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Dietary Patterns, Body Mass Index, Physical Fitness, and Perceived Exertion among Male Adolescent Athletes: A Cross-Sectional Study in Maluku Utara, Indonesia

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Abstract

This study examined associations of dietary patterns, body mass index (BMI), and reported nutrient intake with physical-fitness categories and perceived exertion among male adolescent athletes. A cross-sectional analysis included 50 athletes aged 16–18 years from a sports school in Maluku Utara, Indonesia. Dietary information comprised food-frequency questionnaire scores, recorded dietary categories, and 24-hour recall estimates. BMI was recalculated from weight and height; fitness was available as school-recorded categories, and exertion was assessed with the Borg 6–20 scale. Spearman correlations and seven-test false-discovery-rate adjustments were reported. Higher fitness category was associated with lower perceived exertion ($\varrho = -0.659$, $p < 0.001$). Dietary category showed nominal associations with fitness ($\varrho = 0.312$, $p = 0.028$, $q = 0.194$) and exertion ($\varrho = -0.363$, $p = 0.010$, $q = 0.067$), but neither remained significant after adjustment. Continuous food-frequency score was unrelated to fitness ($\varrho = 0.034$, $p = 0.814$). Fitness–exertion was the clearest association, whereas dietary findings were exploratory and measurement-dependent. These results cannot establish causality or objective performance advantages. Replication requires validated dietary scoring, documented fitness protocols, and complete measurement records.

Keywords

Adolescent Athletes; Dietary Patterns; Food-Frequency Questionnaire; Perceived Exertion; Physical Fitness

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1. INTRODUCTION

Adolescence is a sensitive period in which nutritional intake must support growth, maturation, school participation, and sport simultaneously. Dietary patterns may influence the availability of fuel for training and recovery, while body mass index (BMI) provides only a limited description of body size. Physical fitness represents capacity to undertake exercise; perceived exertion captures the subjective effort experienced during a particular task. These indicators are therefore related but not interchangeable. Developmentally appropriate nutrition guidance emphasizes individual needs rather than direct application of adult performance prescriptions (Capra et al., 2024; Everett, 2025).

Sports-nutrition position statements identify adequate energy availability, carbohydrate matched to exercise demands, sufficient protein distributed across the day, and appropriate hydration as central components of athlete care (Burke et al., 2019; Thomas D. T., Erdman K. A., 2016). Nevertheless, dietary

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quality and nutrition knowledge are often suboptimal in young athletes. In addition, (Gibbs et al., 2025) documented limited general and sport-specific nutrition knowledge among adolescent athletes, while (Jagim et al., 2025) found that secondary-school athletes underestimated energy and carbohydrate requirements. In adolescent swimmers, sports-nutrition knowledge was positively associated with healthier food habits, suggesting that dietary behavior reflects more than nutrient quantities alone (Alkasasbeh & Akroush, 2024).

Recent evidence connects these domains while identifying important limits. (Hulland et al., 2024) found heterogeneous, often insufficiently validated nutrition-knowledge measures; (Deslippe et al., 2025) showed that food literacy involves social and information-source influences as well as factual knowledge. In a school-based randomized intervention, (Lee et al., 2024) observed improvements in knowledge and intake after intensive behavioral education. These findings motivate assessment of dietary behavior but do not establish that a dietary category necessarily predicts physical fitness.

The relationship between diet and physical fitness is biologically plausible but methodologically difficult to establish. Dietary patterns represent combinations of food frequency, variety, and eating behavior, whereas single-day nutrient estimates capture only a short exposure window. Athlete-specific diet indices may improve the assessment of food-based quality, but meaningful interpretation requires transparent scoring rules and demonstrated measurement validity (Capling et al., 2017; Dion et al., 2025). Cross-sectional studies can identify potentially relevant associations, but they cannot establish temporal ordering or causal effects.

Diet assessment also requires population-specific validation. (Id et al., 2024) evaluated an athlete FFQ against repeated recalls, whereas (Marta Kozior, Phillip M Jakeman, Norton, 2020) emphasized linking dietary assessment to training context. (Ferraris et al., 2019) documented under-reporting in collegiate team-sport athletes, and (Costello et al., 2017, 2019) evaluated photography-assisted intake assessment in adolescent and young rugby players. Collectively, these studies make measurement transparency a prerequisite for interpreting diet–fitness associations.

BMI introduces additional complexity. Body mass index (BMI) is inexpensive and practical but cannot distinguish adipose tissue from lean mass, and its interpretation in 5-19-year-olds requires age- and sex-specific BMI-for-age reference data rather than adult cut-points (World Health Organization, n.d.). For athletes, the relationship between dietary intake, body composition, and physical capabilities is further shaped by sport discipline, maturation, training exposure, sleep, and recovery (Alexandra Martín-Rodríguez et al., 2024). Thus, BMI alone should not be treated as a definitive measure of nutritional status or sport-specific body composition.

Perceived exertion complements dietary and fitness assessment by describing the internal response to exercise. Session-based monitoring combines perceived effort with exercise duration, but the Borg 6–20 and CR-10 scales require distinct interpretation (Arney et al., 2019; Haddad et al., 2017). A lower RPE could reflect greater physiological capacity, a less demanding task, or differences in recovery and psychological state. Consequently, perceived exertion and an RPE-derived internal-load index cannot substitute for objective athletic performance.

The reviewed literature addresses related but distinct questions: nutrition-knowledge studies examine what young athletes know, diet-quality studies evaluate food-based patterns, and load-monitoring studies examine internal responses to exercise. Knowledge, food intake, body size, fitness capacity, and perceived effort cannot be assumed to form a demonstrated causal chain. Within the literature reviewed here, evidence remains limited on whether a school-recorded dietary category and its continuous FFQ score yield concordant associations with fitness and perceived exertion in the same male adolescent cohort. Maluku Utara offers a relevant setting for examining this measurement and interpretation gap without assuming unmeasured regional food insecurity or dietary disadvantage.

The primary aim was to examine whether dietary-pattern category, continuous food-frequency

score, recalculated BMI, and reported energy and macronutrient intakes were associated with physical-fitness categories in male adolescent athletes. Secondary aims were to evaluate associations with perceived exertion and an RPE-derived internal-load index, to examine the relationship between physical fitness and perceived exertion, and to test the robustness of dietary findings to alternative operationalizations, multiple-testing adjustment, and data-quality sensitivity analyses. The contribution is an exploratory integrated assessment that explicitly tests whether dietary findings depend on exposure definition, influential observations, and multiplicity adjustment; it is not evidence of a new causal nutritional pathway.

2. METHODS

Study design and setting

This observational cross-sectional study analyzed athlete records from a specialized sports secondary school in Maluku Utara, Indonesia. The proposal described recruitment from athletics, football, and pencak silat. However, sport discipline was not retained in the individual-level analysis dataset and could not be verified or included as an adjustment variable. Exact recruitment and measurement dates remain to be confirmed against field records before submission.

Participants and sampling

The available dataset included 50 male athletes aged 16-18 years. The proposal specified purposive sampling of adolescent athletes enrolled in the school and involved in its selected sport programs. All 50 records contained values for age, sex, weight, height, recorded BMI, food-frequency score, energy intake, protein, fat, carbohydrate, dietary-pattern category, fitness category, RPE, and internal-load index. No exclusions were made in the primary analysis. The sample size reflects the available school cohort rather than a documented a priori power calculation.

Dietary assessment

Dietary information was collected using a food-frequency questionnaire (FFQ) and 24-hour dietary recall. The proposal described recall on two non-consecutive days; the analysis file, however, contained one summarized value for energy, protein, fat, and carbohydrate per athlete and did not retain day-specific records. Accordingly, values are reported as recorded daily estimates rather than independently verified habitual intake. The FFQ produced a continuous total score, and the source file additionally classified dietary patterns as poor, adequate, or good.

The algorithm or cut-points used to create the three dietary-pattern categories were not documented in the available materials. Categories were therefore treated as pre-existing ordinal exposure labels: poor = 1, adequate = 2, and good = 3. Their relationship with the continuous FFQ score was assessed to evaluate operational consistency. Nutrient intakes were additionally normalized to measured body mass: energy in kcal/kg/day and protein, carbohydrate, and fat in g/kg/day. These normalized values were descriptive and were not used to diagnose low energy availability because exercise energy expenditure and fat-free mass were unavailable. Specifically, the available material did not specify food-group indicators, item weights, aggregation rules, or numerical boundaries for poor, adequate, and good categories. The 1–3 codes express ordering only and do not reconstruct the original scoring algorithm. Consequently, the reported category frequencies describe source-record labels rather than independently validated dietary adequacy. Respondents are asked to indicate the frequency of consumption of each type of food based on the provided frequency options, such as never, 1–3 times per month, 1 time per week, 2–4 times per week, 5–6 times per week, 1 time per day, and more than 1 time per day. The commonly used number of food recall days (24 hours) is 2 to 3 non-consecutive days to describe an individual's nutritional intake, whereas 1 day (1 × 24 hours) is generally sufficient to assess the average intake of a group. Dietary intake measurement using the 24-Hour Food Recall

method is conducted 2–3 times on non-consecutive days to obtain a more representative picture of an individual's energy and nutrient intake. Repeated measurements are necessary because an individual's food consumption may vary from day to day (within-person variation). Meanwhile, if the research objective is to estimate the average dietary intake at the group level, a single recall measurement per respondent may be sufficient, provided that data collection days are proportionally distributed between weekdays and weekends (Cade et al., 2017; Kirkpatrick et al., 2022; institute of Medicine, 2001).

Anthropometric assessment

Body mass was recorded in kilograms and height in centimeters. To avoid transcription and rounding inconsistencies in the pre-existing BMI column, BMI was recalculated for all participants as body mass (kg) divided by height in meters squared. Recalculated BMI was used as the primary anthropometric variable, and recorded BMI was examined in a sensitivity check. Because age was supplied only in whole years and dates of birth and measurement were unavailable, age-specific BMI z-scores could not be calculated reliably. Consequently, no adolescent nutritional-status category based on adult BMI thresholds was assigned. (World Health Organization, 2007).

Physical-fitness classification

Physical fitness was supplied as an ordinal classification labeled Tes Kebugaran Jasmani Indonesia (TKJI): moderate, good, or very good. For nonparametric analyses, categories were coded as moderate = 1, good = 2, and very good = 3. The proposal described seven testing elements, including sprinting, sit-and-reach, sit-ups, push-ups, shuttle running, trunk lifting, and one-leg balance, but also reproduced a classification table with a maximum score of 25. Because seven five-point components would generate a maximum of 35 rather than 25, and because component-level results and summed scores were absent from the dataset, the exact scoring protocol could not be reconstructed. Results should therefore be interpreted as associations with the supplied fitness category, not as independently audited standardized TKJI scores.

Perceived exertion and internal-load index

Perceived exertion was recorded using the Borg 6-20 scale after a training session. The source file also provided a training-load value calculated as RPE multiplied by session duration in minutes. Forty-nine of 50 entries corresponded to 90-minute sessions. One entry recorded RPE = 11 with an internal-load value of 900 rather than the expected 990 for a 90-minute session. Because raw session duration was unavailable, the original value was retained in the primary analysis and omitted in a sensitivity analysis.

Session-RPE monitoring commonly uses a modified CR-10 scale (Haddad et al., 2017). Borg 6–20 and CR-10 scores can be strongly associated but produce different absolute values (Arney et al., 2019). The present product is therefore termed a Borg 6–20-derived internal-load index, expressed in arbitrary units (AU). It must not be compared directly with CR-10-based thresholds or interpreted as objective athletic performance.

Statistical analysis

Continuous variables are summarized as mean ± standard deviation (SD), median with interquartile range (IQR), and minimum-maximum values; categorical variables are summarized as counts and percentages. Because fitness and diet categories were ordinal, outcome distributions were asymmetric and tied, and the sample was modest, associations were assessed using two-sided Spearman rank correlations. A chi-square test was used only as a descriptive cross-check for the three-by-three diet-by-fitness table, and expected cell counts were explicitly examined.

For each outcome family, seven diet-related or anthropometric predictors were evaluated: dietary-pattern category, continuous FFQ score, recalculated BMI, energy intake, protein intake, fat intake, and carbohydrate intake. Benjamini-Hochberg false-discovery-rate (FDR) adjustment was applied

separately within each seven-test family, and both unadjusted p values and adjusted q values are reported **(Benjamini & Hochberg, 1995).** Associations with $p < 0.05$ but $q \geq 0.05$ were interpreted as exploratory rather than confirmatory. Percentile bootstrap 95% confidence intervals (CIs) were generated from 5,000 participant-level resamples for key associations. Additional sensitivity analyses repeated the diet-fitness correlation after excluding the three very-good-fitness observations and repeated the diet-load correlation after excluding the inconsistent load entry. Analyses were performed using Python, NumPy, pandas, and SciPy.

Ethical considerations

The source proposal and analysis spreadsheet did not contain an ethics committee name, approval number, approval date, or documentary confirmation of informed consent and, where applicable, parental permission and adolescent assent. These items must be verified from institutional records and inserted into the final submission. No ethics approval or consent procedure should be claimed without supporting documentation.

3. FINDINGS AND DISCUSSIONS

Findings

Participant characteristics and dietary intake

All 50 records were complete. Participants were aged 16 years (n = 16, 32.0%), 17 years (n = 24, 48.0%), or 18 years (n = 10, 20.0%); mean age was 16.88 ± 0.72 years. Mean weight and height were 56.50 ± 4.99 kg and 167.58 ± 4.37 cm, respectively. Recalculated BMI averaged 20.11 ± 1.43 kg/m², compared with 20.21 ± 1.46 kg/m² in the recorded BMI column.

Mean reported energy intake was 1,261.05 ± 112.47 kcal/day, corresponding to 22.50 ± 2.94 kcal/kg/day. Protein and carbohydrate intakes averaged 1.07 ± 0.15 g/kg/day and 2.71 ± 0.42 g/kg/day, respectively. In descriptive benchmark comparisons, 37 athletes (74.0%) reported less than 3 g/kg/day of carbohydrate and 40 athletes (80.0%) reported less than 1.2 g/kg/day of protein; these thresholds are contextual guides, not individualized diagnoses.

Table 1. Participant characteristics, dietary intake, and training-response measures (n = 50)

Variable	Mean ± SD	Median (IQR)	Range
Age (years)	16.88 ± 0.72	17.00 (16.00-17.00)	16.00-18.00
Body mass (kg)	56.50 ± 4.99	54.60 (53.60-57.85)	48.15-69.20
Height (cm)	167.58 ± 4.37	167.00 (165.00-171.00)	157.00-180.00
Recalculated BMI (kg/m²)	20.11 ± 1.43	19.91 (19.17-20.49)	17.69-23.91
FFQ total score	45.68 ± 4.64	45.00 (42.25-49.75)	37.00-56.00
Energy (kcal/day)	1,261.05 ± 112.47	1,252.65 (1,194.83-1,336.65)	1,031.40-1,554.00
Energy (kcal/kg/day)	22.50 ± 2.94	22.68 (20.22-24.40)	16.14-28.99
Protein (g/day)	59.96 ± 5.76	60.05 (56.40-64.15)	47.50-70.30
Protein (g/kg/day)	1.07 ± 0.15	1.09 (1.00-1.17)	0.74-1.32

Variable	Mean ± SD	Median (IQR)	Range
Fat (g/day)	47.34 ± 5.03	47.65 (43.12-50.88)	38.00-57.20
Fat (g/kg/day)	0.84 ± 0.12	0.83 (0.76-0.92)	0.60-1.19
Carbohydrate (g/day)	151.86 ± 18.07	151.80 (140.12-164.57)	112.50-199.50
Carbohydrate (g/kg/day)	2.71 ± 0.42	2.77 (2.37-3.01)	1.84-3.72
Borg 6-20 RPE	11.56 ± 0.79	11.50 (11.00-12.00)	10.00-13.00
Internal-load index (AU)	1,038.60 ± 73.21	1,035.00 (990.00-1,080.00)	900.00-1,170.00

BMI, body mass index; FFQ, food-frequency questionnaire; IQR, interquartile range; RPE, rating of perceived exertion; AU, arbitrary units. BMI was recalculated from recorded body mass and height.

Distribution of dietary patterns and physical-fitness categories

Dietary-pattern categories were poor in 21 athletes (42.0%), adequate in 10 (20.0%), and good in 19 (38.0%). Fitness was classified as moderate in nine athletes (18.0%), good in 38 (76.0%), and very good in three (6.0%). No athlete was classified as poor or very poor in fitness. The continuous FFQ score correlated strongly with the pre-existing dietary category ($\varrho = 0.843$, $p < 0.001$), indicating broad ordinal agreement, although score ranges overlapped and the category-generation algorithm could not be verified. This agreement does not validate the categories: neither the food indicators nor the boundaries separating the three labels were available for verification.

Table 2. Dietary-pattern category by physical-fitness classification

Dietary category	Moderate n (%)	Good n (%)	Very good n (%)	Total n (%)
Poor	6 (28.6)	15 (71.4)	0 (0.0)	21 (42.0)
Adequate	1 (10.0)	9 (90.0)	0 (0.0)	10 (20.0)
Good	2 (10.5)	14 (73.7)	3 (15.8)	19 (38.0)
Total	9 (18.0)	38 (76.0)	3 (6.0)	50 (100.0)

Percentages inside dietary categories are row percentages; total-column percentages are percentages of the whole sample. Pearson chi-square = 7.47, df = 4, p = 0.113; minimum expected count = 0.60, so the chi-square approximation is unreliable.

Dietary and anthropometric correlates of physical fitness

Dietary-pattern category showed a modest positive nominal association with fitness ($\varrho = 0.312$, 95% bootstrap CI 0.033 to 0.534, $p = 0.028$). After FDR adjustment across seven fitness-related predictors, this association was not statistically significant ($q = 0.194$). In contrast, the continuous FFQ score was not associated with fitness ($\varrho = 0.034$, $p = 0.814$). Recalculated BMI also showed no statistically significant association ($\varrho = 0.230$, $p = 0.109$), and none of the individual energy or macronutrient variables reached significance. Thus, the categorical diet–fitness result should not be described as a strong or multiplicity-adjusted association.

Table 3. Spearman associations of dietary and anthropometric variables with physical fitness

Predictor	Spearman ϱ	p value	FDR q value
Dietary-pattern category	0.312	0.028	0.194
Continuous FFQ score	0.034	0.814	0.949
Recalculated BMI	0.230	0.109	0.253
Energy intake	−0.156	0.280	0.490
Protein intake	−0.008	0.958	0.958
Fat intake	−0.082	0.573	0.803
Carbohydrate intake	−0.233	0.103	0.253

Dietary pattern was coded poor = 1, adequate = 2, and good = 3; fitness was coded moderate = 1, good = 2, and very good = 3. Benjamini-Hochberg q values were calculated across the seven predictors shown.

Dietary and fitness correlates of perceived exertion

Higher dietary-pattern category was associated with lower RPE in unadjusted analysis (ϱ = -0.363, 95% bootstrap CI -0.593 to -0.096, p = 0.010); this association did not survive FDR adjustment (q = 0.067). Mean RPE declined across poor, adequate, and good dietary categories (11.86 ± 0.73, 11.60 ± 0.70, and 11.21 ± 0.79, respectively). Neither continuous FFQ score nor recalculated BMI was significantly related to RPE.

The strongest observed association was between fitness category and RPE (ϱ = -0.659, 95% bootstrap CI -0.823 to -0.421, p < 0.001). All three athletes classified as very good in fitness reported RPE = 10, whereas six of the nine moderately fit athletes reported RPE = 13. Because training-session external load was not recorded, this finding indicates an association with perceived effort rather than proven superiority in athletic performance. Its statistical significance pertains to the separately examined secondary test; it should not be described as having survived the dietary-family FDR correction.

Table 4. Spearman associations of dietary, anthropometric, and fitness variables with perceived exertion

Predictor	Spearman ϱ	p value	FDR q value
Dietary-pattern category	-0.363	0.010	0.067
Continuous FFQ score	-0.180	0.212	0.371
Recalculated BMI	-0.248	0.083	0.290
Energy intake	-0.074	0.607	0.708
Protein intake	-0.052	0.718	0.718
Fat intake	-0.203	0.156	0.365

Predictor	Spearman ϱ	p value	FDR q value
Carbohydrate intake	0.087	0.546	0.708
Physical-fitness category	-0.659	<0.001	Not in dietary family

RPE was measured using the Borg 6-20 scale. FDR adjustment applies only to the seven dietary/anthropometric predictors; the fitness-RPE association was examined as a separate secondary question.

Internal-load index and sensitivity analyses

The Borg-derived internal-load index averaged 1,038.60 ± 73.21 AU and was negatively associated with dietary category (ϱ = -0.376, p = 0.007, q = 0.050 as rounded in the source manuscript). The rounded q value lies at the decision boundary; the unrounded value and full seven-test load family are needed to determine whether it is below 0.05. It is therefore treated as borderline and exploratory here. The association remained directionally similar after excluding the anomalous load entry (ϱ = -0.350, p = 0.014; n = 49). Fitness was negatively associated with the load index (ϱ = -0.652, p < 0.001). Because 49 entries reflected a 90-minute duration, the load index was almost a linear rescaling of RPE and should not be interpreted as independent corroboration.

When the three very-good-fitness observations were excluded, the dietary-category association with fitness weakened and was no longer significant (ϱ = 0.191, p = 0.198; n = 47). This sensitivity result, the null continuous-FFQ finding, the unreliable chi-square approximation, and the FDR-adjusted q value collectively indicate that the observed dietary-fitness signal is not robust.

Table 5. Reported robustness and data-quality checks

Check	Result	Interpretation
Diet category vs. continuous FFQ	ϱ = 0.843; p < 0.001	Broad agreement; scoring rules unavailable
Diet category vs. fitness, FDR	q = 0.194	Does not survive multiplicity adjustment
Diet category vs. RPE, FDR	q = 0.067	Does not survive multiplicity adjustment
Diet vs. fitness without very-good group	ϱ = 0.191; p = 0.198	Association depends partly on three observations
Diet vs. load without inconsistent entry	ϱ = -0.350; p = 0.014	Direction remains similar after exclusion
Recorded vs. recalculated BMI	29/50 differ by >0.05 kg/m²	Recalculated BMI used for main analysis
Fitness scoring documentation	Seven components; 25-point table	Scoring cannot be independently reconstructed

FDR, false discovery rate; FFQ, food-frequency questionnaire; BMI, body mass index; RPE, rating of perceived exertion.

Discussion

Principal findings

The clearest result in these 50 male adolescent athletes was the inverse association between supplied physical-fitness category and perceived exertion ($\rho = -0.659$, $p < 0.001$). This result describes subjective effort, not superior objective performance. The dietary-category associations with fitness and RPE were nominal and did not remain significant after the respective seven-test FDR adjustments; the continuous FFQ score did not reproduce the fitness association. BMI and reported nutrient intake provided no statistically significant correlates of fitness in this sample. The contribution is an initial account of how practical school monitoring indicators relate, together with an explicit demonstration of the sensitivity of dietary conclusions to measurement choices.

Dietary quality and the developmental demands of adolescent sport

The proportion of poor or merely adequate dietary patterns is consistent with evidence that adolescent athletes often lack practical knowledge about sport-specific energy and macronutrient requirements. (Gibbs et al., 2025) reported low general and sport-specific nutrition knowledge, while (Jagim et al., 2025) observed substantial underestimation of energy and carbohydrate needs among secondary-school athletes. (Alkasasbeh & Akroush, 2024) additionally demonstrated that stronger nutrition knowledge was associated with healthier food habits in adolescent swimmers. Together, these studies support the practical relevance of nutrition education in school-based athlete development.

Comparison of prevalence across studies is constrained by the scoring construct. (Thoma et al., 2024) assessed Mediterranean-diet adherence in adolescent athletes, whereas (Werner et al., 2022) used the Healthy Eating Index in collegiate athletes. Their numerical categories are not interchangeable with the undocumented labels used here. Moreover, (Lorcan Mason, James Connoly, Lydia E. Devenney, Karl Lacey, Jim O'Donovan, 2023; Mason et al., 2025) frame adolescent recovery through interacting sleep, nutrition, and stress processes; the present dataset did not measure these factors and cannot attribute its dietary classifications to a specific knowledge or recovery deficit.

A key alternative explanation is dietary under-reporting. In a systematic review of athlete dietary assessment, (Capling et al., 2017) found that self-reported energy intake underestimated expenditure measured by doubly labeled water by an average of approximately 19%. The current dataset lacked original recall forms, day-specific estimates, portion-size validation, exercise energy expenditure, and fat-free mass. Therefore, low recorded intake cannot distinguish true inadequate intake from measurement error, nor can it establish low energy availability or relative energy deficiency in sport. The IOC consensus emphasizes that such conditions require assessment of dietary energy relative to exercise expenditure and broader clinical context (Kathryn et al., 2023). Evidence from male endurance athletes further illustrates that low estimated availability does not automatically map onto measurable performance decrements in every sample (Jurov et al., 2021).

Comparisons across studies must distinguish measurement design and population. (Azen et al., 2016) examined young modern pentathletes using dietary assessment alongside energy-balance evaluation, whereas (Nishisaka et al., 2022) assessed collegiate male basketball players across a season. The former is closer in developmental stage, while the latter offers temporal information unavailable in this single cross-sectional assessment. Neither permits direct transfer of adequacy classifications to this mixed-sport school cohort. The low recorded energy values here require verification before any physiological deficit is inferred.

Why the dietary association was not robust

The positive ordinal association between dietary category and physical fitness is directionally compatible with established physiological mechanisms: appropriate fueling may support glycogen availability, muscle repair, training quality, and recovery. Nevertheless, directionally plausible

mechanisms do not overcome contradictory measurement results. The pre-existing three-level dietary category was related to fitness, whereas the underlying continuous FFQ score was essentially uncorrelated with fitness. This divergence means that the apparent relationship depends on how the exposure is defined.

Three features amplify the concern. First, the rule used to convert FFQ information into poor, adequate, and good categories was absent, preventing replication of the categorical exposure. Second, all three athletes classified as very good in fitness were placed in the good dietary category even though their FFQ scores were not the highest in the sample. Removing these three observations reduced the diet-fitness association to a nonsignificant ϱ of approximately 0.19. Third, the unadjusted association did not withstand FDR correction across the seven examined dietary and anthropometric predictors. The appropriate interpretation is therefore an exploratory, category-dependent signal rather than a stable nutritional determinant of fitness.

The broader literature supports the need for validated, transparent diet-quality scoring. (Capling et al., 2017) developed an athlete-specific diet index to evaluate food-based patterns more coherently, while (Dion et al., 2025) found that many athlete populations have suboptimal dietary quality but emphasized substantial heterogeneity in indices and target groups. Future research in Indonesian sports-school settings should prespecify scoring thresholds, establish local content and construct validity, and retain item-level FFQ responses. Treating a poorly documented categorical label as interchangeable with a validated diet-quality index would overstate the available evidence.

Anthropometry and the interpretation of nutritional status

Recalculated BMI was not significantly associated with either physical fitness or perceived exertion. This null finding should not be interpreted as showing that body composition is unimportant. BMI conflates fat mass and fat-free mass, and adolescent athletes with the same BMI may differ in maturity, muscularity, and sport-specific demands. Reviews of athlete nutrition and body composition stress that meaningful interpretation often requires more direct measures, such as skinfolds, bioelectrical impedance, dual-energy X-ray absorptiometry, or other appropriately validated composition measures (Martín-Rodríguez et al., 2024).

More specific measurements can reveal relationships that BMI misses. Furthermore, (Miranda et al., 2024) incorporated maturity information into fat-free-mass estimation in male adolescent athletes, while (Hoteit et al., 2025) assessed body composition and hematological indicators in taekwondo athletes. (Cophie et al., 2024) related hemoglobin to fitness components in adolescent athletes, and (Miranda Costa et al., 2025) examined nutrient intake against DXA-derived bone outcomes with covariate adjustment. These different outcomes and measurement strategies help explain why a null BMI correlation cannot exclude nutritional or physiological differences.

An equally important issue is age-specific classification. The WHO growth-reference framework for individuals aged 5–19 years uses BMI-for-age z-scores, with thinness and overweight defined relative to sex- and age-specific reference distributions rather than adult BMI cut-points. Because the dataset recorded age in whole years only, valid BMI-for-age z-scores could not be generated without additional birth-date and measurement-date information. Consequently, describing the observed BMI values as definitive nutritional-status categories would be unjustified.

The decision to recalculate BMI also improved data integrity. Twenty-nine of 50 recorded BMI values differed by more than 0.05 kg/m² from the weight-height calculation, and the largest discrepancy approached 0.43 kg/m². The correlation pattern changed little after recalculation, but retaining the derived value from verified raw anthropometry is more transparent and reproducible. Before publication, the original measurement sheets should be checked to determine whether discrepancies reflect rounding, transcription, or input errors.

Physical fitness, perceived exertion, and internal training load

The inverse fitness–RPE association may arise because a comparable task represents a smaller fraction of physiological capacity in a fitter athlete. This is a plausible explanation rather than a mechanism established by the present data. Contemporary monitoring evidence treats RPE as an internal-response indicator influenced by exercise context and individual characteristics (Arney et al., 2019; Haddad et al., 2017). Without a standardized external workload, lower RPE cannot be attributed uniquely to better fitness.

However, perceived exertion is not identical to objective performance. A lower RPE could reflect superior fitness, lower external workload, a different sport, greater familiarity with the task, psychological factors, or a less demanding session. The current dataset did not retain sport discipline, session content, external workload, heart rate, running distance, power output, or standardized performance results. Therefore, the data support an association between supplied fitness category and perceived effort, not a demonstration that the fitter athletes achieved superior competitive or training outcomes.

The distinction is reinforced by newer monitoring research. (Clemente et al., 2025) synthesized longitudinal training-load and performance-adaptation studies and reported limited associations for session-RPE measures, underscoring that internal effort is not equivalent to adaptation. (Torres et al., 2025) mapped RPE evidence in continuous sports, and (Li et al., 2025) examined how external load and pre-training well-being contribute to RPE in collegiate male soccer. These designs and populations differ from a single mixed-sport adolescent assessment, so they contextualize rather than validate the present correlation.

(Haddad et al., 2017) discuss the commonly used CR-10-based session-RPE framework, while (Arney et al., 2019) compared Borg 6–20 and CR-10 session-intensity estimates. These scales yield different absolute values. Accordingly, the present Borg 6–20-by-duration index should not be compared directly with CR-10-derived thresholds. Because duration was effectively constant for nearly all observations, the index adds little information beyond RPE and does not independently confirm the fitness–RPE relationship.

One additional recording inconsistency further limits interpretation: an athlete with RPE 11 had a recorded load of 900 AU, which would correspond to 81.8 minutes rather than the 90-minute duration implied by the remaining entries. Excluding this record did not reverse the dietary-load association, but the original session sheet is needed to distinguish an atypical duration from a calculation error. Training-load monitoring should capture the actual duration of each session as a separate variable rather than infer it after the fact.

Instrument audit and implications for study credibility

The most consequential measurement limitation concerns the physical-fitness protocol. The proposal lists seven component tests, but the classification table has a maximum total score of 25. If each listed component were scored on a five-point scale, seven components would yield 35 points, not 25. Because the dataset contains only final categories, readers cannot determine which components were administered, how scores were combined, whether age-specific norms were applied, or whether the recorded labels conform to a recognized TKJI version.

This inconsistency does not invalidate the observed statistical pattern automatically, but it prevents independent verification of the outcome construct. To make the outcome reproducible, the research team should retrieve the raw component sheets, identify the exact test battery and normative source, clarify whether five or seven components were used, reproduce total scores, and document examiner training and scoring quality. Without this reconciliation, the article must describe the outcome conservatively as a supplied school-based fitness classification rather than an unquestionably standardized TKJI measure.

Practical implications for school-based athlete development

A reasonable institutional response is a coordinated monitoring program rather than a claim that the present data prove a specific dietary intervention. First, repeated dietary assessment should include both training and rest days, documented portion estimation, food-group frequency, meal timing, and culturally appropriate menus. Second, athletes, coaches, parents, and school food providers should receive coordinated education about age-appropriate fuelling and recovery. Third, anthropometric monitoring should include dates required for BMI-for-age assessment and, where feasible, a validated estimate of body composition.

Education should therefore be evaluated rather than presumed effective. Additionally (Boidin et al., 2021) found inconsistent dietary changes across heterogeneous athlete education programs, despite improvements in some studies. The controlled adolescent intervention of (Lee et al., 2024) offers a more direct design for testing change than the present observational records. A local program should specify behavioral goals and assess repeated dietary outcomes instead of using the current correlation as evidence that instruction will improve fitness.

Fourth, fitness and training records should be standardized. Component-level fitness results, the precise normative protocol, actual session duration, sport discipline, and objective external-load or performance measures should be retained. RPE remains attractive because it is inexpensive and practical, but it should be interpreted alongside session content and, when available, heart rate, distance, sprint times, repetitions, or discipline-specific performance tests. Finally, individuals with persistently low reported intake or concerning clinical features should be referred for professional nutritional and medical assessment rather than diagnosed from a single spreadsheet.

Strengths, limitations, and future research

The study integrates multiple practical domains within one school-based dataset and includes complete observations for all recorded variables. The manuscript reports recalculating BMI, presenting both categorical and continuous diet measures, reporting multiplicity-adjusted q values, estimating bootstrap intervals, and conducting targeted sensitivity analyses improve transparency relative to reliance on unadjusted significance alone.

Important limitations remain. Cross-sectional data cannot establish temporal ordering or causality. The purposively selected sample was limited to 50 male athletes from one institution, and no a priori sample-size calculation was documented. Sport discipline, biological maturity, socioeconomic conditions, sleep, training history, external load, and body composition were unavailable as potential confounders. Dietary recall may have substantially underestimated true intake, FFQ category rules were not retained, physical-fitness category scoring could not be independently audited, and one internal-load entry was inconsistent. Fitness categories were heavily concentrated in the good range, reducing outcome variability. Multiple comparisons further weakened the dietary findings.

Two further comparisons illustrate unmeasured confounding, (Rueda-cordoba et al., 2025) documented different body-composition and dietary profiles across endurance, strength, and intermittent sports; sport discipline was unavailable here. (Fitch et al., 2025) examined growth, maturation, training load, injury, and illness in youth triathletes, highlighting the developmental information missing from this dataset. Associations in this cohort may therefore partly reflect sport and maturation differences rather than an independent dietary effect.

Future studies should use a prospective or repeated-measures design with a prespecified primary outcome, validated and reproducible diet-quality scoring, age-specific anthropometry, component-level fitness scores, and objective sport-specific performance measures. Multilevel analysis would allow changes within athletes to be distinguished from differences between athletes, while recruitment across schools, sports, and both sexes would improve generalizability. If energy availability is of interest, exercise energy expenditure and fat-free mass must be measured rather than inferred from total energy

intake alone.

4. CONCLUSION

Higher supplied physical-fitness category was associated with lower perceived exertion among 50 male adolescent athletes from one Maluku Utara sports school. Dietary-category associations with fitness and RPE did not remain significant after FDR adjustment, and the continuous FFQ score did not reproduce the diet–fitness association. These exploratory cross-sectional findings do not establish causality or objective performance advantages. Further research requires validated dietary scoring, documented component-level fitness tests, standardized external workloads, complete measurement records, and verified ethics and consent documentation.

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