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Research Article
Dietary Intake and Strength Training Management among Weight Sports Athlete Category: Role of Protein Intake Level to Body Composition and Muscle Formation

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Abstract
Background and Objective: Protein has an effect on the muscle formation, but in Indonesia the fulfillment of protein and dietary intake in athletes are below the daily needs allowances. The purpose of this study is to provide recommendation intake of nutrient especially protein for weight sports athlete. **Materials and Methods:** There were 90 athletes as subjects participated in this experimental study. Every subjects has different calculation of nutrients needs, based on age, gender, level of activity and exercise. Recommendation for protein intake was given 1.7 g kg^{-1} of b.wt./day adjusted with strength training is considered as high protein intakes. Fats intake was 20% from total energy and carbohydrate were calculated from total energy after adjusted with energy for protein and fats. **Results:** The results of protein intake after intervention were found that 90 subjects are divided into 3 categories; low protein intake (Group A; <1 g kg^{-1} of b.wt./day), normal protein intake (Group B; 1-1.6 g kg^{-1} of b.wt./day) and high protein intake (Group C; >1.7 g kg^{-1} of b.wt./day). **Conclusion:** This study shows the correlation between high protein intake group with significant improve on subscapula and suprailiaca skinfolds. It means the body composition and muscle formations on those areas were improved followed by continuing nutritional education, especially on protein intake with the recommendation 1.7 g kg^{-1} of b.wt./day for weight sport athletes in Indonesia.

Key words: Protein, athlete, skinfold, energy, carbohydrate, fats, magnesium, anthropometry

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Weight sport is a type of sports that focus on muscle formation following by lower body fat value and the sports are divided into several classes based on their body weight. Body building, martial arts, rowing, weightlifting and wrestling are examples of weight sports category[1]. Athletes who are competing on this category focus with intake of nutrition associated with muscle formation[2]. Several studies mentioned the relationship between nutritional intake and muscle formation in normal and athletes population[3-5].

Protein is one of macro-nutrients that are closely related with muscle formation. About 40% protein found in skeletal muscle, it presents 43% of body weight[6]. Sintesis of muscle mass is associated with net protein balance, positive balance showed the growth of muscle mass while negative value indicates decrease in muscle mass. This balance is strongly influenced by protein intake and another nutrients such us; carbohydrate, fats and magnesium[7].

Athletes in weight sport category has protein intake above normal population even another type of sports[8,9]. High protein needs on this category of sport are related to muscle hyperthrophy process. Hyperthrophy of muscle begin when the body performs physical activity precisely on part of myofibril muscle protein. Physical activity leads to an increase in muscle protein breakdown (MPB) and muscle protein synthesis (MPS), but without adequate energy and nutrients, MPB value will higher and process of muscle hyperthrophy will not achieved[7].

The balance of protein, carbohydrate and fats must be maintained to meet energy needs. Carbohydrate are the main nutrients in supplying energy under normal condition[1]. Carbohydrate helps increase muscle protein synthesis on muscle tissue, this related to the presence of insulin. Insulin is produced when blood detects glucose and myofibril production increase[7]. Insulin-like growth factor 1 (IGF-1) is a protein growth factor that can induce skeletal muscle hypertrophy by activating the phosphatidylinositol 3-kinase (PI3K)-Akt pathway[10]. Fats known as part of membrane cell structure[11]. Another function of fats in skeletal muscle is when it changes to sphingosine-1-phosphate (S1P). S1P can alter calcium handling via transient receptor potential canonical channels that induce muscle contraction and level of S1P in plasma will increase with exercise[12,13].

Magnesium is a macro-mineral that can be found in the body[14]. The role of magnesium in metabolism is known as coenzyme (Mg-dependent) on enzymatic reactions. Some of metabolic processes are glycolysis, krebs cycle, beta oxidation and active ion transport. The main function of magnesium is to activated the enzymes which are responsible to synthesis, storage and using of high energy compounds[15].

Some of nutrients above especially protein have an effects on the process of muscle formation, but in Indonesia the fulfillment of dietary intake in athletes are below daily needs[16,17]. The purpose of this study is to provide recommendation intake of nutrient especially protein for weight sports athlete. In addition, this study also observe the relationship of high protein intake with body composition and muscle formation. The longitudinal monitoring is followed also with continuing nutritional education during the research study.

MATERIALS AND METHODS

Study area and population: Total subjects on the beginning of this study were 158 athletes, but at the end of intervention reduced to 90 athletes (87.8% men and 12.2% women). The subject flowchart can be seen in Fig. 1. Subjects are athletes with speciality on weight sport category who were training at fitness centre in Yogyakarta, Indonesia. Athlete's training focus on strength type exercise. This study began in April-June, 2017 and has been granted with permission of ethics committee of Faculty of Medicine, Universitas Gadjah Mada, Indonesia with number KE/FK/0768/EC/2017. Inclusion criteria was athletes who were training minimum 2 times a week in fitness centre. Athletes with medical treatment or injury that can not meet minimum frequencies for training will be excluded from this study. The drop out athletes were caused by going out of town for match and sick.

Intervention program: The study design was an experimental with longitudinal cohort retrospective for 3 months. The intervention for subjects were education of nutritional needs with high protein intake. Each subject has different calculation of nutritional needs, adjusted by age, gender, level of activity and exercise. Basal energy was obtained through measurement by using bioelectrical impedance (BIA). Energy for physical activity by using conversion factors and it adjusted for Indonesian society[18]. Energy for exercise was calculated based on type and duration of exercise[1]. Recomendation for protein intake is 1.7 g kg^{-1} of b.wt./day adjusted for exercise with strength training[19]. Fats intake was 20% from total energy[18] and carbohydrate was calculated from total energy after adjusted with energy for protein and fats. Athlete's nutritional recomendation was given an information about

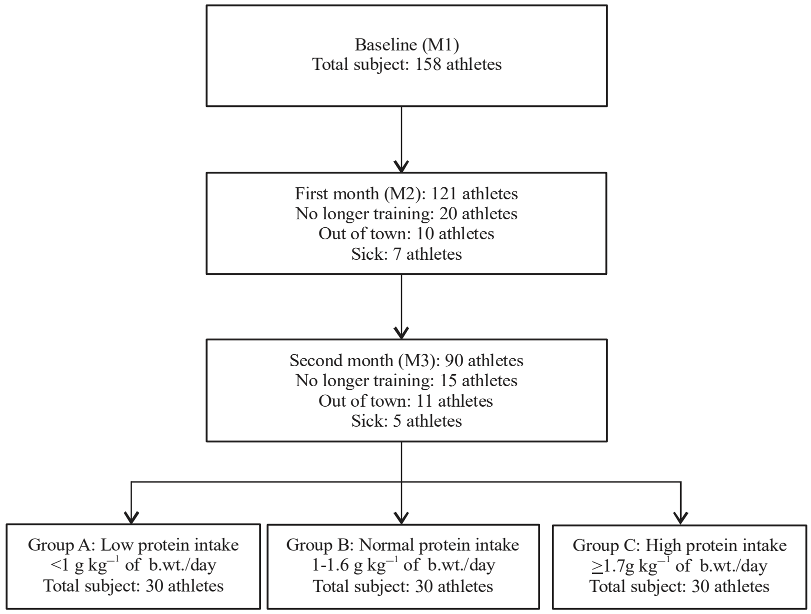

Fig. 1: Subject flowchart

portion of meals in a day consist of type of carbohydrates, proteins, fats, vegetables, fruits and sugar. Athletes were given leaflets containing exchanges of foodstuffs based on type and portion, it makes athletes easier to choose another food with their own preference.

At the end of the study, there were three different level of daily protein intake among subjects. The subjects devided into 3 categories; Group A as low protein intake (<1 g kg^{-1} of b.wt./day); Group B as normal protein intake (1-1.6 g kg^{-1} of b.wt./day) and Group C as high protein intake (>1.7 g kg^{-1} of b.wt./day). Each categories has the same number of subjects, 30 athletes.

Measurements: Monitoring of dietary intake and indicators of muscle mass (body comoposition, body weight, skinfolds and somatotype) were done every months, baseline (M1), first months (M2) and second months (M3). Body weight and composititon were measured by using a Karada Scan HBF-375 digital scale. Body composition consists of segmental subcutaneous fat (leg, arm, trunk, total (%)) and segmental skeletal muscle (leg, arm, trunk, total (%)). Height measurement obtained by using a GEA microtoise. Somatotype was measured by using Harpender skinfold caliper, Meiden spreading caliper and ABN metline. The components of somatotype are skinfolds (tricep, subscapular, suprailiaca and calf), bone width (humerus and femur biepicondylar), calf and maximum arm circumference. The measurements results were formulated into a Carter Formula[20].

Data analysis: Statistical analysis was performes with SPSS Version 19. Data are presented as mean±standard error for the mean. The results of protein intake after 3 months monitoring were found 90 subjects devided into 3 categories; low protein intake (Group A), normal protein intake (Group B) and high protein intake (Group C). Statistical test for changing variables every months by using paired t-test. ANOVA was used to see the differences of each variable according to the intake of protein level. Correlation test was used to see the relationship between protein intake with body composition and muscle mass.

RESULTS

Subjects characteristic: The subjects flow (Fig. 1) showed 158 athletes at the beginning of the study and reduced to 90 athletes at the end of intervention. The reason for withdrawal subjects were they no longer coming to fitness centre for strength training (n = 35 athletes; 51%), going out of town for travels or matchs (n = 21 athletes; 30.8%) and sick (n = 12 athletes; 18.2%). The subjects of this study were mostly male (87.8%). The results of classification of sleeping hours showed mostly (63%) had less than 8 h sleep. Subjects education history showed mostly from bachelor degree (Table 1).

Results of variable: The results of all variables can be seen in Table 2 with average value for 3 months of observation.

Table 1: Characteristics subjects

Characteristics	No.	%
Sex		
Men	79	87.8
Women	11	12.2
Hours of sleep		
<8 h/day	57	63.0
8-10 h/day	33	37.0
Last education		
Junior high school	2	2.1
Senior high school	29	32.3
Bachelor degree	53	59.0
Master degree	6	6.6

Table 2: Avarage results of all variable

Variables	Min.	Max.	X	SD
Ages (years)	14.0	50.0	25.6	7.0
Weight (kg)	44.0	112.0	70.2	12.7
Energy (ccal)	555.0	3696.0	1912.6	710.7
Intake of carbohydrate (g)	47.0	520.0	242.7	101.0
Intake of protein (g)	18.0	305.0	87.0	49.3
Intake of fats (g)	8.0	219.0	68.5	38.9
Magnesium (mg)	0.0	977.0	305.4	218.5
Duration of training (min/week)	60.0	1260.0	311.4	177.7
Mesomorph	0.0	9.0	4.5	1.7
Total muscle (%)	25.0	40.0	32.9	3.3
Trunk muscle (%)	10.0	35.0	26.4	4.6
Arms muscle (%)	27.0	45.0	37.3	3.4
Legs muscle (%)	37.0	57.0	49.5	4.4
Skinfold suprailiaca (mm)	5.0	35.0	15.9	6.8
Skinfold subscapula (mm)	6.0	31.0	14.2	4.3
Skinfold trisep (mm)	4.0	28.0	10.6	5.1
Skinfold bisep (mm)	2.0	26.0	6.9	3.9
Tense arm circumference (cm)	22.0	113.0	34.54	9.5

Min: Minimum value, Max: Maximum value, X: Average value, SD: Standard deviation

The study showed different food consumption patterns in Indonesia especially in athletes. Professional athletes in Indonesia are known to have problems in meeting energy, protein and carbohydrate needs which are lacking while fats are overfilling[16,17]. Fulfillment of proteins that are low is certainly less than 1 g kg^{-1} of b.wt./day, so the new findings from this study, which turns out that in the weight sports category fulfillment of protein can be said to be good. Recommendations from several studies are also subsequently appropriate to help improve the anthropometric profile of athlete's weight sport category in Indonesia.

Group A was defined with intake of protein less than 1 g kg^{-1} of b.wt./day; Group B or normal group when intake of protein 1-1.6 g kg^{-1} of b.wt./day and Group C or high protein intake group when it was >1.7 g kg^{-1} of b.wt./day. The classification was based on a recommendation for athletes with intensive resistance training, protein intake minimum 1.7 g kg^{-1} of b.wt./day[19] and for normal population in Indonesia recommendation for intake of protein is 1 g kg^{-1} of b.wt./day[18].

Triceps skinfold decrease in the normal protein group (Group A) because of significant decrease in fats and carbohydrate intake in the second month (M2) (Table 3). While in high protein group (Group C) increased fats and carbohydrate intake although the value is not significant. The value of other nutrients intake that experienced significant changes is Magnesium (Mg). The high protein group saw a significant increase in the 3rd month. The Mg is a mineral that has a function as a coenzyme in metabolic processes such as the Krebs cycle, glycolysis, β-oxidation and other metabolism that produce ATP[21].

Statistical analysis of muscle formation and body composition indicator: Table 4 showed statistical result for ANOVA test between protein intake and indicators of muscle mass. Significant values are found on suprailiaca and subscapula skinfolds (p = 0.011 and 0.025). High protein intake group has the smallest skinfold value, then normal protein intake group and the highest skinfolds value is low protein intake group. Skinfold showed the fat fold value in the tissue under the skin, if the value is small, it showed that the value of fats are small and there are occurs muscle formation needed by athletes[20]. Weight sport category athletes need more muscle composition than fat, because it will affect the performance during the competition.

Statistical correlation between intake protein and muscle formation: As seen in Table 5, the correlation between protein intake and indicators of muscle mass, it was adjusted with dietary intake and training. From the Table 5, it was seen that protein intake after adjusted with dietary intake significant reduce the value of fats on suprailiaca and subscapula (Model 1). Based on this analysis, providing education on nutritional needs can help athletes fulfill daily nutritional needs, especially proteins that play an important role in weight sports athletes. Well-fulfilled protein requirements can improve skinfold values that can improve athlete's performance.

DISCUSSION

High protein intake group experience the highest number of dietary intake (Table 4). This suggested that with higher of dietary intake (energy, protein, fat, carbohydrates and

Table 3: Analysis of all variables

	Group A (X+SD)			Group B (X+SD)			Group C (X+SD)			*p-value		
Variables	M1	M2	M3	M1	M2	M3	M1	M2	M3	Group A	Group B	Group C
Body weight (kg)	74.2±10.5	73.9±10.5	73.7±10.4	68.3±15.6	67.9±15.0	68.2±15.4	68.3±11.7	67.6±11.5	68.9±12.3	a. 0.367 b. 0.180 c. 0.281	a. 0.197 b. 0.621 c. 0.368	a.0.096 b.0.209 c.0.053
Mesomorph	5.4±1.6	5.3±1.6	5.2±1.6	4.9±1.8	4.9±1.8	4.9±2.0	4.7±1.6	4.6±1.6	4.6±1.6	a. 0.206 b. 0.113 c. 0.508	a. 0.642 b. 0.955 c. 0.752	a.0.092 b.0.445 c.0.836
Total muscle (%)	33.6±2.8	33.7±2.7	33.6±2.7	33.3±3.9	33.3±3.7	33.1±3.6	33.5±3.5	33.2±3.5	33.3±3.7	a. 0.240 b. 0.443 c. 0.416	a. 0.927 b. 0.496 c. 0.390	a.0.005 b.0.124 c.0.620
Trunk muscle (%)	26.2±5.7	26.5±5.6	26.5±5.6	26.8±4.8	26.8±4.6	26.7±4.2	27.6±3.6	27.2±3.7	27.2±3.8	a. 0.318 b. 0.325 c. 0.938	a. 0.841 b. 0.662 c. 0.719	a.0.012 b.0.032 c.0.718
Arms muscle (%)	37.9±3.0	38.2±2.4	38.2±2.4	37.3±5.4	37.9±3.4	37.4±3.8	37.7±3.7	37.5±3.8	37.4±3.9	a. 0.299 b. 0.307 c. 0.737	a. 0.424 b. 0.934 c. 0.179	a.0.027 b.0.008 c.0.078
**Legs muscle (%)	50.4±3.4	50.6±3.3	50.5±3.4	49.7±5.0	49.8±4.7	49.5±5.0	49.9±5.0	49.6±5.0	49.5±5.4	a. 0.141 b. 0.592 c. 0.422	a. 0.519 b. 0.577 c. 0.686	a.0.002 b.0.023 c.0.850
Suprailiaca (mm)	18.6±8.4	18.0±8.3	18.5±8.5	15.4±5.4	16.5±6.0	16.3±7.1	12.7±4.5	13.4±4.9	13.3±4.9	a. 0.164 b. 0.790 c. 0.304	a. 0.016 b. 0.276 c. 0.794	a.0.069 b.0.054 c.0.977
Subscapular (mm)	16.0±5.3	15.9±5.2	15.6±5.4	13.4±3.9	13.9±4.0	14.5±4.7	12.6±3.6	12.5±3.9	13.2±3.7	a. 0.854 b. 0.515 c. 0.430	a. 0.174 b. 0.212 c. 0.493	a.0.890 b.0.038 c.0.061
Trisep (mm)	11.5±6.3	11.2±6.0	10.6±6.0	10.3±5.1	11.6±5.8	10.9±6.0	9.7±4.3	10.6±4.7	10.4±4.5	a. 0.415 b. 0.175 c. 0.172	a. 0.011 b. 0.520 c. 0.304	a.0.008 b.0.084 c.0.668
**Bisep (mm)	7.9±5.1	7.8±4.9	7.7±5.2	7.3±3.5	7.9±4.1	7.4±4.1	6.0±2.5	6.3±2.6	6.1±2.4	a. 0.878 b. 0.859 c. 0.878	a. 0.148 b. 0.717 c. 0.196	a.0.066 b.0.289 c.0.351
**Tense arm circumference (cm)	33.9±3.7	33.9±3.9	34.1±3,9	33.2±5.7	33.3±5.7	33.5±5.8	36.4±15.3	36.2±15.4	36.4±15.4	a. 0.593 b. 1.000 c. 0.480	a. 0.232 b. 0.061 c. 0.136	a.0.236 b.0.897 c.0.490
Energy (kkal)	1346.3±671.4	1296.3±718.4	1330.3±550.9	1970.3±610.9	1892.3±472.5	2050.3±718.3	2411.3±551.9	2445.3±525.3	2669.3±651.9	a. 0.348 b. 0.851 c. 0.710	a. 0.243 b. 0.456 c. 0.141	a.0.779 b.0.073 c.0.080
**Protein (g)	52.1±38.9	48.9±39.4	50.1±26.0	76.8±22.4	78.7±29.0	86.3±37.5	114.4±45.8	160.9±131.7	128.6±41.3	a. 0.286 b. 0.875 c. 0.286	a. 0.316 b. 0.277 c. 0.164	a.0.179 b.0.194 c.0.858
**Fats (g)	42.1±26.2	41.2±26.3	39.3±19.7	79.3±54.6	62.6±23.1	70.9±52.7	91.6±43.9	99.3±40.7	102.2±47.4	a. 0.128 b. 0.388 c. 0.929	a. 0.039 b. 0.178 c. 0.794	a.0.168 b.0.078 c.0.313
Carbohydrate (g)	184.2±98.8	177.4±104.4	184.3±98.8	263.1±105.5	247.3±82.2	291.7±119.5	284.9±77.8	262.6±114.6	311.6±99.6	a. 0.375 b. 0.988 c. 0.459	a. 0.243 b. 0.041 c. 0.015	a.0.256 b.0.103 c.0.008
**Magnesium (mg)	178.2±205.5	163.4±220.6	194.8±225.3	315.9±146.2	311.3±243.3	386.7±273.4	411.1±224.1	347.6±242.9	468.5±257.2	a. 0.241 b. 0.701 c. 0.286	a. 0.338 b. 0.099 c. 0.073	a.0.601 b.0.057 c.0.017

X: Average value, SD: Standard deviation, M1: Baseline, M2: First month, M3: Second month, *Paired t-test, **Non parametric test, significant difference at p<0.05 (Italic)

Table 4: ANOVA test for all variables according to protein intake group

Variables	Group A (X±SD)	Group B (X±SD)	Group C (X±SD)	p-value
Weight (kg)	74.2±10.6	68.9±15.3	68.3±11.5	0.124
Mesomorph	5.3±1.6	4.9±1.8	4.6±15	0.283
Total muscle (%)	33.6±2.7	33.2±3.5	33.3±3.5	0.876
Trunk muscle (%)	26.4±5.7	26.7±4.3	27.3±3.6	0.761
Arms muscle (%)	38.1±2.5	37.5±2.5	37.6±3.8	0.739
Legs muscle (%)	50.5±3.3	49.7±4.7	49.7±5.1	0.649
Skinfold				
Suprailiaca (mm)	18.4±8.2	16.1±5.9	13.2±4.6	0.011
Subscapula (mm)	15.9±5.0	14.0±3.7	12.8±3.6	0.025
Trisep (mm)	11.1±5.9	11.0±5.3	10.3±4.4	0.830
*Bisep (mm)	7.9±4.9	7.6±3.7	6.2±2.5	0.173
*Tense arm circumference (cm)	34.0±3.7	33.3±5.7	36.3±15.3	0.446
Intake				
Energy (ccal)	1316.2±582.6	1977.5±527.7	2505.4±19.7	0.000
**Protein (g)	49.8±29.6	80.7±21.6	132.6±50.5	0.000
*Fats (g)	68.5±19.3	70.7±37.6	97.6±34.4	0.000
Carbohydrate (g)	180.8±98.4	266.9±90.5	286.7±81.9	0.000
*Magnesium (mg)	174.8±200.7	345.3±190.2	406.5±203.4	0.000

p-value is significant analysis value, *Means non-parametric test, Significant difference at $p<0.05$ (Italic), X: Average value, SD: Standard deviation, Group A: Protein intake <1 g kg^{-1} b.wt./day), Group B: Protein intake 1-1,6 g kg^{-1} of b.wt./day, Group C: Protein intake >1,7 g kg^{-1} of b.wt./day

Table 5: Correlation analysis between muscle mass variables and protein intake

	Model 1		Model 2		Model 3	
Variables	R	p-value	R	p-value	R	p-value
Weight	-0.334	0.002*	-0.186	0.081	-0.346	0.001*
Mesomorph	-0.249	0.021*	-0.174	0.104	-0.257	0.024*
Total muscle	-0.081	0.459	-0.033	0.759	-0.010	0.931
Trunk muscle	0.023	0.832	0.079	0.464	0.114	0.325
Arms muscle	-0.016	0.887	-0.067	0.532	0.061	0.601
Legs muscle	-0.131	0.229	-0.082	0.442	-0.096	0.409
Skinfold suprailiaca	-0.221	0.041*	-0.318	0.002*	-0.263	0.021*
Skinfold subscapula	-0.330	0.002*	-0.296	0.005*	-0.355	0.002*
Skinfold trisep	-0.081	0.461	-0.065	0.545	-0.123	0.288
Skinfold bisep	-0.129	0.237	-0.184	0.084	-0.144	0.213
Tense arm circumference	0.016	0.884	0.101	0.347	-0.017	0.884

Model 1: Variable control with energy, carbohydrate, fats and magnesium, Model 2: Variable control with duration of training, Model 3: Variable control with energy, carbohydrate, fats, magnesium and duration of training, p-value is significant results of correlation test, *Significant difference results at $p<0.05$, R: Correlation coefficient

magnesium) with no significant different on exercises are able to produce better results in the body composition and muscle formation through suprailiaca and subscapular skinfolds values.

Athletes have nutritional needs above the normal average requirement, this is due to the high level of physical activity they are performed daily. Athletes in the weight sports category focus on muscle building rather than endurance, so protein requirements are higher over other athlete's categories. Some study mentioned that the normal protein requirement is about 1 g kg^{-1} of b.wt./day, increasing to 1.3-1.8 g kg^{-1} of b.wt./day for athlete and for strength category athletes having higher requirement which is above 1.8 g kg^{-1} of b.wt./day[9]. This recommendation is slightly higher than other study who was wrote a recommendation of 1.7 g kg^{-1} of b.wt./day of protein intake for someone underwent strength training for muscle building[19]. This study focused on strength category athletes, but in fact the conditions of fulfillment of protein intake in accordance with protein needs reached 33% of the total respondents. The problem of the lack of nutrient needs also mentioned by some study where 345 male and female athletes only 26% are sufficient for protein and 15% for carbohydrate needs[22]. Athlete's diet tends to high in saturated fats, cholesterol and sodium, in addition that the amount of consumption in male athletes is higher than women[16,17,22].

Weight sport is a sport that focuses on the formation of muscle mass. Almost all forms of resistance and strength training are performed by athletes in this type of sport. The main focus is to make the muscle into hypertrophy periodically. Athletes of this type of exercise are also known has great attention to the intake of nutrients especially those associated with muscle building[23].

The analysis was performed by using SPSS software with partial correlation type presented with 3 models (Table 5). Muscle formation with suprailiaca and subscapular skinfolds indicated significant effect when controlled with duration of strength training (Models 2: 31.8 and 29.6%). Intake of other macro-nutrients (energy, carbohydrates, fats) and magnesium when it controlled, it can have a significant effect between the intake of protein and skinfolds suprailiaca, subscapular values, body weight and mesomorphic somatotype (Model 1; 22.1, 33, 33.4 and 24.9%, respectively). Similar results were obtained when adding nutritional intake and exercise variables to control variables (Model 3, suprailiaca 26.3%, subscapular 35.5%, body weight 34.6% and mesomorph 25.7%).

The relationship between body weight and protein intake is negatively correlated, it means that the higher the amount of protein consumed, the lower body weight (Models 1 and 3). One study showed increase of protein intake in athletes in line with weight loss with a hypo-energy diet[24].

Model 2 showed increased protein intake associated with decreased skinfolds in the subscapular and suprailiaca sections. Strength exercises are generally focused on the arms and abdomen to give effect on the decrease in fat mass in the section. High protein intakes make the body have adequate protein reserves in the muscle, which in muscle tissue while performing protein activity also plays a role in the provision of energy sources and protein synthesis[1]. It means that having high protein diet will improve body composition and also muscle mass formation.

The addition of dietary intake for control variables as well as the duration of training can influence the relationship of protein intake with mesomorph and body weight (other than subscapular and suprailiaca). Mesomorph is an indicator that describes the human morphology of musculoskeletal development[25]. This section developed in the organogenesis phase of the mesoderm layer. This layer will then differentiate into muscle, reproduction body frame, circulatory system and body excretion system[26]. Based on these descriptions, mesomorph has considerable coverage so that other macro-nutrient needs (energy, carbohydrates, fats and magnesium) are needed in this variable.

A study lists several factors that affect the percentage of fat and muscle athletes. Some of these factors are nutritional intervention, training and physical activity[27]. Nutrition interventions are given in the form of calculation of individual nutritional needs of each individual, portion size of each time meal and nutrition consultation. Another study conducted on athletes in Indonesia were given the same nutritional intervention as the study before for 9 weeks, it showed that nutritional status related to anthropometric and somatotype profiles, eating habit of athletes also affects the nutritional status of athletes[28]. The difference between the two studies above with the current study is that there is no comprehensive nutrition intervention. This research was completed with monitoring the measurements every month, without giving athletes meal portion at each meal because the respondent were not in the condition of a single dorm so, it was not possible to do so. Therefore, the end result of this study intake of food can not affect until the somatotype profile. Other factors that have not been studied further are the factor of exercise and physical activity. Considering that respondents who were not in a dormitory condition should further monitor the duration, frequency and type of exercise and physical activity on a regular basis as this study was conducted once at the beginning of the study to minimize the bias.

CONCLUSION

The recommendation intake for athletes with weight sports category are 20% fats, 1.7 g kg^{-1} of b.wt./day for protein (with strength training) and carbohydrate is calculated from total energy after adjusted with protein and fats. High protein intake (1.7 g kg^{-1} of b.wt./day) following with strength training (frequency 4-5 times a week and duration 60 min each training) significantly improve on subscapula and suprailiaca skinfolds followed by continuing nutritional education.

SIGNIFICANCE STATEMENT

This study found the correlation between high protein intake group with significant improve on subscapula and suprailiaca skinfolds. It means the body composition and muscle formations on those areas were improved followed by continuing nutritional education, especially on protein intake with the recomendation 1.7 g kg^{-1} of b.wt./day for weight sport athletes in Indonesia.

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