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by Adnan Fardi

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Supplements and high-protein foods in weight training: How do they affect maximum muscle strength?

Adnan Fardi^{acde*}, Tjung Hauw Sin^{abcd}, Angga Okta Pratama^{acde},
Deby Tri Mario^{bcd} 

Universitas Negeri Padang, Indonesia

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ABSTRACT

Consumption of protein in weight training when adjusted to the needs will result in perfect muscle growth and development, especially in increasing maximum strength. In fact, many Fitness Members consume protein without paying attention to the dose, so that increasing maximum strength is not realized properly. This study aims to provide high-protein supplements and high-protein foods in weight training to increase maximum muscle strength. The design used in this study is a three group pre test and post test, consisting of a group consuming high protein supplements, a group consuming a high protein diet and a control group. The population in this study are FIK UNP students, with a total sample of 39 people. The instrument used in this study is a maximum strength test (leg & Hand Dynamo Meter test). The data obtained in this study are analyzed by analysis of variance (ANOVA) with $\alpha = 0.05$. The results showed: (1) There was a difference in effect between the group given high protein supplements, high protein diet and the control group, (2) The group given high protein supplements had a difference from the average of the other two groups, (3) The group given high protein supplements high-protein supplements had a difference from the average of the other two groups, (4) The high-protein diet group did not have a mean difference with the control group. The limitation in this study is that the researcher was not able to control aspects that were outside the research activities such as other high protein contamination consumed by the research food samples. The next stage, this research will look at the effects of consuming high-protein supplements on a sustainable basis on human health.

Keywords: Maximum strength; high protein foods; high protein supplements



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Corresponding Author: Adnan Fardi, Department of Sports Coaching Education, Faculty of Sports Science, Universitas Negeri Padang, Padang, Indonesia
Email: adnanfardi6315@gmail.com

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Authors' Contribution: a – Study Design; b – Data Collection; c – Statistical Analysis; d – Manuscript Preparation; e – Funds Collection

INTRODUCTION

Weight training is one type of exercise that will benefit the body. Weight training that is done regularly will provide benefits such as increasing physical fitness and muscle strength and endurance (Sukadiyanto, 2011). In addition, weight training can also increase a person's muscle mass. Thus, exercise is one type of exercise that is highly recommended to improve physical fitness and increase muscle mass. Weight training is a type of sport that aims to develop strength, wherebody muscles experience contraction use body weight or

device another for stimulates muscle growth or work, strength and endurance, by targeting specific muscle groups and types of movement (Sukadiyanto, 2011). Understanding the relationship between weight and re-lifting ability is essentially an understanding of the relationship between anaerobic ability and aerobic ability or an understanding of the relationship between intensity and duration, at maximum performance (Giriwijoyo & Didik, 2013). Weight training is a motor stimulus (motion) that can be regulated and controlled to improve the functional quality of various organs of the body, and is usually associated with the components of exercise, namely intensity, volume, recovery, and intervals (Sukadiyanto, 2011).

Recent literature mentions the importance of muscle strength in sports skills, in addition to reduce injury rate (Suchome et al., 2016). The development of muscle strength is supported by a combination of several morphological and neural factors. However, the mechanisms that increase muscle strength are considered to be multi-factorial and may be influenced by other factors such as initial strength and genetics (Balshaw et al., 2017; Buckner et al., 2017). In addition, a history of muscle contractions (e.g, fatigue, post-exercise, temperature, etc.) can also affect muscle strength.

Over the past few years, the popularity of strength training has been designed to optimize its efficiency and benefits (García-López et al., 2016). Resistance training is recognized as an important model of exercise to achieve fitness and health (Kenney et al., 2011). Strength training programs include variable resistance training performed using accessories, such as rubber bands or chains, and machines that allow for variations in load transfer speed and load size. One of the main purposes of using elastic chains or bands is to induce a high variety of excitability with a view to neural adaptations that increase different levels of strength, including maximal length or 1 maximal repetition (1RM) (Joy et al., 2016). This kind of neuromuscular adaptation can be a consequence of better coordination between antagonists and synergists muscles to control movement (Muller et al., 2011).

A weight training program should take into account the intensity of the exercise, the volume of the exercise, the frequency of the exercise, the recovery and sequence of the exercises, the speed of repetition and the rest intervals. Although each of these training variables is important, training volume and training intensity need to be considered in increasing muscle strength, training intensity and training volume have an inverse relationship. The number of weights lifted directly and negatively correlated with the number of repetitions performed.

Periodization is considered an integral part of the training process and provides a conceptual framework for designing training programs (DeWeese et al., 2015). Periodization is a logical method for organizing training into sequential phases to increase the potential for achieving a certain performance while minimizing the potential Over Training (DeWeese et al., 2013). Periodization and programming are difficult to separate, as each focuses on a different aspect of the training process. Periodization introduces variation through cycle phases and period time, whereas programming consists of structuring training variables (loads, sets, repetitions, and exercises) in phases to enhance the effect of training (DeWeese et al., 2015).

Regular and programmed exercise is the main key for someone to have good strength (Sukadiyanto, 2011). In addition, nutritional factors cannot be ignored in obtaining maximum results for strength training (Mitchell et al., 2015). This is because protein is the main nutrient most needed by muscles to be able to grow and develop perfectly. Fulfillment of body nutrition can be done by consuming food and supplements (Churchward-Venne et al., 2012). However, both meet the nutritional needs of the body in different ways. Food meets nutritional needs along with various other components, while supplements provide specific nutrients depending on the type of supplement. In terms of nutrition, the basic difference between food and supplements is the nutritional composition contained in both. Packaged foods have nutritional value information labels, while supplements have supplement composition information labels (Mitchell et al., 2015).

Individuals who are not trained, consuming additional protein is likely to have no impact on decreasing body mass and muscle strength. However, as the duration, frequency, and volume of resistance training increase, protein supplementation can produce muscle hypertrophy and increase muscle strength. Evidence also shows that protein supplementation provides benefits in increasing aerobic and anaerobic strength (Pasiakos et al., 2014).

Consumption of protein according to needs is the main effort to meet muscle needs. Natural protein can be obtained from various food ingredients such as tofu, tempe, egg white, milk, and so on. In addition, protein can also be obtained from supplementation materials in the form of high-protein milk. The response of muscle protein synthesis depends on the availability of essential amino acids, particularly leucine, which varies significantly between different protein sources (Gorissen et al., 2016). In this regard, plant and animal proteins differ in their essential amino acid content (Gorissen et al., 2018; Vliet et al., 2015). Several studies have consistently demonstrated lower anabolic responses to plant protein (soy or wheat) than animal protein (whey or milk), under protein-matching conditions combined or not with weight training (Yang et al., 2012). As plasma increase or intramuscularly, leucine has been shown to be a major driver of protein-induced stimulation of muscle protein synthesis (Wilkinson et al., 2013).

Protein supplements are one of the most popular foods used by athletes, active adults (Pasiakos et al., 2013). Taking protein supplements during recovery from exercise provides skeletal muscle anabolism (Lunn et al., 2012; Nelson et al., 2012), stimulates greater levels of Myofibrillar and Mitochondria protein synthesis (Breen et al., 2011). Theoretically, stimulation of muscle protein synthesis with protein supplementation is a critical skeletal muscle adaptive response to mechanical stress that promotes growth and repair of Contractile proteins, thereby facilitating long-term recovery (Breen et al., 2011; Hulston et al., 2011).

Several literatures have reviewed the benefits of protein supplementation. This review examines whether protein supplementation alone or in combination with carbohydrates attenuates carbohydrate oxidation and accelerates muscle glycogen fulfillment in response to endurance-type exercise, and in particular whether protein supplementation increases lean mass gain, muscle strength, and aerobic and anaerobic power (Carbone et al., 2012; Pasiakos, 2012). However, the evidence that performance changes are related to these mechanisms has not been systematically evaluated (Vandenbogaerde & Hopkins, 2011), only two recent meta-analyses to date evaluated the evidence regarding the effect of protein supplementation on actual muscle mass and strength measures (Cermak et al., 2012; Schoenfeld et al., 2012). (Cermak et al., 2012) provided a strong evidence-based analysis to show that protein supplementation augments gains in muscle mass and strength in both younger and older adults. Although (Schoenfeld et al., 2012) also concluded that protein supplementation added gains in muscle mass and strength, their analysis focused on whether timing of protein consumption was an important factor for enhancing muscle adaptation.

Of the many programs offered at fitness centers in the city of Padang, body building program is the program that is most in demand, this is because members can form the muscles in their body, so that they have a muscular body and look proportional. In addition, by following this program, a person's maximum muscle strength will also increase in accordance with the periodization of the exercise he participates in.

Based on the results of observations made by researchers on Members Fitness Center for the Faculty of Sports Science, Padang State University, that less than the maximum results obtained by members in carrying out weight training. This can be seen from the members who have been practicing for a long time, but still haven't gotten a significant increase in maximum strength and muscle hypertrophy. Even though they have done various training methods suggested by local instructors. However, the results obtained are still not optimal.

Basically, many factors affect the increase in a person's maximum strength such as: the right exercise program, the exercise method used, and the technique used when doing weight training (Giriwijoyo & Didik, 2013). In addition to the factors mentioned, nutritional intake is also very important to consider when doing weight training. This is because, adequate nutritional intake will determine a person's muscle development both in quality and quantity (Atherton et al., 2016). Adequate nutritional intake will make muscles develop perfectly, so that the function of these muscles will increase along with their development.

The use of high-protein supplements and high-protein foods is a method that is often used by Members Fitness in obtaining maximum muscle strength. Consumption of protein in weight training when adjusted to the needs will result in perfect muscle growth and development. In fact, many members fitness consumes protein regardless of the dose, so the goal to increase maximum strength is not realized properly. From these problems, researchers will examine the effect of giving high-protein supplements and high-protein foods in

weight training to increase maximum muscle strength. The results of this study are expected to be used as recommendations for members fitness who wants to increase maximum muscle strength.

METHOD

This type of research is quantitative with a quasi-experimental method. The research design used is Two Group Pre Test Post Test. This research is carried out in the Fitness Laboratory Center for the Faculty of Sports Science, State University of Padang with a sample of 39 students of the Faculty of Sports Science, State University of Padang. The selected samples are new members and have never consumed high protein milk supplementation or have not been contaminated with high protein milk supplementation ingredients with a certain dose. This study consisted of two experimental groups and one control group, where each group consisted of 13 people who were taken based on the Ordinary Matching Pearingtechnique. The experimental group is given high protein supplements and high protein foods, while the control group is given neither. The provision of high protein supplements in this study is in the form of milk and high protein foods in the form of tofu, temp egg whites, and milk that are adjusted to the needs of the muscles. This research is conducted for 4 months with a frequency of 4 times a week. The test instruments used in collecting research data are the Leg Dynamo Meter and Hand Dynamo Meter (Eyuboglu et al., 2019), with test validity of 0.75 and reliability of 0.96. The data obtained are analyzed using comparative analysis with a significance level of = 0.05, this aims to see the comparison of the data before being given treatment and after being given treatment.

RESULTS AND DISCUSSION

The description of the data presented in this study is data on increasing the maximum strength of 39 students of the Faculty of Sports Science, Padang State University. For more details, can be seen in table 1.

Table 1. Description of Maximum Strength

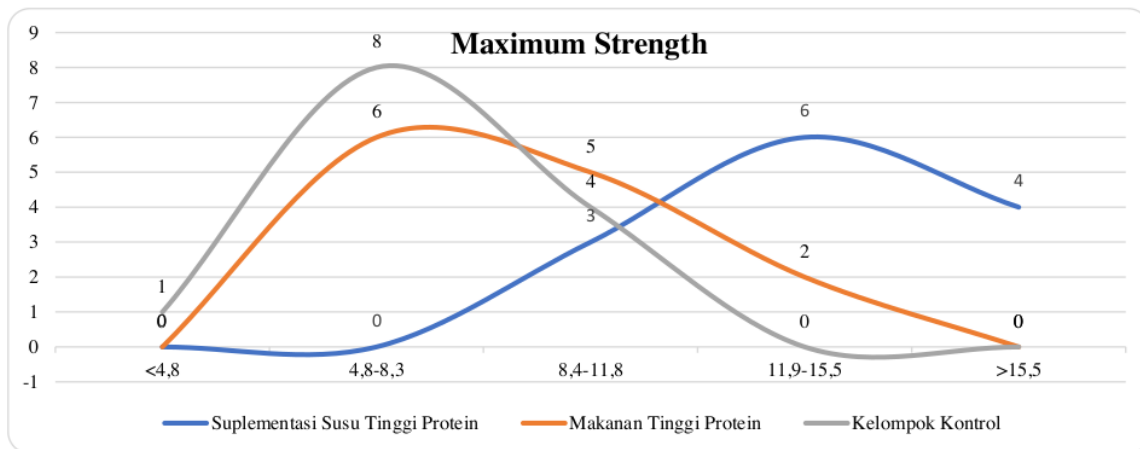
Research Group	n	Mean	Std. Deviation	Max	Min
High Protein Milk	13	13.95	2.48	18.00	11.00
High Protein Food	13	9.19	2.29	13.50	6.00
Control	13	7.31	1.96	11.00	4.50
Total	39	10.15	3.58	18.00	4.50

Based on table 1 above, from the three research groups with a total sample of 13 people in each group, the group given high protein milk supplementation had an average of 13.95, a standard deviation of 2.48, a maximum value of 18,00 and a minimum value of 11.00. The group given the high protein diet had an average of 9.19, a standard deviation of 2.29, a maximum value of 13.50 and a minimum value of 6.00. Furthermore, the control group has an average of 7.31, a standard deviation of 1.96, a maximum value of 11.00 and a minimum value of 4.50. Based on the description of the research data that has been described, the group that consumed high-protein milk supplementation had a higher average compared to the other two groups. For more details, the distribution and comparison of data on increasing the maximum strength of the students of the Faculty of Sports Science, Padang State University can be seen in table 2.

Table 2. Frequency Distribution of Maximum Strength

No	Interval Class	High Protein Milk		High Protein Food		Control	
		Fa	Fr(%)	Fa	Fr(%)	Fa	Fr(%)
1	>15.5	4	30.77%	0	0.00%	0	0.00%
2	11.9-15.5	6	46.15%	2	15.38%	0	0.00%
3	8.4-11.8	3	23.08%	5	38.46%	4	30.77%
4	4.8-8.3	0	0.00%	6	46.15%	8	61.54%
5	<4.8	0	0.00%	0	0.00%	1	7.69%
Total		13	100%	13	100%	13	100%

Based on table 2 above, from the three research groups with a total sample of 13 people in each group, there were 4 people who were given high protein milk supplementation with interval class above 15.5 as many as 4 people (30.77%), interval class 11.9-15.5 as many as 6 people (46.15%), interval class 8.4-11.8 as many as 3 people (23.08%), interval class 4.8-8.3 as many as 0 people (0,00%) and 0 people (0.00) for the interval class below 4.8. The group that was given high protein food with interval class above 15.5 was 0 people (0.00%), 2 people were given interval class 11.9-15.5 (15.38%), interval class was 8.4-11, 8 as many as 5 people (38.46%), interval class 4.8-8.3 as many as 6 people (46.15%) and interval class under 4.8 as many as 0 people (0.00). The control group with the interval class above 15.5 was 0 people (0.00%), the interval class 11.9-15.5 was 0 people (0.00%), the interval class 8.4-11.8 was 4 people (30.77%), interval class 4.8-8.3 as many as 8 people (61.54%) and in interval class under 4.8 as many as 1 person (7.69). The histogram of data on increasing the maximum strength of the students of the Faculty of Sports Science, Padang State University can be seen in graph 1.



Graph 1. Maximum Strength Improvement Data

Furthermore, the results of the research data analysis using the Analysis of Variance (ANOVA) will be presented in table 3.

Table 3. Results of Research Data Analysis

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	305,047	2	152,523	30,042	,000
Within Groups	182,771	36	5,077		
Total	487,817	38			

Based on the results of the data analysis above, the value of Sig. = 0.000 < 0.05. It can be concluded that there is a significant difference in the effect of the research treatment that has been given to the three research groups. To compare which group had the better maximal strength increase, further analysis is carried out using the Tukey test. The results of the Tukey test of the research group can be seen in tables 4 and 5.

Table 4 . Table of Results of Multiple Comparison of Research Data

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95 % Confidence Interval	
					Lower Bound	Upper Bound
High Protein Milk	High Protein Food	4.7615 *	,8838	,000	2,601	6,922
	Control Group	6.6462 *	,8838	,000	4,486	8.806
High Protein Food	High Protein Milk	-4.7615 *	,8838	,000	-6,922	-2,601
	Control Group	1.8846	,8838	,097	-,276	4.045
Control Group	High Protein Milk	-6,6462 *	,8838	,000	-8.806	-4,486
	High Protein Food	-1.8846	,8838	,097	-4,045	,276

*, The mean difference is significant at the 0.05 level.

Table 5. Tukey Hsd table ^a

Group	N	Subset for alpha = 0.05	
		1	2
High Protein Milk	13	7,308	
High Protein Food	13	9,192	
Control Group	13		13,954
Sig.		,097	1,000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 13,000.

The results of data analysis shows that the group given high protein milk supplementation in weight training gives a significant effect on increasing maximal muscle strength ($p = 0.000 < 0.05$) with an average increase of 13.95 kg. The group that is given a high-protein diet in weight training also provided an increase in maximal muscle strength ($p = 0.000 < 0.05$) with an average increase of 9.19 kg. The same thing also happened to the control group in the study ($p = 0.000 < 0.05$) with an average increase of 7.31 kg. It can be concluded that the group given high protein milk supplementation, high protein diet, and the control group in weight training both experienced an increase in maximum muscle strength. However, if a comparison is made to increase the maximum strength in each group, the group given high protein milk supplementation has the most significant effect compared to the other two groups ($p = 0.000 < 0.05$). Different things happened in the other two research groups, namely the research group that is given high protein food and the control group in weight training showed that there is no significant difference in the effect of increasing maximum muscle strength ($p = 0.009 > 0.05$).

Protein is the main nutrient in weight training so that muscles can develop properly and perfectly. In line with that, the daily consumption of protein needs should be met in accordance with the amount of protein needed by the body. The average amount of protein needed by each person in one day is 15-20% protein in one proportion of food eaten. Consumption of sufficient protein and accompanied by weight training will increase muscle mass and increase muscle strength. Eating high protein is the easiest thing to get in everyday life. Several types of high-protein foods that can be consumed after weight training such as foods derived from nuts, eggs, meat and so on. The results of this study have revealed that high protein milk supplementation is very effective when consumed after weight training. This will certainly increase the maximum strength in the muscles during the post-exercise recovery period.

There are several research results that discuss the evidence base for the use of protein supplements (McLellan et al., 2013; Pasiakos et al., 2014). The review discusses whether protein supplementation alone or in combination with carbohydrates accelerates glycogen replenishment, thereby increasing repetition of resistance training performance (Pasiakos et al., 2014), as well as the effects of protein supplementation on muscle breakdown and restoration of muscle function and physical performance.

A balanced post-workout supplement should contain whey protein that provides at least 3 g of leucine per serving. This post-workout supplementation is most effective in increasing muscle protein synthesis, resulting in greater muscle hypertrophy and strength. Studies on dairy consumption have shown that post-workout fat-

free milk is effective in increasing physical performance, training session recovery, decreasing body fat, muscle hypertrophy, and strength. To further increase muscle hypertrophy and strength, a weight training program of at least 10-12 weeks by training the upper and lower body movements (Stark et al., 2012).

Protein consumption produces a strong anabolic stimulus to increase muscle protein synthesis. The ability of a protein portion to stimulate muscle protein synthesis depends on the absorption and blood kinetics of amino acids (Burd et al., 2012; Peñings et al., 2011; West et al., 2011), amount of protein ingested (Mitchell et al., 2015a; Witard et al., 2014), and the amino acid composition of the protein source (Atherton et al., 2016). Only the essential amino acids, especially leucine, initiate an immediate increase in muscle protein synthesis, so that protein is digested quickly with a high leucine content. In addition to programmed exercise, supplementation with soy protein can increase muscle thickness, especially for people starting to train muscle strength. Soy protein can be used as an alternative to replace whey supplements (Babault et al., 2015). This study shows that exercise resistance is an effective way to increase muscle mass and strength, regardless of from protein supplementation (Maltais et al., 2016).

Another study, found that despite differences in absorption kinetics and amino acid composition, when measured at sufficient intervals (4-6 hours), milk and casein increased muscle protein synthesis as effectively as whey protein (Mitchell et al., 2015b). This may be the case, because the amount of protein and the complete profile of essential amino acids are important for the maintenance of muscle protein synthesis (Churchward-Venne et al., 2012). The mechanism behind the anabolic effect of amino acids remains to be fully elucidated. At the molecular level the mechanistic target complex of rapamycin 1 (mTORC1) and its substrates (p70S6K and 4E-BP1) is believed to be largely responsible for the synthetic response protein to resistance exercise and protein intake, with resistance exercise potentially the effect of protein consumption (Witard et al., 2014).

CONCLUSION

Based on the research findings, that weight training that is carried out in a planned, programmed, sustainable and according to the principles of exercise will increase maximum muscle strength. In addition, the consumption of protein nutrients in the form of high protein milk supplementation and high protein foods is important to get maximum results. However, consumption of high-protein milk supplementation has better results than high-protein foods even though they both have an effect on increasing maximum muscle strength. This is because the protein contained in high-protein milk supplementation is absorbed more quickly by the muscles. Thus, researchers recommend the importance of consuming high-protein supplements and high-protein foods in accordance with the needs of the muscles in weight training so that maximum muscle strength can be achieved, without ignoring the principles in exercise.

In carrying out this research, the researcher also experienced several limitations, such as; researchers are not able to fully control the external factors that can affect the results of the study. The factors in question are the resting factor of the research sample and the amount of protein intake consumed outside the trials carried out. In the future, the researcher recommends to further researchers to see the effect of consuming high protein supplements on a sustainable basis on human health. In addition, researchers also recommend looking at other factors that can increase muscle strength such as; the method of exercise used, the level of motor skills and others.

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CONFLICT OF INTEREST

The author states that there is no conflict in the writing of this article.

REFERENCES

- Atherton, P. J., Kumar, V., Selby, A., Rankin, D., Hildebrandt, W., Phillips, B. E., Williams, J. P., Hiscock, N., & Smith, K. (2016). Enriching a protein drink with leucine augments muscle protein synthesis after resistance exercise in young and older men. *Clinical Nutrition*, 36(3), 888-895. <https://doi.org/10.1016/j.clnu.2016.04.025>
- Babault, N., Pařzis, C., Deley, G., Guřin-Deremaux, L., Saniez, M.-H., Lefranc-Millot, C., & Allaert, F. A. (2015). Pea proteins oral supplementation promotes muscle thickness gains during resistance training: a double-blind, randomized, Placebo-controlled clinical trial vs. Whey protein. *Journal of the International Society of Sports Nutrition*, 12(1), 6-13. <https://doi.org/10.1186/s12970-014-0064-5>
- Baechle, T. R., & Earle, R. E. (2008). *Essentials of strength training and conditioning*. Human Kinetics.
- Balshaw, T. G., Massey, G. J., Maden-Wilkinson, T. M., Morales-Artacho, A. J., McKeown, A., Appleby, C. L., & Folland, J. P. (2017). Changes in agonist neural drive, hypertrophy and pre-training strength all contribute to the individual strength gains after resistance training. *European Journal of Applied Physiology*, 117(4), 631-640. <https://doi.org/10.1007/s00421-017-3560-x>
- Breen, L., Philp, A., Witard, O. C., Jackman, S. R., Selby, A., Smith, K., Baar, K., & Kevin D, T. (2011). The influence of carbohydrate-protein co-ingestion following endurance exercise on myofibrillar and mitochondrial protein synthesis. *The Journal of Physiology*, 589(16), 4011-4025. <https://doi.org/10.1113/jphysiol.2011.211888>
- Buckner, S. L., Mouser, J. G., Jessee, M. B., Dankel, S. J., Mattocks, K. T., & Loenneke, J. P. (2017). What does individual strength say about resistance training status? *Muscle & Nerve*, 55(4), 455-457. <https://doi.org/10.1002/mus.25461>
- Burd, N. A., Yang, Y., Moore, D. R., Tang, J. E., Tarnopolsky, M. A., & Phillips, S. M. (2012). Greater stimulation of myofibrillar protein synthesis with ingestion of whey protein isolate v. micellar casein at rest and after resistance exercise in elderly men. *British Journal of Nutrition*, 108(06), 958-962. <https://doi.org/10.1017/s0007114511006271>
- Carbone, J. W., McClung, J. P., & Pasiakos, S. M. (2012). Skeletal Muscle Responses to Negative Energy Balance: Effects of Dietary Protein. *Advances in Nutrition*, 3(2), 119-126. <https://doi.org/10.3945/an.111.001792>
- Cermak, N. M., Res, P. T., Groot, L. C. de, Wim HM, S., & Loon, L. J. van. (2012). Protein supplementation augments the adaptive response of skeletal muscle to resistance-type exercise training: a meta-analysis. *The American Journal of Clinical Nutrition*, 96(6), 1454-1464. <https://doi.org/10.3945/ajcn.112.037556>
- Churchward-Venne, T. A., Burd, N. A., Mitchell, C. J., West, D. W., Philp, A., Marcotte, G. R., Steven K, B., Baar, K., & Phillips, S. M. (2012). Supplementation of a suboptimal protein dose with leucine or essential amino acids: effects on myofibrillar protein synthesis at rest and following resistance exercise in men. *Journal Physiologi*, 590(11), 2751-2765. <https://doi.org/10.1113/jphysiol.2012.228833>
- DeWeese, B. H., Gray, H. S., Sams, M. L., Scruggs, S. K., & Serrano, A. J. (2013). Revising the definition of periodization: Merging historical principles with modern concern. *Olympic & Paralympic Coach*, 24(1), 5-19.
- DeWeese, B. H., Hornsby, G., Stone, M., & Stone, M. H. (2015). The training process: Planning for strength-power training in track and field. Part 1: Theoretical aspects. *Journal of Sport and Health Science*, 4(4), 308-317. <https://doi.org/10.1016/j.jshs.2015.07.003>
- Eyuboglu, E., Aslan, C. S., Karakulak, I., & Sahin, F. N. (2019). Is there any effect of non-suitable pull technique in back & leg dynamometers on the leg strength test results. *Acta Medica Mediterranea*, 35(3), 1373-1378.

- García-López, D., Hernández-Sánchez, S., Martin, E., Martin, P.J., Zarzosa, F., & Herrero, A.J. (2016). Free-Weight Augmentation With Elastic Bands Improves Bench Press Kinematics in Professional Rugby Players. *Journal of Strength and Conditioning Research*, 30 (9), 2493–2499. <https://doi.org/10.1519/jsc.0000000000000374>
- Giriwijoyo, & Didik, ZS (2013). *Sports Physiology (Sports Physiology) Functions of the Human Body in Sports For Health and Achievement*. Bandung: PT Pemuda Rosdakarya Offset.
- Gorissen, S.H., Horstman, A.M., Franssen, R., Crombag, J.J., Langer, H., Bierau, J., & Respondek, Frederique Van Loon, L.J. (2016). Ingestion of Wheat Protein Increases In Vivo Muscle Protein Synthesis Rates in Healthy Older Men in a Randomized Trial. *The Journal of Nutrition*, 146(9), 1651–1659. <https://doi.org/10.3945/jn.116.231340>
- Gorissen, S.H., Crombag, J.J., Joan M. G. S., WA Huub, W., Jörgen, B., Verdijk, L.B., & Loon, L.J van. (2018). Protein content and amino acid composition of commercially available plant-based protein isolates. *Amino Acids*, 50, 1685–1695. <https://doi.org/10.1007/s00726-018-2640-5>
- Hulston, C., Wolsk, E., Grondahl, T., Yfanti, & Hall G, V. (2011). Protein Intake Does Not Increase Vastus Lateralis Muscle Protein Synthesis during Cycling. *Medicine & Science in Sports & Exercise*, 43(9), 1635–1642. <https://doi.org/10.1249/mss.0b013e31821661ab>
- Joy, J. M., Lowery, R. P., de Souza, E. O., & Wilson, J. M. (2016). Elastic Bands as a Component of Periodized Resistance Training. *Journal of Strength and Conditioning Research*, 30(8), 2100–2106. <https://doi.org/10.1519/jsc.0b013e3182986bef>
- Kenney, W. L., Wilmore, J. H., & Costill, D. L. (2011). *Exercise in hot and cold environments*. Physiology of Sport and Exercise. 5th Ed Champaign: Human Kinetics.
- Lunn, W. R., Pasiakos, S. M., Colletto, M. R., Karfonta, K. E., Carbone, J. W., Anderson, J. M., R, N., & Rodriguez. (2012). Chocolate milk and endurance exercise recovery: protein balance, glycogen, and performance. *Medicine & Science In Sports & Exercise*, 44(6), 82–91. <https://doi.org/10.1249/MSS.0b013e3182364162>
- Maltais, M. L., Ladouceur, J. P., & Dionne, I. J. (2016). he Effect of Resistance Training and Different Sources of Postexercise Protein Supplementation on Muscle Mass and Physical Capacity in Sarcopenic Elderly Men. *Journal of Strength and Conditioning Research*, 30(6), 1680–1687. <https://doi.org/10.1519/jsc.0000000000001255>
- McLellan, T. M., Pasiakos, S. M., & Lieberman, H. R. (2013). Effects of Protein in Combination with Carbohydrate Supplements on Acute or Repeat Endurance Exercise Performance: A Systematic Review. *Sports Medicine*, 44(4), 535–550. <https://doi.org/10.1007/s40279-013-0133-y>
- Mitchell, C. J., McGregor, R. A., D'Souza, R. F., Thorstensen, E. B., Markworth, J. F., Fanning, A. C., Poppitt, S. D., & Cameron-Smith, D. (2015a). Consumption of Milk Protein or Whey Protein Results in a Similar Increase in Muscle Protein Synthesis in Middle Aged Men. *Nutrients*, 7(10), 8685–8699. <https://doi.org/10.3390/nu7105420>
- Mitchell, W. K., Phillips, B. E., Williams, J. P., Rankin, D., Lund, J. N., Smith, K., & Atherton, P. J. (2015b). A dose- rather than delivery profile-dependent mechanism regulates the “muscle-full” effect in response to oral essential amino acid intake in young men. *The Journal of Nutrition*, 145(2), 207–214. <https://doi.org/10.3945/jn.114.199604>
- Muller, M. D., Barkley, J. E., Kim, C.-H., Ida, K., Ryan, E. J., Bliss, M. V., & Glickman, E. L. (2011). The Effects of Combined Elastic- and Free-Weight Tension vs. Free-Weight Tension on One-Repetition Maximum Strength in the Bench Press. *Journal of Strength and Conditioning Research*, 25(2), 459–463. <https://doi.org/10.1519/jsc.0b013e3181c1f8b6>

- Nelson, A. R., Phillips, S. M., Stellingwerff, T., Rezz, S., Bruce, S. J., Breton, I., Thorimbert, A., Guy, P. A., Clarke, J., Broadbent, S., & Rowlands, D. S. (2012). A protein-leucine supplement increases branched-chain amino acid and nitrogen turnover but not performance. *Medicine & Science in Sports & Exercise*, 44, 57–68. <https://doi.org/10.1249/MSS.0b013e3182290371>
- Pasiakos, S. M. (2012). Exercise and Amino Acid Anabolic Cell Signaling and the Regulation of Skeletal Muscle Mass. *Nutrients*, 4(7), 740–758. <https://doi.org/10.3390/nu4070740>
- Pasiakos, S. M., Montain, S. J., & Young, A. J. (2013). Protein Supplementation in U.S. Military Personnel. *The Journal of Nutrition*, 143(11), 1815–1819. <https://doi.org/10.3945/jn.113.175968>
- Pasiakos, S. M., Lieberman, H. R., & McLellan, T. M. (2014). Effects of Protein Supplements on Muscle Damage, Soreness and Recovery of Muscle Function and Physical Performance: A Systematic Review. *Sports Medicine*, 44(5), 655–670. <https://doi.org/10.1007/s40279-013-0137-7>
- Pennings, B., Boirie, Y., Senden, J. M., Gijzen, A. P., Kuipers, H., & Loon, L. J. van. (2011). Whey protein stimulates postprandial muscle protein accretion more effectively than do casein and casein hydrolysate in older men. *The American Journal of Clinical Nutrition*, 93(5), 997–1005. <https://doi.org/10.3945/ajcn.110.008102>
- Schoenfeld, B. J., Aragon, A. A., & Krieger, J. W. (2012). Protein supplementation augments the adaptive response of skeletal muscle to resistance-type exercise training: a meta-analysis. *The American Journal of Clinical Nutrition*, 96(6), 1454–1464. <https://doi.org/10.3945/ajcn.112.037556>
- Stark, M., Lukaszuk, J., Prawitz, A., & Salacinski, A. (2012). Protein timing and its effects on muscular hypertrophy and strength in individuals engaged in weight-training. *Journal of the International Society of Sports Nutrition*, 9(1), 54. <https://doi.org/10.1186/1550-2783-9-54>
- Suchome, TJ, Nimphius, S., & Stone, MH (2016). The Importance of Muscular Strength in Athletic Performance. *Sports Medicine*, 46 (10), 1419–1449. <https://doi.org/10.1007/s40279-016-0486-0>
- Sukadiyanto. (2011). *Introduction to Physical Training Theory and Methodology*. Bandung: CV Lubuk Agung.
- Vliet, S., Nicholas A, B., & Loon, L. J. van. (2015). The Skeletal Muscle Anabolic Response to Plant- versus Animal-Based Protein Consumption. *The Journal of Nutrition*, 145(9), 1981–1991. <https://doi.org/10.3945/jn.114.204305>
- Vandenbogaerde, T. J., & Hopkins, W. G. (2011). Effects of Acute Carbohydrate Supplementation on Endurance Performance. *Sports Medicine*, 41(9), 773–792. <https://doi.org/10.2165/11590520-000000000-00000>
- West, D., NA, B., Coffey, V., Baker, S., Burke, L., & Hawley, M. (2011). Rapid aminoacidemia enhances myofibrillar protein synthesis and anabolic intramuscular signaling responses after resistance exercise. *Am J Clin Nutr*, 94(3), 795–803. <https://doi.org/10.3945/ajcn.111.013722>
- Wilkinson, D. ., Hossain, T., Hill, D. ., Phillips, B. ., Crossland, H., Williams, J., & Loughna, P. (2013). Effects of leucine and its metabolite β -hydroxy- β -methylbutyrate on human skeletal muscle protein metabolism. *The Journal of Physiology*, 591(11), 2911–2923. <https://doi.org/10.1113/jphysiol.2013.253203>
- Witard, O. C., Jacman, S. R., Breen, L., Smith, K., Selby, A., & Tipton, K. D. (2014). Myofibrillar muscle protein synthesis rates subsequent to a meal in response to increasing doses of whey protein at rest and after resistance exercise. *Am. J. Clin. Nutr*, 99(1), 86–95. <https://doi.org/10.3945/ajcn.112.055517>
- Yang, Y., Churchward-Venne, T. A., Burd, N. A., Breen, L., Tarnopolsky, M. A., & Phillips, S. M. (2012). Myofibrillar protein synthesis following ingestion of soy protein isolate at rest and after resistance exercise in elderly men. *Nutrition & Metabolism*, 9(1), 57. <https://doi.org/10.1186/1743-7075-9-57>

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