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Nutrition intake, insulin-like growth factor-1 hormone levels, somatotype score, and strength performance of adolescent athletes

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ABSTRACT

Background Problems: Currently, there is still limited identification of nutritional intake, hormonal, and physical performance in adolescent athletes in Indonesia. **Research Objectives:** This study aims to identify anthropometric, nutritional intake, IGF-1 hormone level, and adolescent athletes's performance. **Methods:** The research method used a cross-sectional study. A convenient sample of 58 athletes under Balai Pemusatan Pendidikan dan Latihan Pelajar. The research instrument used Bioelectrical Impedance Analysis (BIA), leg dynamometer, hand grip dynamometer, tape measure, height stature, SQ-FFQ Form, and body fat caliper. Blood samples were collected and tested by a professional laboratory. Data analysis techniques used Pearson's test for normally distributed data and Spearman's rank for non-normally distributed data. **Findings and Results:** The result of this study found a significant ($p < 0.05$) correlation between energy intake, anthropometric measurement of z score (BMI/Age), and endomorph score with an athlete's muscle strength. We also found significant differences ($p < 0.05$) in macronutrient and micronutrient consumption in male and female athletes, and we also found significant differences in somatotype score and muscle strength in male and female athletes. **Conclusion:** We conclude that many athletes are not consuming the recommended levels of carbohydrates, fat, protein, and some micronutrients. We found a correlation between energy intake and fat intake with leg muscle strength. However, there was no correlation between IGF-1 hormone levels and athlete strength. Intake is thought to indirectly affect grip strength and leg strength.

Keywords: Nutritional intake; IGF-1 hormone level; adolescent athlete; athlete antropometric; athlete

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INTRODUCTION

Monitoring athletes' muscle strength is beneficial for increasing athlete strength and decreasing injury rates (Suchomel et al., 2016). Periodic evaluation of the muscle strength of athletes has been identified as a key factor in ensuring optimal performance and the efficacy of training programmes (Penggalih et al., 2019a). It is not only athletes engaged in strength sports who require exercises that enhance muscle strength; in several other sports, muscle strength is also a prerequisite for optimal performance (Cid-Calfucura et al., 2023; Lubis et al., 2021; Suchomel et al., 2018). Studies about adolescent athlete muscle strength in Indonesia were conducted on various sports and found that less than 50% of athletes had good muscle strength categories (Amin & Adnan, 2020; Purwaningtyas et al., 2021; Setiowati, 2014). Athletes' nutrient intake has a linear relationship with athlete's strength. Adolescent athletes need increased intake to meet their basic needs and increase physical activity. However, in Indonesia, adolescent athletes' intake of energy and carbohydrate nutrients has yet to meet the recommendations compared to the individual needs of athletes (Anderson et al., 2018; Penggalih et al., 2019b). Consumption of carbohydrates and fats in adolescent girls in Indonesia is known to influence IGF-1 hormone levels (Primariayu et al., 2017).

Besides macronutrient intake monitoring, micronutrient intake is also essential for evaluation in athletes. Some important micronutrients for athletes are zinc, magnesium, and vitamin B6. Athletes' zinc consumption needs to be evaluated because zinc is related to the production of oxidative stress in muscles (Hernández-Camacho et al., 2020). Magnesium has an essential role as a cofactor in various enzymatic reactions, including energy metabolism, cell growth, glycolysis, and protein synthesis, and has a relationship with muscle strength (Moslehi et al., 2013; Zhang et al., 2017). Vitamin B6 plays a role in homocysteine metabolism associated with glycogenolysis and gluconeogenesis during exercise (Brancaccio et al., 2022; Lee et al., 2023). A previous study identified inadequate intake of several macronutrients among adolescent athletes. However, the investigation did not assess the intake of micronutrients and growth hormones, which may have an impact due to the athletes' daily intake (Mukarromah 2017). Besides nutrition intake, there are hormonal statuses that have an essential role with muscle strength. Hormone Insulin-like Growth Factor-1 (IGF-1) is one of the markers of muscle status in athletes that reduces protein breakdown by acting as a mediator of anabolic actions (Lee et al., 2017). The IGF-1 hormone is essential in resistance training and can induce muscle hypertrophy in athletes (Abe et al., 2005; Marangoz & Var, 2018; Muhammad, 2023). A decrease in IGF-1 levels indicates excessive muscle adaptation due to overtraining (Lee et al., 2017). Athlete intake can also affect the hormone insulin-like growth factor-1 (IGF-1) levels (Santos et al., 2011). A high-fat diet given to athletes causes IGF-1 hormone levels in athletes to decrease significantly compared to Western diets (Paoli et al., 2021).

At present, the research on the IGF-1 hormone in adolescent athletes in Indonesia is limited. Currently, research on the relationship between the IGF-1 hormone and adolescent athletes is limited. However, there are studies that have been conducted on adolescent girls in Jakarta (Primariayu et al., 2017). There is currently no research in Indonesia investigating the relationship between dietary intake, IGF-1 hormone, somatotype components, and muscle strength in adolescent athletes. Different muscle formation in athletes due to exercise and food intake will affect the athlete's body shape. Athletes with a sport-appropriate somatotype structure compete well (Buśko et al., 2013). An athlete's somatotype is known to be related to the outcome of an athlete's strength (Marta et al., 2011). It has been established that athletes with endomorph and mesomorph somatotype components are more likely to demonstrate superior muscle strength than those with ectomorph somatotypes (Penggalih, 2022). Based on the description that has been explained, the researcher was interested in conducting research that aimed to obtain adolescent athletes' nutrient intake, somatotype, IGF-1 hormone levels, and strength performance (hand grip and low leg muscle strength).

METHOD

Type of Research

The research method used is a cross-sectional study. This type of research was chosen because it allows for the collection of data from a population at a specific point in time, making it suitable for analysing the relationships between variables without requiring extended observation periods. It provides a snapshot of the characteristics, behaviours, and outcomes relevant to the study's objectives.

Participants

Subjects were adolescent athletes aged 13-18, and the study was conducted on 58 adolescent athletes at Balai Pemusatan Pendidikan dan Latihan Olahraga Pelajar (BPPLOP), Central Java, Indonesia. This study was conducted on athletes from 13 sports, namely fencing, athletics, basketball, sand volleyball, volleyball, wrestling, judo, karate, pencak silat, swimming, takraw, tae kwon do, and boxing. The criteria for the subjects were that male athletes had experienced wet dreams, female athletes had experienced menarche, guardians/parents of athletes signed informed consent to the study, and athletes were able to communicate well and were physically healthy (without injury). The exclusion criteria in this study were athletes using or consuming steroids. The research was carried out after the issuance of Ethical Clearance number 012/EC/KEPK/FK-UNDIP/1/2024 from the Ethics Commission of the Faculty of Medicine, Diponegoro University.

Research Procedures

Anthropometry

Anthropometric measurements, including weight and fat mass percentage, are measured using Bioelectrical Impedance Analysis (BIA). Height is measured using a GEA brand for stature meter. Femoral width, humeral width, and fat fold thickness (tricep, calves, subscapular, and supra iliac) are measured using a body fat caliper. Upper arm circumference and calf circumference are measured using a tape measure.

Somatotype

The antropometric data are then continued with the measurement of somatotype using the Heath-Carter method. Then, the endomorph, mesomorph, and ectomorph somatotype components were calculated using the Heath-Carter formula. The results of the component calculations were mapped onto the X and Y axes of the somatochart. Additionally, the athlete's somatotype can be identified based on its location on the Somatochart diagram (Bertuccioli et al., 2022).

IGF-1 Hormone Level

The concentration of the IGF-1 hormone was quantified through the analysis of blood samples obtained from the subjects. All subjects were required to fast for 12 hours before taking blood samples. The samples were collected via venipuncture by a trained professional following standardised procedures. The samples were then stored and analysed using the enzyme-linked immunosorbent assay (ELISA) method. The IGF-1 hormone level for characteristics of the subject presented in Table 1.

Table 1. IGF-1 Hormone Level Reference

Age (years)	Male (nmol/l)	Female (nmol/l)
11-12	25-37	24-78
13-14	21-87	37-103
15-16	32-84	48-91
17-18	20-56	35-73

(Tyne Hospitals NHS Trust, 2018)

Dietary Intake

Dietary intake data of macronutrients and micronutrients were obtained by interviewing using a semi-quantitative food frequency questionnaire (SQ-FFQ) and collected by experienced enumerators. The data obtained from the SQ-FFQ form is 1-month historical intake data. These data are manually converted into daily intake data. Intake data was then analysed using Nutrisurvey 2007. Any food ingredients not included in the Nutrisurvey application are idenitified and added from two sources: firstly, the Food Ingredients Composition Table of the Ministry of Health of the Republic of Indonesia (2020), and secondly, the Fat Secret website.

Strength Muscle Measurement

The strength of the lower leg muscles was quantified using a leg dynamometer. Subjects were invited to take up a position on the dynamometer with their body upright and knees bent at an angle of 130°-140°. The dynamometer chain was then adjusted according to the athlete's body position. The handle stick was grasped with the hand position facing the back. The subject was then asked to pull the handle stick as hard as possible and straighten the knee slowly. The strength of the hand grip was quantified using a leg dynamometer. The athlete stands upright with legs shoulder-width apart. Both arms are held straight beside the body, grasping the handgrip dynamometer. The athlete is asked to squeeze the tool with all his or her strength, alternating between the right and left hand. Each measurement is taken three times, and the best grip strength value is selected. The measurements were conducted by trained personnel. The results were averaged after two repetitions (Penggalih, 2022).

Data Analysis

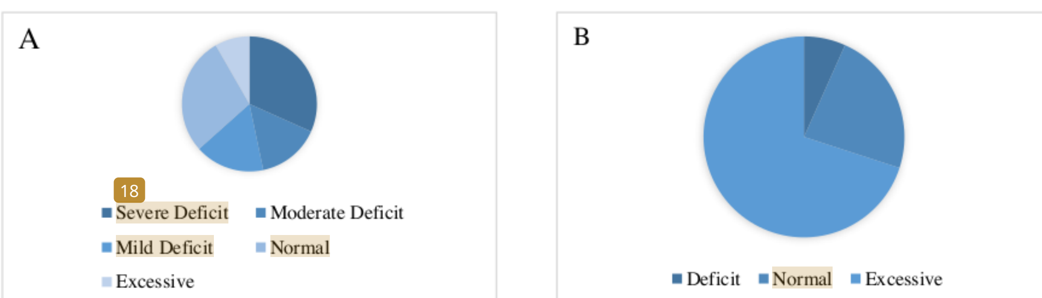
Univariate analysis was used to describe the characteristics of respondents using the mean and standard deviation. Bivariate analysis, the statistical technique of examining the relationship between two variables, was employed to investigate the association between three independent variables (nutrient intake, IGF-1 hormone levels, and somatotype) and two dependent variables (grip muscle strength and leg muscle strength). Normally distributed data were analysed using the Pearson test, while non-normally distributed data were analysed using the Spearman Rank Test.

RESULTS AND DISCUSSION

Table 1. Subject Characteristics

Characteristics	Mean ± SD/median (n = 58)	Min-max
Age (years)	15.53 ± 1.19	13 - 18
Energy (kcal)	2554 ± 774.5	1061.3 - 4456.6
Carbohydrate (gram)	313.74 ± 111.85	93.5 - 506.7
Fat (gram)	94. 53 ± 35.85	38.2 - 228.6
Protein (gram)	115.52 ± 47.54	39.8 - 236.2
Zinc (mg)	13.21 ± 5.28	4.7 - 27.7
Magnesium (mg)	484.90 ± 276.07	138.8 - 1903.3
Vitamin B6 (mg)	2.51 ± 1.23	0.7 - 7.10
Somatotype score		
Endomorph	3.61 ± 1.9	0.85 - 8.09
Mesomorph	2.61 ± 1.75	-2.81 - 7.28
Ectomorph	3.08 ± 1.25	0.10 - 5.62
Muscle strength		
Low Leg Muscle Strength (kg)	136.80 ± 72.88	36.5 - 300
Right-Hand Grip Strength (kg)	36.86 ± 12.08	21.8 - 99.9
Left Hand Grip Strength (kg)	32.49 ± 9.04	18.73 - 60.73

We have also carried out calculations to see how the nutritional needs of the athletes are being met, as shown in Figure 1. Athletes whose energy intake was classified as normal were 28.3% and excessive were 8.3%. Carbohydrate intake was classified as normal in 23.3% of athletes and excessive in 6.7%. Protein intake was classified as normal in 26.7% of athletes and as excessive in 28.3%. Fat intake was excessive in 58.3% of athletes. The details of daily intakes show that some athletes are still not meeting their intakes.



Section A content of Energy intake fulfillment
Section B content of Carbohydrate intake fullfilment
Section C content of Protein intake fullfilment
Section D content of Fat intake fullfilment

Figure 1. Macronutrient intake fulfilment

Figure 2 presents subjects' IGF-1 hormone levels, which were found to be 58.6% low when compared to the standard reference of IGF-1 hormone level.

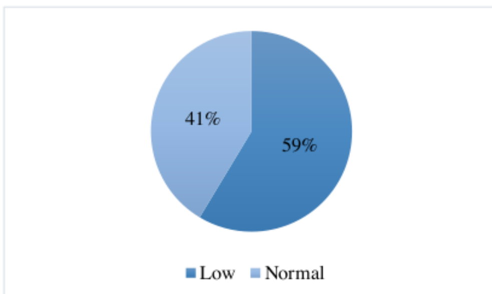


Figure 2. IGF-1 Hormone level

Figure 3 presents a somatotype athlete. The average somatotype component of all respondents is 3.6-2.6-3.1, which can be considered the central type.

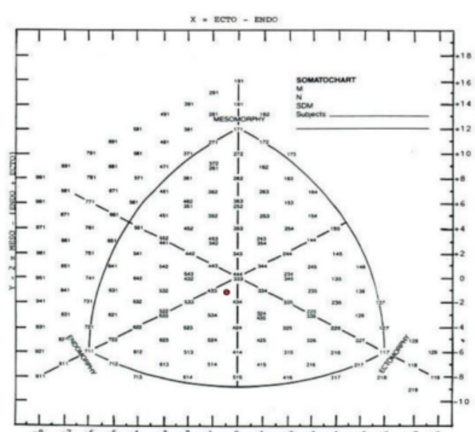


Figure 3. Athlete somatotype

Table 2 presents the relationship between variables and athletes' strength performance. Based on the correlation test conducted,energy intake and endomorph scores were found to be related to leg muscle strength.

Table 2. Correlation between Nutritional Intake, IGF-1 Hormone Levels, and Somatotype with Athletes' Strength Performance

Variable	Leg Muscle Strength		Right Hand Grip Strength		Left Hand Grip Strength	
	p	r	p	r	p	r
Energy (kcal)	**0.038***	0.273	0.178*	0.179	0.232*	0.159
Carbohydrate (gram)	0.120*	0.206	0.298*	0.139	0.505*	0.089
Protein (gram)	0.178*	0.180	0.590*	0.072	0.822*	0.030
Fat (gram)	0.048*	0.261	0.166*	0.184	0.159*	0.187
Zinc (mg)	0.085*	0.228	0.443*	0.103	0.441*	0.103
Magnesium (mg)	0.063*	0.246	0.506*	0.089	0.613*	0.068
Vitamin B6 (mg)	0.489*	0.093	0.924*	-0.013	0.792*	-0.035
IGF-1 Hormone Level (nmol/L)	0.168*	0.183	0.589*	-0.072	0.852*	0.025
Z-Score (BMI/Age)	**0.016***	0.316	**0.004***	0.373	**0.000***	0.469
Somatotype score						
Endomorph	**0.032****	-0.282	0.100**	-0.218	0.312**	-0.135
Mesomorph	0.872*	0.022	0.114*	0.210	0.130*	0.201
Ectomorph	0.975*	0.004	0.548*	-0.081	0.205*	-0.169

* Pearson Test, ** Spearman Test

The subjects, male and female, had differences in macronutrient intake (energy, carbohydrates, and protein), micronutrient intake (zinc and magnesium), endomorph scores, and low leg muscle strength. The difference test is presented in Table 3.

Table 2. Variable Differences by Gender

Variable	Male (n=33)	Female (n=25)	p
Macronutrients Intake			
Energy (kcal)	2871 ± 716.8	2135.6 ± 647.8	**0.000***
Carbohydrate (gram)	359.9 ± 99.46	252.86 ± 98.68	**0.000***
Fat (gram)	103.05 ± 38.04	83.28 ± 29.84	**0.071**
Protein (gram)	127.08 ± 47.87	100.26 ± 43.42	**0.027***
Muscle strength			
Low Leg Muscle Strength (kg)	175.89 ± 69.08	85.2 ± 37.13	**0.000***
Right-Hand Grip Strength (kg)	41.70 ± 12.60	30.49 ± 7.77	**0.000***
Left Hand Grip Strength (kg)	36.68 ± 7.76	26.97 ± 7.61	**0.000***

The value is presented as the mean ± standard deviation, using the Mann-Whitney Test, *significant difference p<0.05.

Anthropometric measurements in athletes using body type based on the somatotype method and knowing the nutritional status of adolescent athletes need to be done regularly to monitor the suitability of physical activity and nutritional therapy to be given to athletes (Penggalih, 2022). Based on differences between male and female athletes presented in Table 4, the average nutritional status presented as z-score (BMI/Age) of adolescent athletes in BPPLOP is included in the normal nutritional status category and needs to be maintained with appropriate training for better functional and health-related outcomes (Pomohaci & Sopa, 2017).

There were significant differences ($p < 0.05$) in macronutrient intake (energy, carbohydrate, protein, and fat) between male and female athletes. Regarding macronutrients, energy, carbohydrates, protein, and fat may have been insufficient to support optimal performance. An appropriate energy intake needs to be calculated personally according to the individual needs of the athlete in order to provide optimal support to body function and body composition (Thomas et al., 2016). Our study found that the intake of macronutrients such as energy, protein, fat, and carbohydrates was below the daily requirement (presented at figure 1). Higher protein intake must be consumed because of their increased utilisation of amino acids for long-duration activity and recovery from muscle damage (Doering et al., 2016; Louis et al., 2020). Despite the importance of carbohydrates in sports performance, replacing carbohydrates with protein is a common practice. This is because protein is generally associated with gaining lean mass, and excessive intake among males may be due to gendered differences in body image patterns that caused differences in protein consumption between male and female athletes (Nascimento et al., 2016). In this study, energy significantly correlated with athletes's foot strength but not with hand grip strength; this is contrary to previous studies where protein intake has a relationship with leg muscle strength (Ross et al., 2020). Given the importance of athletes' energy intake that correlates with athletes' leg muscle strength, athletes' energy intake needs to be considered in accordance with the needs of individual athletes. Therefore, this study can enrich research on the relationship between macronutrient intake and athlete muscle strength.

Based on the recorded athlete food data that we have collected, athletes' food intake tends to consume chicken, eggs, tempeh, fish, and tofu. Athletes rarely consume protein sources such as beef and beef liver, which are sources of vitamin B6 (Mahdavifar et al., 2021). This food record showed the intake of zinc and vitamin B6 athletes tend to be low. We have found that the intake of magnesium and omega-3 adolescent athletes has met their daily needs, but zinc and vitamin B6 intake are still less than the recommended intake. Adolescent athletes are recommended to consume 100 mg of magnesium, 20 mg of zinc, 50 mg of vitamin B6, and 2-4 grammes of Omega-3 daily (Beck et al., 2021; Lee et al., 2023). There were significant differences ($p < 0.05$) in micronutrien intake (zinc and magnesium) between male and female athletes. The consumption of food sources of zinc and vitamin B6 athletes needs to be increased, and, even if necessary, it can be added with the consumption of supplements under the supervision of coaches (Cerqueira et al., 2021).

Based on this study, more than 50% of athletes' hormones fall into the low category. A low level of the IGF-1 hormone can be caused by the athlete's food consumption. Based on research conducted by another researcher, zinc and magnesium consumption has a relationship with IGF-1 hormone levels (Cerqueira et al., 2018). As both vitamin B6 and magnesium have been hypothesised to have a synergistic effect and need to be given more in athletes (Pouteau et al., 2018). A decrease in IGF-1 levels indicates excessive muscle adaptation due to overtraining (Lee et al., 2017). Our findings on consuming less than the required amount are worth further investigation to see if this is a factor that can have a direct effect on the hormone IGF-1 and the muscle strength of athletes.Significant differences in muscle strength male and female athletes showed differences in leg muscle strength, right-hand grip strength, and left-hand grip strength. The findings of our study support the results of most previous studies, which reported differences between female and male athletes's muscle strength (Amo-Setién et al., 2020; Lehnert et al., 2020). It is recommended to evaluate the training given to athletes to provide maximum performance.

CONCLUSION

Athletes at the Balai Pemusatan Pendidikan and Latihan Olahraga Pelajar consume macronutrients and micronutrients below the recommended levels to support their optimal performance. Athletes' energy consumption needs to be considered to suit their needs so that they can provide good physical performance and performance in the future. In addition, the consumption of micronutrients such as zinc and vitamin B6 needs to be evaluated for fulfilment in order to have a positive impact on athletes' bone density and provide additional performance to athletes' strength performance. Based on the level of IGF-1 hormone in athletes and the difference in muscle strength between male and female athletes, regular evaluations of the training given are necessary to prevent overtraining that hinders athlete performance. We recommend further study and additional mapping of potential issues associated with the IGF-1 hormone level. Further research can be done by differentiating the levels of the IGF-1 hormone in athletes in several seasons of competition to clarify the picture of intake and exercise given to athletes.

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CONFLICT OF INTEREST

The authors state no conflict of interest.

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