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Original Article

High-protein foods in weight training as an alternative for muscle hypertrophy: Soy milk, egg whites, and tofu

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Abstract:
High protein supplements are a mainstay for weight training performers to obtain optimal muscle hypertrophy. However, the high costs of these supplements makes it difficult for some performers toconsume these products, hencethe need for alternatives. Therefore, this study aims to analyze and prove the ability to use a high protein foods, such as soy milk, egg whites, and tofu, in weight training as an alternative for muscle hypertrophy. It consists of a true-experimental pretest-posttest control group design with 26 fitness members recruited randomly from Padang, Indonesia. The sample was divided into experimental and control groups with each containing 13 respondents. The factorsin this study comprises ofmeasurement of muscle circumference pretest data, post-test data, as well as weight training with (experimental) and without (control) high protein foods consumption. High-protein foods were given based on the average protein consumption of the sample. Weight training is given to the arm and thigh muscles for ± two months with a frequency of 4 times a week, 75%-85% intensity, 4-12 repetitions, 1-5 sets, and 30-40 seconds intervals. The muscle circumference and fat thickness using the tapeline and skinfold and analyzed using the t-test. The results showed that the experimental group was better than the control for posttest arm and thigh muscles at values of 274.59 > 262.48 and 478.71 > 468.78 as well as mean differences of 12.11 and 9.93. In conclusion, high-protein foods in weight training can be used as an alternative for muscle hypertrophy. It is essential to note that consuming foods and supplement rich in protein will not lead to muscle hypertrophy without participating in well-programmed weight training. The results of this study are expected to be useful for weight training performers, such as fitness instructors, members, and athletes to obtain alternative means of muscle hypertrophy programs. Future studies need to include high-protein supplements as a comparison to test the high-protein foods during training.
Keywords: hypertrophy, weight training, high protein food, soy milk, egg white, tofu

Introduction

Muscle hypertrophy occurs when protein synthesis develop in themuscle over a cumulative period (Damas et al., 2017). There are numerous benefits ofmuscle mass levels (Wolfe et al., 2017), such as a decrease in obesity (Santos et al., 2020), and functional prevention associated with aging (Bradlee et al., 2018). Various cardiovascular disorders have been linked to an elevated risk at different degrees of muscular hypertrophy (Srikanthan et al., 2016) adolescent cardiometabolic risk (Burrows et al., 2017), and diabetes in middle-aged or older adults (Son et al., 2017).

Muscle hypertrophy can be obtained by resistance training and protein consumption (Phillips, 2014). The main kind of exercise to increase strength and promote muscular growth is resistance training. Furthermore, from a nutritional perspective, protein intake and resistance training are strong stimuli for hypertrophy. Therefore, at least 1.6 g of protein per kg of body weight needs to be consumed daily (Morton et al., 2017). The health benefits associated with protein, particularly in older adults, is an increase in lean body mass (Hudson et al., 2019; Mitchell et al., 2017; Oikawa et al., 2018; Park et al., 2018). Several components related to resistance training need to be known, such as intensity and volume of exercise, sequence, repetition number, sets, the movement tempo, rest duration between sets, and type of training (Ralston et al., 2018). Additionally, volume and intensity are basic components that directly impact muscle adaptation (Schoenfeld et al., 2015, 2017).

The American College of Sports Medicine advises beginners to perform 13 sets of an exercise with 8-12 repetitions at 70-85%t of 1RM and experienced athletes to perform 3-6 sets of 1-12 repetitions at 70-100% of 1RM (Kraemer et al., 2002). According to several studies, training with low weights that are between 30 and 60 percent of one's maximum lift results in the same type of hypertrophy as training with medium and high loads that are over 60 percent 1RM (Schoenfeld et al., 2015). Additionally, resistance training that is undertaken six days a week is thought to be a key factor in muscle hypertrophy because it has a lower volume per session and a lower capacity to stimulate anabolism than less frequent training that is conducted with a larger volume per session (Dankel et al., 2016). This theory is supported by the observation that when someone acquires resistance

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exercise expertise, the process of muscle protein synthesis slows down (Damas et al., 2015). The combination of ideas, in the opinion of Dankel et al., establishes a threshold for the volume of exercise that must be performed in a single session in order to promote muscle growth (Dankel et al., 2016). Therefore, muscle hypertrophy can be obtained through resistance training with the right program and supported by high protein consumption.

Protein is one of the important macronutrients for body function maintenance (Welis, 2017). It is a popular nutrient with increasing consumer demand obtained from plants and animals (Henchion et al., 2017). High-protein foods are often recommended (Phillips et al., 2015), thus it's crucial to ascertain how high-protein diets affect metabolism when other elements of a healthy lifestyle are present, such regular exercise and a weight-training regimen. Most of the data supporting improving dietary protein requirements are obtained from studies examining adaptive responses to animal protein (Burd et al., 2015). Studies have revealed that the features of different diets, such as the sources of protein (Burd et al., 2015) and the quantity consumed (Pennings et al., 2012) may affect the quantity of food amino acids that are present in the bloodstream to increase the pace of postprandial muscle protein synthesis. However, a number of research have concentrated on drinking isolated protein that has been dissolved in liquids (Burd et al., 2015; Churchward-Venne et al., 2015; Gorissen et al., 2017; Macnaughton et al., 2016). This is significant because whole food nutrition is more frequently ingested in a typical diet to meet daily protein guidelines and concurrently improve bulk and muscle quality. This is in contrast to isolated extra protein sources.

Soybeans are high in protein and low in carbohydrates hence it also serves as a unique source of plant-based protein compared to other legumes (Hoffman & Falvo, 2004). Producing plant-based protein sources might be a sustainable way to lessen ecological exploitation, claim Kumar et al (Kumar et al., 2015). Additionally, soybeans may be combined with heat to extract soy milk and can be processed with calcium sulfate or magnesium chloride to produce tofu. Various fermentations are also beneficial for making tempeh (Zaheer & Akhtar, 2015).

Additionally, soy products like soy milk are acknowledged as functional meals that are abundant in isoflavones like genistein, daidzein, and glycitein as well as bioactive peptides, unsaturated fatty acids, and fiber. Additionally, some experimental investigations have demonstrated a rise in glycemic measurements following the addition of protein or soy-isoflavone supplements (Kani et al., 2013). It is advised that soy isoflavones can reduce the activity of the digestive enzyme alpha-glucosidase (Hanhineva et al., 2010) and protein tyrosine kinase (Liu et al., 2011). Compared to animal protein, soy protein may offer a variety of benefits, such as decreasing blood cholesterol levels (Tokede et al., 2015), increase muscle mass and muscle strength. Other studies have linked animal proteins such as white eggs, fat-free and high-protein foods because they contain many essential amino acids, with an overall score of 100, and is a high-quality protein source compared to those from milk and soybeans (Livesey, 1987).

In this regard, several studies have examined the use of high-protein supplements and high-protein foods for muscle, such as the effects of resistance training and nutritional supplementation on muscle quality and muscle growth (Hofmann et al., 2016), how protein supplements affect muscle size, strength, and aerobic and anaerobic capacity (Pasiakos et al., 2014), impact of creatine supplementation along with resistance training for lean muscle mass (Pinto et al., 2016), mycoprotein as an alternative protein source that allows to support muscle health and metabolism (Coelho et al., 2020), considering the value of nutrients and how they affect physical and health function in relation to plant proteins (Hertzler et al., 2020), consumption whole egg after resistance training (Sawan et al., 2018), egg white protein accelerates liver oxidation to increase body protein mass and decrease body fat mass (Matsuoka et al., 2017), compared to eating egg whites, eating entire eggs increases the quantity of isonitrogen that stimulates muscle protein synthesis after exercise (van Vliet et al., 2017), in-vitro digestion and swelling kinetics of whey protein, egg white protein, and sodium caseinate aerogels (Kleemann et al., 2019), peptide from soy that stimulates lipolysis and guards against skeletal muscle apoptosis brought on by a high-fat diet (Asokan et al., 2018), skeletal muscle AMP-activated protein kinase during exercise (Pagliara et al., 2020), impact of whey protein on the development of an adaptation to endurance training (Hulmi et al., 2015). However, very limited studies have examined the consumption of high-protein foods in weight training for muscle hypertrophy, such as soy milk, egg whites, and tofu.

Therefore, this study aims to analyze and prove the effect of a high-protein foods in weight training as an alternative for muscle hypertrophy using foods such as soy milk, egg whites, and tofu. It is expected to be used as an alternative for weight training performerswilling to undergo a muscle hypertrophy program, fitness instructors, members, and athletes.

Materials & Methods

Study design

This study consists of true-experimental and pretest-posttest control group designs. The experimental group is given weight training by consuming foods high in protein, such as soy milk, egg whites, and tofu. Meanwhile, the control group does not consume high protein foods (supplements) despite the administration of weight training.

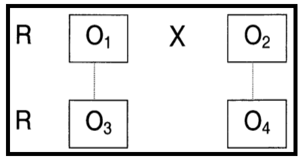

Figure 1. Experimental design

Note:

R = Random
X = Weight training that consumes high protein foods
O1 = Pretest data of muscle hypertrophy in the experimental group
O2 = Posttest data of muscle hypertrophy in the experimental group
O3 = Pretest data of muscle hypertrophy in the control group
O4 = Posttest data of muscle hypertrophy in the control group

Figure 1 showsthat two groups were chosen randomly, and a pretest was conducted to determine the initial state of the sample. The effect of this treatment is described as (O2-O1)-(O4-O3).

Participant

Data were collected from a sample of 26 fitness members in Padang, Indonesia, randomly selected based on some considerations. These include males aged 18 to 25 years, enrolled in a fitness center ± 1 month, and those undergoing a muscle hypertrophy program who had never taken any form of high protein supplements. Additionally, the sample complied with the conditions during the treatment and volunteered by agreeing to a written agreement.

Procedure

The procedure in this study consisted of several stages.

Stage 1 (pretest)

- The arm and thigh muscle circumference measurement is carried out at this stageto determine the sample muscle size before treatment.
- The sample was divided into two categories, the experimental (n=13) and the control (n=13) groups. This division prevents the two group pretest data from having a significant difference in average.

Stage 2 (treatment)

- Both groups performed weight training on the arm and thigh muscles. The training movements for the arm are barbell curl, dumbbell hammer curl, bent over tricep extension, tricep press down, and overhead dumbbell extension. Meanwhile, those for the thigh muscles are leg press, squat, leg extension, and leg curl. Weight training is given for ± 2 months with a frequency of 4 times a week, 75%-85% intensity, 4-12 repetitions, 1-5 sets, and 30-40 seconds intervals. The training materials include warming up, core exercises on the arm and thigh muscles, and cooling down.
- After conducting weight training, only the experimental group consumed a high-protein foods.
- High protein food were soy milk, egg whites, and tofu at dosages of 100 grams, as shown in Figure 2. The dose was obtained through the average protein consumption of the experimental group for seven days before treatment.

Figure 2. High-protein foods such as soy milk, egg whites, and tofu

Stage 3 (posttest)

- At this stage, post-test data measurement of arm and thigh muscle circumference was conducted to determine muscle hypertrophy from both treatments after being given weight training.

Instruments

Table 1 shows arm and thigh muscle circumference measurements using tapeline and skinfold thickness, respectively. After the data is obtained, it is formulated as follows MMC = MMC-(3.14 x SFT) (Caballero et al., 2005)

Table 1. Muscle hypertrophy measurement

Tool	Purpose	Unit
Tapeline	Measuring arm and thigh muscle circumference	Millimeter
Skinfold	Measuring arm and thigh muscle fat thickness	

Statistical analysis

Data were analyzed using paired and independent samples t-tests. The paired method was used to determine the difference between the two groups' pretest and post-test muscle hypertrophy data. Meanwhile, independent was used to compare post-test muscle hypertrophy data from the two groups.

Result

Data description

The data description aims to evaluate the pretest and posttest data of muscle hypertrophy in the experimental and the control groups.

Table 2. Descriptive statistics of muscle hypertrophy data

Group	N	Data	Muscle	Min*	Max*	Mean*	Std.dev*	Average difference	
								Pretest-posttest	Posttest
Experiment	13	Pretest	Arm	227.30	278.02	252.67	16.05	21.92	12.11
		Posttest		250.58	300.72	274.59	16.89		
	13	Pretest	Thigh	440.88	466.76	459.49	6.70	19.22	9.93
		Posttest		461.16	491.32	478.71	9.06		
Control	13	Pretest	Arm	230.30	290.02	255.61	17.69	6.87	
		Posttest		231.30	299.16	262.48	17.21		
	13	Pretest	Thigh	441.74	479.76	458.32	8.72	10.46	
		Posttest		449.02	492.90	468.78	11.54		

Note.*- metric unit: mm

From Table 2, it can be seen that there are differences in each study group's data average, whereby the experimental group's muscle hypertrophy data is better than the control.

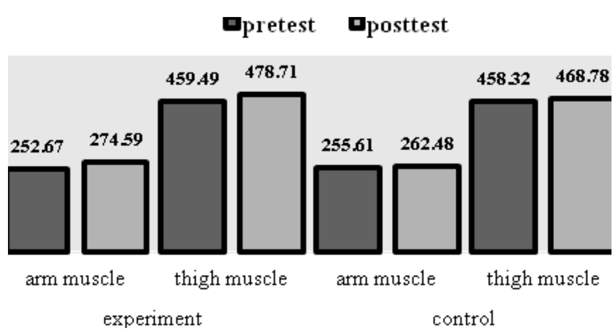

Figure 3. The average difference between pretest and posttest muscle hypertrophy data for the experimental and control groups

Figure 3 indicates the average muscle hypertrophy difference between the experimental and control groups' pretest and posttest data. After weight training, the experimental group given a high-protein foods showed significant muscle hypertrophy with a pretest-posttest average of 21.92 and 19.22 between the arm and thigh muscles. Meanwhile, the control group showed muscle hypertrophy with a pretest-posttest average of 6.87 and 10.46 between the arm and thigh muscles. Furthermore, the average muscle hypertrophy of the two posttest data for the arm and thigh muscles is 112.11 and 9.93.

Data normality

Normality testing was conducted using Shapiro-Wilk, to determine whether the pretest and post-test data of the two groups were usually distributed.

Table 3. Normality test

Group	N	Data	Muscle	p*
Experiment	13	Pretest	Arm	0.769
		Posttest		0.351
	13	Pretest	Thigh	0.080
		Posttest		0.549
Control	13	Pretest	Arm	0.924
		Posttest		0.811
	13	Pretest	Thigh	0.104
		Posttest		0.547

Note.*- data is normally distributed (p>0.05)

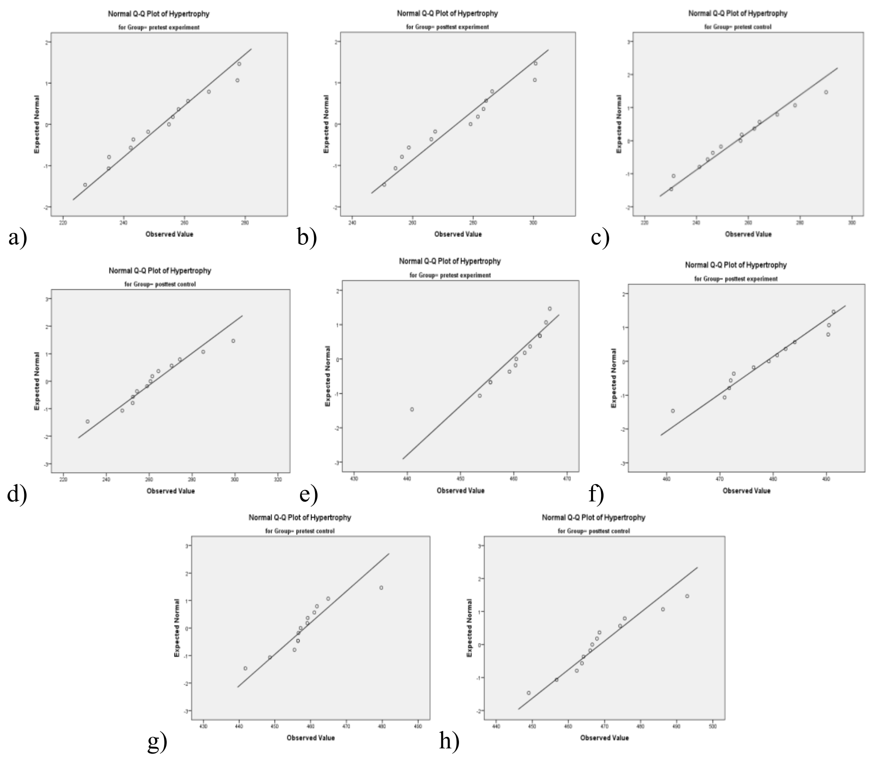

Figure 4. a) normality test of the experimental group arm muscle pretest graph, b) experimental group arm muscle posttest, c) control group arm muscle pretest, d) control group arm muscle posttest, e) normality test of the experimental group thigh muscle pretest graph, f) experimental group thigh muscle posttest, g) control group thigh muscle pretest, h) control group thigh muscle posttest

Table 3 shows that the normality value of the pretest and posttest data for both groups is >0.05. This is also shown in Figure 4, where the data follows or approaches the diagonal line thereby indicating that they are all normally distributed.

Data homogeneity

Homogeneity testing was carried out using Levene's test, which aims to determine whether the data of the two groups are homogeneous, with the results shown in Table 4.

Table 4. Homogeneity test

Group	Data	Muscle	p*
Experiment	Pretest-posttest	Arm	0.673
		Thigh	0.234
Control	Pretest-posttest	Arm	0.716
		Thigh	0.329
Experiment-control	Posttest	Arm	0.606
		Thigh	0.700

Note.*- data is homogeneous (p>0.05)

Hypothesis testing

Hypothesis testing was carried out using paired and independent samples t-tests. Paired samples t-test was used to test the difference between the pretest and posttest data of the two groups. Meanwhile, the independent samples t-test was used to compare the two groups' posttest data.

Table 5. Paired samples t-test for pretest-posttest data for the experimental and control group

Pretest-posttest	Data	Paired differences					t	df	p*
		Mean	Std. dev	Std. error mean	95% confidence Lower	95% confidence Upper			
Experiment	Arm	21.92	3.05	.84	23.76	20.07	25.91	12	.000
	Thigh	19.22	5.27	1.46	22.40	16.02	13.13	12	.000
Control	Arm	6.87	4.64	1.29	9.67	4.07	5.34	12	.000
	Thigh	10.46	5.51	1.53	13.79	7.13	6.85	12	.000

Note.*- the difference is significant (p<0.05)

Table 5 shows a significant difference between the pretest and posttest data in the experimental and the control groups. Both groups experienced muscle hypertrophy after weight training in the pretest-posttest arm experimental group 252.67 < 274.59, and thigh muscles 459.49 < 478.71. Meanwhile, the pretest-posttest control group arm and thigh muscles before training were 255.61 < 262.48 and 458.32 < 468.78, meaning that the differences are 21.92, and 19.22. Meanwhile, for the control group, the difference between the average pretest-posttest of the arm muscles is 6.87, and the thigh muscles are 10.46.

Table 6. Independent samples t-test for the posttest data of the experimental and control group

Posttest	Data	t-test for Equality of Means						
		T	df	p*	Mean difference	Std. error difference	95% confidence	
							Lower	Upper
Experiment-control	Arm	2.21	24	.043	12.11	6.69	1.69	25.91
	Thigh	2.44	24	.023	9.93	4.06	1.52	18.31

Note.*- the difference is significant ($p<0.05$)

Table 6 shows the significant difference between the posttest data of the experimental and control groups. The experimental was better than the control for muscle and thigh hypertrophy by 274.59 > 262.48 and 478.71 > 468.78. The differences between the average muscle hypertrophy of the two posttests data for two are 12.11 and 9.93. Therefore, the experimental group's consumption of high-protein foods in weight training produced muscle hypertrophy.

Discussion

Based on the results of this study, weight training resulted in muscle hypertrophy in both experimental and control groups. Significant muscular growth was observed in the experimental group that received foods high in protein, such as soy milk, white eggs, and tofu. As a result, high-protein diets can be utilized in place of supplements during weight training to achieve the best results in terms of muscle development. These findings are consistent with earlier research showing that protein intake affected young adults' skeletal muscle development following resistance exercise (Stokes et al., 2018). There is proof that elderly persons maintain their muscular mass (Paddon-Jones et al., 2015; Phillips, 2017; Phillips et al., 2016) is associated withthepromotion or retention of its training adaptations in athletes (Wall et al., 2015), and regulation of ideal body weight (Westerterp-Plantenga et al., 2012). According to analysis, the quality of soybean protein is quite comparable to that of cow's milk and egg protein (Amigo-Benavent et al., 2008). Bean protein consumption has a beneficial impact on muscle mass and strength (Mangano et al., 2017). These results also confirm preliminary studies that soy protein and whey protein produce lean muscle hypertrophy and resistance training. Furthermore, soy protein may also protect against oxidative damage (Brown et al., 2004). According to earlier studies, soy protein hydrolyzate and other hydrolyzed protein extracts were crucial in lowering blood triglycerides and body fat (Chiang et al., 2016; Hu et al., 2015; Huang et al., 2015). Soy consumption has increased due to its superior nutritional value and health-related benefits (Wang et al., 2020). The findings of this study are consistent with those of other studies, which have shown that soy milk is an aqueous extract of soybeans that is a superior source of dietary fiber, a variety of minerals, and phytochemicals. Additionally, soy milk is a cost-effective source of protein, acceptable for vegans and those who are lactose intolerant, and low in fat (Ewe & Yeo, 2015). Additionally, because it includes a number of useful elements such soy protein, peptides, saponins, oligo-polysaccharides, and isoflavones, it is regarded as a nutritious beverage around the globe (Messina, 2016; Shinjiro, 2015).

Previous studies have also reported that egg whites are rich in protein and devoid of fat. A source of high-quality protein, egg white protein has an amino acid score of 100 and is made up of a number of necessary amino acids (Livesey, 1987). Additionally, the consumption of amino acids, such as the branched amino acids found in egg white, might raise blood levels of these acids (Kato et al., 2010). After exercise, the concentration of this amino acid decreases (Kato et al., 2010), branched amino acids found in egg white protein may also be utilised for muscle repair and muscular hypertrophy during exercise. Consistent with this, strength training and eating egg white protein together have been shown to boost muscular growth and strength (Kato et al., 2011). Then, the lipid content and bioactive components in tofu are what make it one of the top sources of vegetable protein (especially isoflavones, saponins, and phytosterols). Essential fatty acids like linoleic and linolenic acids are present in tofu (Guo et al., 2018). For seitan, tofu, soy milk, and pea emulsion including pea protein isolate, the Digestible Indispensable Amino Acid Score (DIAAS) was determined to be 28, 97, 117, and 60, respectively (Reynaud et al., 2021). It is crucial to understand that eating meals high in protein will not cause muscles to swell up without engaging in carefully planned physical exercise (weight training). This opinion is in accordance with previous studies, that a training program that has the right intensity, frequency, and duration (Josse et al., 2010). Regardless of the protein source, protein supplements provide advantages for muscular development, strength, and myofibrillar protein synthesis (whey, soy, and dairy) (Josse et al., 2010). Another study states that training that is designed with a good program, based on the basic principles of exercise will get optimal results (Mario, 2017). In addition, the role of technology is an important factor to support this achievement (Firdaus & Mario, 2022; Komaini et al., 2021, 2022).

Based on the data we obtained, we believe that the effect of consuming high-protein foods after weight training is very effective for muscle hypertrophy. However, we recognize that there are some limitations that need to be validated for future research. These limitations include the provision of high protein foods in this study, namely, soy milk, egg whites, and tofu, so it is necessary to add other high protein food variants as an alternative for muscle hypertrophy. The weight training given is the arm and thigh muscles (several variations of movement), so it is necessary to involve other muscle groups with added variations of movement. Weight training is given for ± 2 months with a program that has been designed as well as possible (validated by sports coaching experts), we believe that a longer time (>2 months of training) and a better program will affect the results of this study. The sample size used is still limited, so it is necessary to involve a wider sample size. We did this to minimize errors in controlling both groups during treatment. Then, it is necessary to involve other treatment groups as a comparison group (such as high protein supplements), so that the effectiveness of consuming high protein foods can be known..

Conclusions

The conclusion from the results of this study are, consumption of high protein foods in weight training is very effective as an alternative or substitute for high protein supplements for muscle hypertrophy. This statement is in line withthe result that the experimental group is better than the control with post-test arm and thigh muscles of 274.59 > 262.48 and 478.71 > 468.78. The average difference in muscle hypertrophy from the two post-test data for the arm and thigh muscles is 12.11 and 9.93. It is essential to note that consuming foods and supplement rich in protein will not lead to muscle hypertrophy without participating in well-programmed weight training. Furthermore, supplement consumption should be adjusted to the muscle needs of each individual for optimal outcomes. The advantage of this high-protein food is that it has more combinations or variants and does not contain substances that are harmful to health. In addition, the price is relatively low and affordable compared to high-protein supplements. The results of this study are expected to be useful as an alternative for weight training performers undergoing muscle hypertrophy programs, such as fitness instructors, members, and athletes. Moreover, it is important to analyze and prove the effectiveness of a high-protein foods in weight training by involving other treatment groups using supplements

Conflict of interest- The authors declare no potential conflicts of interest

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