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Association between Nutrient Intake and Height among Adolescent Athlete in Indonesia: A Cross-Sectional Study

Hubungan antara Asupan Zat Gizi dan Pertumbuhan Tinggi Badan pada Atlet Remaja di Indonesia: Studi Potong Lintang

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ABSTRACT

Background: Adequate nutritional intake in young athletes is important to support physical activity, growth, development, recovery, and performance. Inadequate intake may result in non-optimal growth and performance.

Objectives: This study aimed to assess the association between nutrient intake and height among adolescent athletes in Indonesia.

Methods: This cross-sectional study was conducted during May-August 2022 in 5 athlete training centers in Indonesia. There were 330 athletes aged 12-18 years old who participated in study. The primary variables consisted of sociodemographic status, body height, nutritional status and nutrient intake.

Results: Median age of subjects was 16 years old, and predominately participating in sports more as strength athletes (66.1%) compared to endurance. Median height was 165 (140.4–191.5) cm, and the proportion of stunted was 3% and overweight-obese was 15.2%. Nutrient intakes per day were energy as 2,050 (582–4,355) kcal, protein 70.9 (15.9–184.4) g, fat 74.9 (11.3–230) g, carbohydrate 263.9 (65.1–708.4) g, calcium 347.6 (21.1–4507.5) mg, and vitamin D 1.80 (0–62.80) mg. The adequacy of energy was 71.2 (18.1–209.7)%, protein 67.5 (13.2–162.1)%, fat 61.3 (6.3–255.6)%, and carbohydrate 87.9 (13.8–352.9)%. Macronutrient intakes were significantly higher in endurance than strength subjects. Significant associations were found between energy, fat and carbohydrate intake with height and z-score height for age ($p<0.05$); while protein intake was significantly associated with body height.

Conclusions: Energy, protein, fat, and carbohydrate intake were significantly associated with adolescent athletes' height. Optimizing macronutrients among athletes, especially height-oriented sports, is necessary for supporting athletes' performance.

INTRODUCTION

Adolescence is known as the primary period for individuals to grow and experience changes in anatomical, physiological, and metabolic development. Anatomically, the peak of physical development can be seen especially in body height. Growth and development are complex processes, which are affected by several factors such as genetics, hormones, intake of macro and micro-nutrients, and other environmental factors[1]. During adolescence, youth in this age period experience rapid growth in body height parallel with their advancing age. A study revealed a significant increase in both body height and body mass among adolescents, correlating with age and maturity levels[2]. In adolescent athletes, there is a condition called growth spurts, in which peak body height, weight, and bone mass are the main conditions of the growth stage. The bone formation will grow rapidly starting at the age of puberty, typically beginning around 8-15 years old. The bones undergo rapid growth becoming bigger, longer, thicker, and denser and will reach their peak at the age of 30. Rapid growth in young athletes could be different according to body composition, body mass and height[3]. Body height is one of the important factors that can determine an athlete's performance. In some sports, athletes who have better and optimal posture could optimize adolescent

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athletes to perform movement and agility compared to athletes who have poor posture[4].

Adequate nutritional intake is also known as one of the important factors in supporting these young athletes' daily quality activities. For these youth, adequate nutritional intake is not only used for supporting energy in high-intensity daily activities, but also it is essential for their growth, development, and recovery[5]. Adequate nutritional intake includes macro- and micronutrients such as energy, protein, fat, carbohydrates, vitamins, and minerals. For fulfilling the daily nutrition requirements, it is necessary to consider the athlete's daily energy balance. Energy balance is a homeostatic condition between energy intake and energy uptake. When there is a positive energy balance, the rest energy will be stored as fat in the body. Oppositely, the negative energy balance affects the compartmentalization process of the body including causing the muscles to decrease to replace the source of energy by catabolizing the glycogen storage in the muscles[6]. The nutritional needs of young athletes will reach the maximum to support their rapid body growth in response to their daily activities. Inadequate nutritional intake in athletes causes non-optimal growth which consequently will negatively affect their performance[7]. Athletes have daily energy requirements higher than most normal people because of their high activity which makes them need more energy for body metabolism, heat, and hormone synthesis[8]. Muscle glycogen is the main source to help the physical performance and maintain the innate immunity of their body[9]. Athletes in endurance sports such as marathons, cycling, and 10-kilometer runs need glycogen storage in the muscles, liver, and fat storage in the form of triglycerides as a source of energy[10]. The use of glycogen could decrease the amount of storage and contribute to a potentially debilitating dehydration condition, which may cause fatigue in athletes and decrease their athletic performance. Meanwhile, glycogen stores in the liver are used to maintain blood glucose levels[9]. Inadequate energy intake also could suppress the gonadotropin-releasing hormone (GnRH) from the hypothalamus, thereby inhibiting the secretion of the luteinizing hormone (LH) and follicle-stimulating hormone (FSH) from the pituitary gland which inhibits ovarium stimulation to produce the endogenous estrogen and progesterone levels which affect the density of the bones[7]. Besides these complex concerns, the persons' energy requirement can be influenced by the type of sports engaged in by the athletes[11]. Endurance sports have the characteristics of moderate intensity and long duration, while strength sports have the characteristics of high intensity and short duration. The differences between these two main types of sports may cause different energy requirements in each athlete since there are different characteristics in the athlete's physical profile in each sport.

Adequate and optimal nutrition in young athletes may also help to increase their physical performance during training and competitions. Some studies showed that post-pubertal athletes had better fitness tests compared to athletes who were going through puberty. This trend may happen due to an increase in the size of the body, hormones, and muscle strength as the effect of puberty that could increase physical fitness[2]. However, the main problem related to the nutritional intake in athletes was inadequate nutrient intake which could cause non-optimal growth and development. The optimal body height according to the growth line in athletes could support the adolescent athlete's performance, especially in some types of sports that need body height as one of the key factors to win the competition, such as swimming and volleyball. Some studies regarding the adequate intake in athletes and its effect on their body height and performance are often overlooked in the field of athletes. Accordingly, there is still an imperative need to study the current data regarding the nutritional intake, growth, and the association between nutritional intake and growth in young athletes in Indonesia. This research aimed to assess the association between nutritional intake and body height among adolescent athletes in Indonesia.

METHODS

This cross-sectional study was conducted in 5 athlete's training centers (4 student education and training centers/*PPLP* and 1 sports school/ *SKO*) supervised by the Indonesian Ministry of Youth and Sports Affairs (*Kementerian Pemuda dan Olahraga Republik Indonesia*). Those athlete's training centers represent all regions (west, central, and east) of Indonesia; including the sports school of Cibubur, training center of Bandung (West Java), Yogyakarta (Yogyakarta), Lombok (West Nusa Tenggara), and Makassar (West Sulawesi). The sampling procedure was done using cluster sampling to represent all regions of Indonesia, where the selection of each region was conducted using random sampling.

The total of subjects who participated in study was 330 athletes who met the inclusion and exclusion criteria. Inclusion criteria consisted of youth aged 12-18 years old, being an athlete living in dormitory of training centers, had a good health condition (were not sick nor injured), and had the permission to participate in the study from their parents or guardians which was proved by them signing the informed consent form. The exclusion criteria were subjects who did not finish the study procedure, or athletes who competed outside the dormitory during data collection period. Data collection was done in the third week until the fourth week of May 2022. This study was approved by The Medical and Health Research Ethics Committee (MHREC) of The Faculty of Medicine, Public Health and Nursing (FK-KMK), Universitas Gadjah Mada (UGM) in Yogyakarta, Indonesia with the ethical clearance number: KE-FK-0512-EC-2022 on 24th April 2022. In order to maintain the quality of data, all of the data collection was conducted by a well-trained nutritionist who had been trained in data collection procedures and instruments.

The variables in this study consisted of sociodemographic characteristics, body height, nutritional status, and nutrient intake. The sociodemographic data included age, gender, educational level, training center location, joining time, sleep duration, and athlete's injury history. The anthropometric measurements consisted of body weight and height to calculate the body mass index (BMI).

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Bioelectrical Impedance Analysis (BIA) used an OMRON Karada Scanner (OMRON Corp., Kyoto, Japan) to measure the body weight, while a GEA® stature meter (Cganhzou Wuxin Weighing Apparatus Co., Ltd., Zhejiang Yongkang, China) was used to measure body height. The body weight and height were obtained to determine the nutritional status by plotting to z-score of height for age (HAZ) and BMI for age. Nutrient intake data were obtained using a 1x24-hour dietary recall method. Analysis of the total nutrient intake of each subject was done by comparing the nutritional intake with the age-appropriate daily requirements.

Data management was done immediately after the data collection of each subject by rechecking the completeness of questionnaires to ensure all data were complete before data entry. The sociodemographic data were entered into a spreadsheet in Ms. Excel 2019 (Microsoft Corp., Redmond, Wash., USA), while HAZ and BMI for age z-score were obtained using WHO Anthro Plus Software (World Health Organization, Geneva, Switzerland). The dietary intake in the 1x24-hour dietary recall form was converted into grams before imputing the calculation into Nutrisurvey 2007 software to obtain the total nutrient intake. All of the data were analyzed using SPSS version 20.0 (IBM Corp., Armonk, NY).

The univariate analysis was conducted to describe the sociodemographic characteristics of the subjects. The categorical data were presented in percentages as n (%), while numeric data were presented in mean ± standard deviation (SD) for normally distributed data or median with minimum-maximum (min-max) for not normally distributed data. Additional data analysis was done to compare socio-demographic data between strength and endurance athletes using independent-t/Mann-Whitney tests for numerical data and Chi-square/Kolmogorov-Smirnov tests for categorical data to determine the difference in sociodemographic characteristics before conducting further analysis.

Bivariate analysis was conducted to determine the correlation and connection of each variable. Correlation analysis between the subject's nutrient intake with body height and nutritional status (HAZ and IMU/U) was conducted with Pearson correlation tests. Further analysis was done using Chi-square/Kolmogorov-Smirnov tests to see trends in the relationship between nutrient intake of subjects in the following four tiers: <25th percentile, 25th-50th percentile, 50th-75th percentile, and >75th percentile for body height and nutritional status (HAZ and BMI for age). Chi-square/Kolmogorov-Smirnov tests were used to analyze the relationship between nutrient intake and body height and nutritional status (HAZ and BMI for age). All of the statistical analyses were conducted using SPSS software (IBM Corp., Armonk, NY) with a *p*-value <0.05 considered as significant.

RESULTS AND DISCUSSION

A total of 330 athletes participated in this study during May 2022. The characteristics data of subjects consisted of age, education level, training center location, time joining in team, training duration, sleep duration, injury history, and smoking habit. Univariate analysis was performed to determine the characteristics of strength and endurance athletes.

Table 1. Socio-demographic characteristics of subjects (n=330)

Variable	All	Strength (n=218)		*p*-value	Endurance (n=112)		*p*-value
		M (n=111)	F (n=107)		M (n=58)	F (n=54)	
Age (years)[1]	16 (13–18)	16 (13–18)	16 (13–18)	0.716[a]	16 (13–18)	16 (13–18)	0.319[a]
Education level[2]				0.511[b]			0.705[d]
Junior High School	48 (14.5)	18 (8.3)	21 (9.6)		3 (2.7)	6 (5.4)	
Senior High School	282 (85.5)	93 (42.7)	86 (39.4)		55 (49.1)	48 (42.9)	
Location[2]				0.795[b]			0.705[d]
SKO Cibubur	96 (29.1)	19 (8.7)	21 (9.6)		29 (25.9)	27 (24.1)	
PPLP West Java	87 (26.4)	41 (18.8)	43 (19.7)		1 (0.9)	2 (1.8)	
PPLP West Nusa	47 (14.2)	18 (8.3)	18 (8.3)		6 (5.4)	5 (4.5)	
Tenggara	40 (12.1)	9 (4.1)	9 (4.1)		10 (8.9)	12 (10.7)	
PPLP Yogyakarta	60 (18.2)	24 (11)	16 (7.3)		12 (10.7)	8 (7.1)	
PPLP South Sulawesi							
Time joining (year)[1]	6 (1–13)	5 (1–12)	6 (1–12)	0.077[a]	6.5 (1–13)	6.0 (1–12)	0.232[c]
Training duration (hour/day)[1]	3 (1–6)	3 (2–5)	2.5 (1–6)	0.425[a]	4 (2–5)	4 (2–6)	0.948[a]
Sleep duration (hour/day)[1]	8 (5–13)	8 (5–11)	8 (6–13)	0.149[a]	7.5 (5–10)	8.0 (5–12)	0.857[a]
Injury history[2]				0.214[b]			
Yes	190 (57.6)	55 (25.2)	62 (28.4)		33 (29.5)	40 (35.7)	0.057[b]
No	140 (42.4)	56 (25.7)	45 (20.6)		25 (22.3)	14 (12.5)	
Smoking habit[2]				0.786[d]			0.705[d]
Yes	6 (1.8)	4 (1.8)	0 (0)		2 (1.8)	0 (0)	
No	324 (98.2)	107 (49.1)	107 (49.1)		56 (50.0)	54 (48.2)	

M, male, F, female; [1]data are presented in median with minimum-maximum (min-max), [2] data are presented in percentages as n(%), a=Mann-Whitney test; b=Chi-square test; c=Independent t-test; d=Kolmogorov-Smirnov test.

Table 1 shows the median age of the subjects was 16 years old, with an almost equal proportion of male and female athletes. The proportion of athletes in the strength group (66.1%) was higher than in the endurance group (33.9%). Most of the subjects were pursuing senior high school education. The highest proportion of athletes came from one sports school in the capital city of Indonesia, Jakarta, SKO Cibubur (29.1%) and the lowest

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proportion came from a sports training school in Daerah Istimewa Yogyakarta (DIY) PPLP DIY (12.1%). Athletes participating in the study had joined the team for approximately 6 years. Median daily training duration was 3 hours per day, while sleep duration was 8 hours per day. Some athletes had a history of injuries such as knee, hand, foot, and shoulder injury. There were as many as 6 athletes who had smoking habit among all of the athletes. The sociodemographic data for each of the groups showed similar results and did not show a significant difference between males and females in the analysis (*p*-value > 0.05). Therefore, the sociodemographic data between males and females in both strength and endurance group was not considered significantly different and the data were concluded to be homogeneous.

Anthropometric measurements in athletes are aimed to determine the nutritional status based on measurements of weight, height, BMI, and other anthropometric aspects[12]. These also needed to determine the physical conditions related to athletic performance. Body weight measurement is recommended for nutritional assessment since it could observe individual changes in a short period of time. Weight monitoring should be performed regularly, especially for athletes, as suboptimal body weight can lead to a decrease in athletes' movement speed[4]. Moreover, height is also one of the important anthropometric aspects in athletes. Athletes with ideal height have a wider range of motion and faster movements than athletes with suboptimal height[4]. The data in **Table 2** show the results of anthropometric measurements and nutrient intake of subjects. The median body weight and height were 57.3 (32.5–92.5) kg and 165.0 (140.4–191.5) cm, respectively.

Table 2. Anthropometric and nutrients intake of subjects (n=330)

Variable	*All*		*Strength* (n=218)		*Endurance* (n=112)		*p*-value
	n (%)	*Median (Min-Max)*	n (%)	*Median (Min-Max)*	n (%)	*Median (Min-Max)*	
Weight (kg)		57.3 (32.5–92.5)		56.6 (32.5–92.5)		57.9 (40.0–84.5)	0.348^{a}
Height (cm)		165.0 (140.4–191.5)		164.4 (140.4–186.0)		165.3 (148.5–191.5)	0.167^{a}
HAZ category							<0.001^{c}
Stunted-severe stunted (<-2.0 SD)	10 (3.0)		7 (3.2)		3 (2.7)		
Normal (≥-2.0 SD)	320 (97.0)		211 (96.8)		109 (97.3)		
BMI for age category							<0.001^{c}
Underweight (<-2.0 SD)	2 (0.6)		2 (0.9)		0 (0.0)		
Normal (>-2.0 until <1.0 SD)	278 (84.2)		184 (84.4)		94 (83.9)		
Overweight-obese (≥1.0 SD)	50 (15.2)		32 (14.7)		18 (16.1)		
Energy intake (kcal/day)		2050 (582–4355)		1983 (641–4355)		2203 (583–4078)	0.002*^{a}
<25 percentile (<1604)	82 (24.8)		61 (28.0)		21 (18.8)		
25–50 percentile (1604–2050)	83 (25.2)		56 (25.7)		27 (24.2)		
50–75 percentile (2050–2598)	83 (25.2)		55 (25.2)		28 (25.0)		
75–100 percentile (>2598)	82 (24.8)		46 (21.1)		36 (32.1)		
Protein intake (g/day)		70.9 (15.9–184.4)		68.1 (24.0–175.0)		77.7 (15.9–184.8)	0.005*^{a}
<25 percentile (<56.1)	82 (24.8)		62 (28.4)		20 (17.9)		
25–50 percentile (56.1–70.8)	83 (25.2)		60 (27.5)		23 (20.5)		
50–75 percentile (70.9–95.1)	83 (25.2)		48 (22.0)		35 (31.3)		
75–100 percentile (>95.1)	82 (24.8)		48 (22.0)		34 (30.4)		
Fat intake (g/day)		74.9 (11.3–230.0)		70.7 (11.3–206.2)		80.3 (17.2–230.0)	0.046*^{a}
<25 percentile (<49.1)	81 (24.5)		59 (27.1)		22 (19.6)		
25–50 percentile (49.1–74.9)	84 (25.5)		56 (25.7)		28 (25.0)		
50–75 percentile (75.0–102.5)	83 (25.2)		53 (24.3)		30 (26.8)		
75–100 percentile (>102.5)	82 (24.8)		50 (22.9)		32 (28.6)		
Carbohydrate intake (g/day)		263.9 (65.1–708.4)		249.3 (65.1–708.4)		294.9 (77.0–596.1)	<0.001*^{a}
<25 percentile (<205.8)	82 (24.8)		68 (31.2)		14 (12.5)		
25–50 percentile (205.9–263.8)	83 (25.2)		56 (25.7)		27 (24.1)		
50–75 percentile (263.9–336.3)	82 (24.8)		49 (22.5)		33 (29.5)		
75–100 percentile (>336.3)	83 (25.2)		45 (20.6)		38 (33.9)		
Calcium intake (mg/day)		347.6 (21.1–4507.5)		351.2 (27.6–4507.5)		343.1 (21.1–1874.7)	0.286^{a}
<25 percentile (<196.8)	84 (25.5)		58 (26.6)		26 (23.2)		
25–50 percentile (196.8–347.5)	81 (24.5)		50 (22.9)		31 (27.7)		
50–75 percentile (347.6-661.2)	83 (25.2)		48 (22.0)		35 (31.3)		
75–100 percentile (>661.2)	82 (24.8)		62 (28.4)		20 (17.9)		
Vitamin D intake (mg/day)		1.80 (0.00–62.80)		1.80 (0.00–62.80)		1.85 (0.00–16.80)	0.568 ^{a}
<25 percentile (<0.5)	79 (23.9)		59 (27.1)		20 (17.9)		
25–50 percentile (0.5–1.79)	84 (25.5)		49 (22.5)		35 (31.3)		
50–75 percentile (1.80–4.63)	85 (25.8)		57 (26.1)		28 (25.0)		
75–100 percentile (>4.63)	82 (24.8)		53 (24.3)		29 (25.9)		
Energy adequacy (% total need)		71.2 (18.1–209.7)		70.1 (23.6–209.7)		77.7 (18.1–139.7)	0.005*^{a}
<80%	207 (62.7)		146 (67.0)		61 (54.5)		
80%–110%	90 (27.3)		55 (25.2)		35 (31.3)		
>110%	33 (10.0)		17 (7.8)		16 (14.3)		
Protein adequacy (% total need)		67.5 (13.2–162.1)		65.3 (21.8–151.2)		73.1 (13.2–162.1)	0.014*^{a}
<80%	226 (68.5)		155 (71.1)		71 (63.4)		
80%–110%	70 (21.2)		43 (19.7)		27 (24.1)		
>110%	34 (10.3)		20 (9.2)		14 (12.5)		
Fat adequacy (% total need)		61.3 (6.3–255.6)		58.4 (6.3–255.6)		65.9 (8.0–226.9)	0.435^{a}
<80%	193 (58.5)		130 (59.6)		63 (56.3)		
80%–110%	45 (13.6)		30 (13.8)		15 (13.4)		
>110%	92 (27.9)		58 (26.7)		34 (30.4)		

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Variable	*All*		*Strength* (n=218)		*Endurance* (n=112)		*p*-value
	n (%)	*Median (Min-Max)*	n (%)	*Median (Min-Max)*	n (%)	*Median (Min-Max)*	
Carbohydrate adequacy (% total need)		87.9 (13.8–352.9)		83.3 (13.8–352.9)		102.4 (29.0–316.0)	0.001*^{a}
<<80%	139 (42.1)		99 (45.4)		40 (35.7)		
80%–110%	71 (21.5)		49 (22.5)		22 (19.6)		
>110%	120 (36.4)		70 (32.1)		50 (44.6)		

BMI, body mass index; HAZ, height for age; g, gram; mg, milligram; min-max, minimum-maximum; SD, standard deviation; a=Mann-Whitney test, b=Independent t-test, c=Kolmogorov-Smirnov test.

Athletes' nutritional status is one of the important factors affecting their performance, especially for adolescent athletes. Nutritional status assessment in adolescent athletes is essential to observe the optimal growth and development of athletes[12]. Nutritional status determination in adolescence can be measured based on height-for-age (HAZ) and body mass index-for-age (BMI for age). HAZ is an indicator of nutritional status to show the long-term nutrient adequacy in the past (chronic)[13], while BMI for age shows the short-term nutrient adequacy in the present period (acute)[12]. According to data in **Table 2**, most of subjects in both of the strength and endurance groups had normal nutritional status. This result is similar to the findings reported by the study conducted by Rachma and Zulaekah in 2017 on badminton athletes that indicated most of the subjects (87.9%) had normal nutritional status based on BMI for age [14]. However, based on the proportion of nutritional status, there were athletes who had nutritional status as stunted to severely stunted in as many as 10 athletes (3%) and overweight to obesity in as many as 50 athletes (15.2%) from the total subjects. These findings might be because there were still athletes who had less energy intake than required (<80% of total energy needs) or some who had more than required (>110% of total energy needs) (data from **Table 2**). Energy intake that is less than required which is considered as <80% of the total energy expenditure (TEE) may lead to a negative imbalance that could increase the risk of undernutrition, while excess energy intake (>110% TEE) may lead to a positive imbalance that could contribute to overnutrition (overweight/obesity)[15]. According to the sports branch, the proportion of athletes who had stunted to severely stunted nutritional status (HAZ z-score <-2 SD) and underweight (BMI for age z-score <-2 SD) was significantly greater in strength athletes compared to endurance athletes. This significant difference might be because strength athletes, by their sporting nature, require more of a linearity (ectomorph) compared to endurance athletes[16]. Conversely, in this study, subjects in the endurance group had a significant higher proportion of adolescent athletes with overweight-obese nutritional status (16.1%) compared to the strength athletes (14.7%).

According to sport intensity, sports are divided into two categories, which are endurance and strength athletes. The endurance sport is a type of sport that involves playing for a duration of 30 minutes to 4 hours depending on the capacity of the aerobic system to provide energy for the body during the game. Some examples of endurance sports are middle-distance running, swimming, and rowing[17]. In addition, strength sports are predominantly characterized by muscular strength and have a shorter duration depending on the phosphate energy system and anaerobic glycolysis. Strength sports include weightlifting, bodybuilding, wrestling, gymnastics, sprinting, long jumping, and boxing[17]. Endurance sports require a higher standard of endurance than strength sports[18]. Endurance sports require high aerobic endurance because they have a longer intensity and duration than strength sports. A study by Nugraheni in 2017 showed that the VO^{2}max value of game sports athletes (volleyball and basketball) was higher than martial arts sports (taekwondo and karate), respectively 41.49 ml/kg/minute and 34.82 ml/kg/minute[19]. A key element of an athlete's performance is dietary intake. Braun in 2003 stated that the fulfilment of athletes' nutritional requirements will increase along with the increase of strenuous physical activity. The increase of energy requirements in athletes with training / competition is 500–1,000 kcal depending on the duration, type and intensity of training[20]. Adequate energy intake is one of the main components in supporting athletes' performance and ability to expend calories and increase strength, endurance, muscle mass, and health. If the athletes' intake is not fulfilled, then the body's function becomes not optimal so it can affect the athletes' body composition that will negatively impact on athlete performance[21].

In this study, median energy intake of athletes was 2,050 (582–4,355) kcal/day, endurance group had a greater median value (2,202 kcal) than strength group (1,983 kcal) with a *p*-value of 0.002 (**Table 2**). Muth and Zive in 2019 explained that in endurance sports, a large intake of energy and carbohydrates are needed to maintain glycogen stores and optimize athlete performance due to the high intensity and long training duration[22]. In strength sports, the duration required is shorter so the carbohydrate requirement is also lower than in endurance sports[23]. Meanwhile, strength sports such as powerlifting and bodybuilding require high energy and protein intake to optimize the availability of energy to support muscle growth. Higher protein intake can influence a positive protein balance where increased protein synthesis exceeds protein breakdown. Higher protein synthesis results in muscle hypertrophy which affects muscle strength. In endurance sports, protein plays an important role in the recovery process by rebuilding muscles through protein breakdown and re-synthesizing proteins[24]. Table 3 shows the collected data in this study based on nutrient intake and the percentage of fulfilment of its requirements with the median energy intake of 2,050 (582–4,355) kcal/day. The adequacy of energy and nutrient requirements can be divided into several categories, including deficit (<80% recommended dietary allowance/RDA), adequate (80–110% RDA) and excess (>110% RDA)[25]. The findings of the nutrient analysis showed that the percentage fulfilment of

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macronutrient intake (energy, protein, fat and carbohydrate) was still <80% of the requirements for energy, protein and fat intake, and only carbohydrate intake was >80%. However, when considered from the variation of fulfilment, there were subjects whose macronutrient intake was <20% and subjects whose fulfilment was more than 200% of their total requirements. The median intakes of micronutrients, calcium and vitamin D were 347.55 (21.10–4507.50) mg/day and 1.80 (0–62.80) mg/day, respectively.

Similar trends were observed for protein, fat and carbohydrate intakes with significant differences between the two groups (*p*<0.005). The percentage of athletes with adequate energy and protein intake in the endurance group (80-110%) was significantly greater than in the strength group. There were fewer athletes with adequate fat and carbohydrate intake in the endurance group than in the strength group. The Whitney test conducted on both groups of endurance and strength athletes showed a significant difference in the intake and fulfilment of energy, protein and carbohydrates (*p*<0.005). These findings are in line with research conducted by Andari *et al.* in 2021 on student athletes in Central Java that showed the energy and carbohydrate intakes in endurance athletes were greater than strength athletes, but protein and fat intakes were found to be greater in strength athletes[17].

Table 3. Association between nutrient intake with height, HAZ, and BMI for age (n=330)

Variable	All (n=330)						Strength (n=218)						Endurance (n=112)					
	Height		HAZ		BMI for age		Height		HAZ		BMI for age		Height		HAZ		BMI for age	
	r	*p*-value	r	*p*-value	r	*p*-value	r	*p*-value	r	*p*-value	r	*p*-value	r	*p*-value	r	*p*-value	r	*p*-value
Energy intake (kcal/day)	0.267	<0.001*	0.147	0.007*	0.055	0.318	0.205	0.002*	0.134	0.048*	0.042	0.539	0.364	<0.001*	0.154	0.106	0.062	0.515
Protein intake (g/day)	0.222	<0.001*	0.087	0.113	0.071	0.201	0.157	0.021*	0.038	0.580	0.022	0.745	0.325	<0.001*	0.164	0.084	0.148	0.119
Fat intake (g/day)	0.153	0.005*	0.132	0.016*	0.045	0.417	0.104	0.126	0.109	0.109	0.004	0.952	0.238	0.012*	0.169	0.074	0.104	0.275
Carbohydrate intake (g/day)	0.257	<0.001*	0.125	0.024*	0.024	0.663	0.213	0.002*	0.146	0.032*	0.029	0.674	0.315	0.001*	0.061	0.521	-0.012	0.903
Calcium intake (mg/day)	0.018	0.740	-0.044	0.429	0.016	0.773	-0.034	0.617	-0.061	0.373	0.023	0.732	0.159	0.095	0.004	0.963	-0.004	0.965
Vitamin D intake (mg/day)	0.068	0.219	0.031	0.575	0.010	0.852	0.029	0.666	-0.047	0.490	-0.056	0.409	0.121	0.205	0.166	0.080	0.146	0.124

BMI, body mass index; HAZ, height for age; using Spearman test; *significant (*p* value <0.05)

The body requires energy to form the structure of body tissues, and for cell synthesis, among other metabolic functions in the body[12]. Furthermore, the fulfilment of nutritional intake in athletes affects the athlete's height. Height is measured when the individual is in an upright position with an anatomical body position and head position in the Frankfort plane, and represents the distance between the vertex to the floor[26]. Some sports are influenced by height factors, so it is important to pay attention to the athlete's food intake related to the athlete's height such as energy, protein, fat, carbohydrates, calcium, and vitamin D[12,26]. **Table 3** shows the results of a significant association analysis between energy, protein, fat, and carbohydrate intake and athletes height (*p*-value <0.05). Similar results were also shown in the significant correlations between intake of energy, fat, and carbohydrates with nutritional status using the indicator HAZ (*p*-value <0.05). The results of this study indicate that the higher the intake of energy, protein, fat, and carbohydrates, the taller will be the athlete. This result is supported by the data in **Table 4** which shows that the higher the intakes of energy, protein, fat and carbohydrates based on percentiles show significantly higher height data compared to lower intake percentiles. Research in 2017 conducted by Penggalih, Juffrie, Sudargo and Sofro in Indonesia found similar results that energy, carbohydrate, protein and fat intake were significantly associated with athletic performance[27]. The energy production process in athletes during physical activity (both preparation and competition) is mostly derived from carbohydrates and fats as the main energy, while protein intake functions for muscle contraction and formation[12].

Table 4 shows that energy, protein, fat, and carbohydrate intakes were significantly associated with athletes' height (*p*-value <0.05). This association was proven by the trend of intake, indicating that the higher the percentiles of energy, protein, fat, and carbohydrate intakes, the taller will be athletes' mean body height. The difference was shown based on the fulfilment of nutrient intakes which did not show a significant difference in athlete height based on fulfilment (*p*-value >0.05). In the case of the nutritional status data based on HAZ, significant associations were seen in energy and fat intake (*p*-value <0.05), since with the higher percentile of energy and fat intake of athletes, the HAZ value was significantly increased. Similar trends were observed for protein and carbohydrate intake although it was not statistically significant (*p*-value>0.05). Regarding BMI for age status, macronutrient intake did not show a significant association with BMI for age z scores (*p*-value>0.05). Energy, protein, fat and carbohydrate intakes were not significantly associated with HAZ, but were associated with BMI for age for energy and carbohydrate intakes (*p*-value<0.05). Calcium and vitamin D intake showed no statistically significant associations with height, HAZ z score and BMI/U.

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Table 4. Association between nutrient intake with height and nutritional status of subjects (n=330)

Variable	Height (cm)		HAZ		BMI for age	
	Median (Min-Max)	***p*-value**	***Median (Min-Max)***	***p*-value**	***Median (Min-Max)***	***p*-value**
Energy intake (kcal/day)		<0.001*^{a}		0.001*^{b}		0.622^{a}
<25 percentile (<1604.4)	160.4 (140.4 – 184.0)		-0.78 (-3.16 – 1.03)		0.04 (-1.82 – 2.82)	
25–50 percentile (1604.4 – 2050.1)	165.0 (151.5 – 187.5)		-0.38 (-2.58 – 2.26)		0.06 (-1.70 – 2.35)	
50–75 percentile (2050.2 – 2598.1)	166.2 (149.5 – 191.5)		-0.22 (-2.07 – 2.11)		0.07 (-1.96 – 2.81)	
75–100 percentile (>2598.1)	167.8 (150.0 – 186.5)		-0.35 (-2.63 – 2.79)		0.19 (-2.16 – 2.51)	
Protein intake (g/day)		<0.001*^{b}		0.187^{b}		0.627^{b}
<25 percentile (<56.1)	161.8 (140.4 – 181.0)		-0.45 (-3.16 – 1.42)		-0.01 (-1.82 – 2.82)	
25–50 percentile (56.1–70.8)	164.5 (151.0 – 187.5)		-0.47 (-1.98 – 2.07)		0.13 (-2.00 – 2.07)	
50–75 percentile (70.9–95.0)	166.0 (145.0 – 185.5)		-0.47 (-2.55 – 2.26)		0.12 (-1.96 – 2.81)	
75–100 percentile (>95.1)	167.8 (150.0 – 191.5)		-0.31 (-2.63 – 2.79)		0.14 (-2.16 – 2.51)	
Fat intake (g/day)		0.005*^{b}		0.006*^{b}		0.109^{b}
<25 percentile (<49.1)	162.5 (140.4 – 184.2)		-0.51 (-3.16 – 1.96)		0.21 (-1.82 – 2.82)	
25–50 percentile (49.1 – 74.9)	163.9 (145.0 – 191.5)		-0.52 (-2.58 – 2.26)		-0.09 (-2.00 – 2.21)	
50–75 percentile (75.0 – 102.5)	167.0 (151.0 – 187.5)		-0.10 (-2.63 – 2.07)		0.03 (-1.96 – 2.81)	
75–100 percentile (>102.5)	166.0 (150.0 – 186.0)		-0.37 (-1.90 – 2.79)		0.24 (-2.16 – 2.51)	
Carbohydrate intake (g/day)		<0.001*^{a}		0.050^{b}		0.738^{b}
<25 percentile (<205.9)	161.3 (140.4 – 184.0)		-0.63 (-3.16 – 1.12)		0.06 (-1.82 – 2.82)	
25–50 percentile (205.9 – 263.8)	163.1 (150.5 – 187.5)		-0.40 (-2.58 – 2.26)		-0.02 (-1.71 – 2.38)	
50–75 percentile (263.9 – 336.3)	166.0 (150.0 – 191.5)		-0.34 (-1.89 – 4.00)		0.20 (-1.96 – 2.81)	
75–100 percentile (>336.3)	167.5 (149.5 – 186.5)		-0.37 (-2.63 – 2.79)		0.06 (-2.16 – 2.35)	
Calcium intake (mg/day)		0.884^{b}		0.7658^{b}		0.773^{b}
<25 percentile (<196.8)	164.4 (148.5 – 184.2)		-0.42 (-2.58 – 2.26)		0.05 (-1.82–2.81)	
25–50 percentile (196.8–347.5)	165.0 (140.4 – 191.5)		-0.40 (-3.16 – 2.11)		0.18 (-1.72–2.82)	
50–75 percentile (347.6-661.2)	165.0 (151.0 – 186.5)		-0.45 (-2.63 – 2.06)		0.03 (-2.16–2.23)	
75–100 percentile (>661.2)	165.0 (150.0 – 186.0)		-0.46 (-2.38 – 2.79)		0.21 (-2.00–2.38)	
Vitamin D intake (mg/day)		0.176^{b}		0.371^{a}		0.064^{b}
<25 percentile (<0.50)	164.0 (140.4 – 184.2)		-0.35 (-3.16 – 2.79)		0.18 (-1.82 – 2.82)	
25–50 percentile (0.50–1.79)	164.0 (145.0 – 191.5)		-0.43 (-2.55 – 2.11)		-0.14 (-1.88 – 2.51)	
50–75 percentile (1.80-4.63)	166.4 (150.0 – 186.5)		-0.54 (-2.58 – 2.26)		0.21 (-2.00 – 2.81)	
75–100 percentile (>4.63)	166.4 (148.5 – 186.0)		-0.38 (-2.63 – 2.07)		0.03 (-2.16 – 2.23)	
Energy adequacy		0.998^{b}		0.980^{b}		0.032*^{b}
<80%	164.5 (140.4 – 191.5)		-0.43 (-3.16 – 2.26)		0.12 (-1.82 – 2.82)	
80–110%	165.0 (149.5 – 186.0)		-0.45 (-2.33 – 2.79)		0.12 (-1.96 – 2.81)	
≥110%	166.0 (150.5 – 180.0)		-0.40 (-2.63 – 2.06)		-0.18 (-2.16 – 1.31)	
Protein adequacy		0.877^{a}		0.649^{a}		0.972^{b}
<80%	164.4 (140.4 – 187.5)		-0.44 (-3.16 – 2.79)		0.09 (-1.96 – 2.82)	
80–110%	166.0 (150.0 – 191.5)		-0.38 (-2.58 – 2.11)		0.11 (-2.00 – 2.81)	
≥110%	165.3 (145.0–180.0)		-0.39 (-2.63 – 1.17)		0.10 (-2.16 – 2.23)	
Fat adequacy		0.337^{b}		0.212^{b}		0.815^{b}
<80%	164.3 (140.4 – 191.5)		-0.42 (-3.16 – 2.26)		0.03 (-1.88 – 2.82)	
80–110%	166.0 (152.5 – 185.5)		-0.28 (-1.89 – 2.79)		0.11 (-1.70 – 2.23)	
≥110%	165.0 (145.0 – 186.0)		-0.49 (-2.63 – 2.06)		0.17 (-2.16 – 2.51)	
Carbohydrate adequacy		0.903^{b}		0.613^{b}		0.033*^{b}
<80%	165.5 (140.4 – 185.5)		-0.42 (-3.16 – 2.79)		0.22 (-1.96 – 2.82)	
80–110%	164.0 (150.0 – 187.5)		-0.49 (-2.34 – 1.82)		0.12 (-1.70 – 1.95)	
≥110%	165.0 (148.5 – 191.5)		-0.40 (-2.63 – 2.11)		-0.02 (-2.16 – 2.81)	

* *p*-value <0.05=significant; a=Kruskal-Wallis test; b=One-way ANOVA test.

Besides macronutrients, some micronutrients such as calcium and vitamin D also play an important role in the growth and development of athletes. Vitamin D plays a role in stimulating calcium absorption, bone formation, muscle tissue formation and physical performance[12]. Accordingly, vitamin D intake in athletes can also prevent injuries during physical activity, both training and competition. However, the results of this study did not show a significant relationship between calcium and vitamin D intake with height (cm) or HAZ z-score. Athletes need to be aware of calcium and vitamin D intake as vital nutrients that directly support bone formation[28]. This study showed that the median intake of calcium and vitamin D of all athletes was 347.6 mg and 1.80 mcg respectively with insignificant differences between the two groups ($p>0.05$). These amounts remain inadequate when compared to the needs of the population aged 13-18 years based on the daily recommended dietary allowance (RDA) in 2019, which is 1,200 mg calcium per day and 15 mcg vitamin D per day. These results were consistent with a study conducted by Penggalih et al. in 2019 on athletes at PPLP Yogyakarta, PPLP Aceh, and SKO Ragunan which showed that athletes still had an average inadequate intake of several micronutrients such as zinc, calcium, phosphorus, folic acid, fiber, and vitamin D[29].

CONCLUSIONS

The intakes of energy, protein, fat, and carbohydrates were found to be significantly associated with the athletes' height, while the intake of calcium and vitamin D showed no significant correlations. This research is expected to have a strengthening impact on sports stakeholders to pay more attention to the nutritional intake and achievement of athletes' height among sports branches in Indonesia. Fulfilling the intakes of energy, protein, fat, and carbohydrates, particularly in sports branches that emphasize height, needs to be seriously considered to support athletic performance.

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