior. As a result, the overall energy and nutrient intake levels were low, and calcium and dietary fiber intake were found to differ according to the NQ-A grade.

In this study, the daily energy intake of male middle school athletes was 2,301.3 kcal, which is higher than 2,042.2 kcal reported for general male students aged 10–18 in the 2022 National Health and Nutrition Examination Survey (Korea Disease Control and Prevention Agency, 2022). However, it was only 92% of the EER of 2,500 kcal for males aged 12–14 years recommended by the 2020 KDRI. The KDRI provides EER based on physiological changes and body size differences according to life stage. According to the 2020 KDRI, the standard body size for males aged 12–14 years is 161.2 cm in height, 52.7 kg in weight, and 20.5 kg/m^2 in BMI. However, the participants in this study had an average height of 164.3 cm, weight of 54.0 kg, and BMI of 19.7 kg/m^2, which were somewhat different from the reference value. To account for these individual differences, we calculated the EER by inputting the height and weight of each participant. We also derived the corresponding EER values by applying coefficients for

Table 8. Difference of nutrients according to NQ-A grade in middle school male athletes (n=56)

Nutrients	Reference	NQ-A grade			*F*-value	*P*-value
		High (n=15)	Middle (n=27)	Low (n=14)		
Energy intake (kcal/day)	2,500	2,393.23±759.54	2,339.66±659.13	2,128.71±466.12	0.697	0.503
Energy taken by carbohydrate/daily energy intake (%)	55–65	57.593±5.38	55.97±5.82	56.20±7.09	0.364	0.696
Energy taken by fat/daily energy intake (%)	15–30	26.73±4.69	28.90±5.46	27.97±4.06	0.933	0.4
Energy taken by protein/daily energy intake (%)	7–20	15.67±2.45	15.14±2.45	15.84±3.34	0.374	0.69
Vitamin A (μg RAE/day)	750	381.54±117.0	397.10±220.55	406.89±224.46	0.057	0.944
Vitamin E (mg α-TE/day)	11	7.45±3.82	9.67±8.89	6.41±4.67	1.162	0.321
Vitamin C (mg/day)	90	67.88±64.14	51.43±36.51	48.31±23.48	0.922	0.404
Vitamin B_1 (mg/day)	1.1	1.74±0.67	1.56±0.59	2.46±3.67	1.07	0.35
Vitamin B_2 (mg/day)	1.5	1.59±0.41	1.47±0.62	1.31±0.42	1.022	0.367
Niacin (mg NE/day)	15	14.89±6.17	11.9±4.37	13.06±5.63	1.583	0.215
Ca (mg/day)	1,000	706.84±626.59	429.71±216.22	421.99±177.44	3.201	0.049
P (mg/day)	1,200	1,203.97±410.61	1,037.63±411.08	958.69±345.68	1.492	0.234
Fe (mg/day)	14	13.73±3.37	13.47±7.34	16.74±16.45	0.556	0.577
Mg (mg/day)	320	68.90±31.90	49.05±24.35	48.95±26.17	2.985	0.059
Zn (mg/day)	8	9.94±2.57	9.21±4.12	7.97±3.04	1.172	0.318
Fiber (g/day)	30	21.33±8.00	16.83±6.80	15.25±4.68	3.376	0.042

Values are presented as mean±standard deviation.
NQ-A, nutrition quotient for adolescents; RAE, retinol activity equivalents; α-TE, α-tocopherol equivalent; NE, niacin equivalent.

different activity levels (low activity, active, and very active). The EERs for low activity, active, and very active individuals were 2,638.4 kcal, 3,023.0 kcal, and 3,496.3 kcal, respectively. Compared to these values, the athletes' actual daily energy intakes were 89.5%, 78.0%, and 67.4% of the EER for each activity level, respectively. These results indicate that the athletes in this study were significantly under-intaken. Athletes who undergo high-intensity training are vulnerable to relative energy deficit (Bell et al., 2023; Desbrow, 2021; Lehmann et al., 2024), and this risk is even greater for adolescent athletes who undergo rapid growth and significant hormonal changes. Energy deficiencies in growing athletes can lead to a variety of health problems, including delayed puberty, impaired bone health, and increased risk of injury, highlighting the need for careful monitoring and management.

However, some studies have highlighted the limitations of using only age, height, weight, and activity level to estimate EER. This approach does not take into account factors such as metabolic and endocrine variability due to pubertal maturation or the various characteristics of sport and training variability, suggesting that these estimates should be used as reference values rather than absolute criteria (Desbrow, 2021; Desbrow et al., 2014; Meyer et al., 2007). Logue et al. (2020) also noted methodological difficulties in accurately assessing true low energy availability. In fact, several studies have reported lower energy intake in adolescent athletes compared to values predicted by estimation equations (Bell et al., 2023; Desbrow et al., 2014; Lehmann et al., 2024). Given these findings, it is important to establish reliable guidelines for adequate energy intake to support both growth and athletic performance in adolescent athletes. Currently, there are no formal EER guidelines based specifically on the energy costs of the various sports that youth athletes perform. Future research should aim to develop EER estimates that incorporate sport-specific activity levels and physical characteristics to more accurately assess athletes' energy intake.

Analysis of the athletes' nutrient intake showed that many nutrients were consumed below the recommended levels. In particular, calcium intake was only 50.2% of the 2020 KDRI, and vitamin A, vitamin C, magnesium, and dietary fiber were also consumed below 70% of the recommended levels (Table 4). Among these nutrients, calcium and dietary fiber were significantly correlated with the NQ-A score used to evaluate eating habits, and the intake significantly differed by NQ-A grade. Specifically, athletes with high NQ-A grades consumed significantly more of the two nutrients than athletes with medium and low grades (Table 8). One of the main research questions related to calcium intake in the NQ-A assessment was 'How often do you consume plain milk or dairy products?' However, according to the 2021 National Nutrition Statistics, the main calcium intake foods for Korean adolescents aged 12–18 were milk (23.42%), ramen (6.02%), kimchi (5.45%), yogurt (4.34%), eggs (3.74%), and cheese (3.64%).

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This suggests that various foods other than milk may have affected calcium intake. Regarding dietary fiber intake, relevant survey items may be vegetable, fruit, whole grain, and mixed grain intake. However, further evaluation is needed to confirm whether these questions accurately reflect the actual level of dietary fiber intake.

It is very useful to assess dietary behavior and indirectly monitor major nutrient intake through a simple NQ-A questionnaire. In particular, calcium, which was related to NQ-A scores and varied by NQ-A grade, has been consistently reported as a nutrient with insufficient intake compared to the recommended level. During the growth period, adolescence is a critical period of rapid skeletal development, and calcium requirements are highest. The KDRI also reflects this need by setting the calcium recommended nutrient intake (RNI) for males aged 12–14 years at 1,000 mg/day, the highest among all age groups, followed by 900 mg/day for those aged 15–18 years (Ministry of Health and Welfare, 2020). Calcium can also be lost through sweat, although in small amounts. Theoretically, if this loss is large enough to lower serum calcium levels, the body will compensate by increasing parathyroid hormone secretion and promoting bone demineralization to restore calcium balance (Barry et al., 2011; Sale and Elliott-Sale, 2019). Therefore, athletes who train long hours in hot environments should be aware of not only inadequate calcium intake but also calcium loss due to sweating. Dietary fiber, a carbohydrate that is not broken down by mammalian digestive enzymes, reaches the large intestine intact and provides various health benefits. It promotes smooth bowel movements, prolongs satiety, and acts as a prebiotic for the gut microbiota, contributing to improved gut health and immune function (Barber et al., 2020; Deehan et al., 2024; Slavin, 2013). Given these benefits, dietary fiber may be particularly helpful for adolescents. However, excessive fiber intake can cause digestive discomfort such as increased gas production, gastrointestinal side effects, and bloating (Dahl and Stewart, 2015). In this study, the average dietary fiber intake was only 17.6 g/day, which was only 58.9% of the recommended intake. This was slightly lower than the intake of general middle school students (18.9 g/day, 66.1% of AI).

Athletes with high NQ-A grades had significantly higher calcium and fiber intakes than those with medium and low NQ-A grades, but their intakes still fell below the RNI. Specifically, calcium intake in the high NQ-A grade was 706.8 mg/day, which was only 70.7% of the RNI (1,000 mg/day) and lower than the EAR (800 mg/day). Similarly, fiber intake in the high NQ-A grade was only 21.3 g/day, which was only 71% of the AI (30 g/day) for males aged 12–14 years. Therefore, it is important to recognize that NQ-A score or grade alone does not ensure sufficient energy or nutrient intake to meet the dietary reference standards.

Meanwhile, there was no significant difference in physique between NQ-A grades. During adolescence, which is characterized by rapid growth over several years, individuals of the same age may show significant differences in growth and development due to the progression of secondary sexual characteristics. This suggests that there are certain limitations in assessing physical characteristics at a single point in time. In addition, various factors other than nutrition, such as hormonal and genetic factors (Chulani and Gordon, 2014; Fisher and Eugster, 2014), affect growth and development. In particular, the effects of energy and nutrient intake on growth should be assessed in relation to energy expenditure, such as physical activity levels. Therefore, a longitudinal approach may be needed for a more comprehensive assessment in future studies.

This study investigated differences in BMI and nutrient intakes by dietary behaviors in 66 first-year male middle school athletes. Results showed that BMI did not differ by NQ-A grade. However, athletes with higher NQ-A grades consumed more calcium and dietary fiber than those with lower grades. Nevertheless, regardless of dietary behavior grade, energy intake, major micronutrients, and dietary fiber intakes were often significantly below recommended dietary intake levels, suggesting that caution is needed when interpreting NQ-A grades and providing feedback. Currently, studies utilizing the NQ-A to assess dietary behaviors in adolescent athletes are extremely limited, making comparisons between sports and age groups difficult. Therefore, further research on dietary behaviors is needed to develop effective nutritional strategies to support healthy growth and athletic performance in adolescent athletes.

CONCLICT OF INTEREST

No potential conflict of interest relevant to this article was reported

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