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Differential Effect of Plant Protein and Animal Protein Supplements on Skeletal Muscle Hypertrophy: A Review

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Introduction :

Protein consumption has been one of the most researched areas in the nutrition field over past few decades. [1]An area of expanding research in recent times has been the comparative effects of different protein sources on physical activity , the advantages and disadvantages of animal versus plant protein sources and their implications on athletic performances. [2]

In a typical day an adult who does not engage in regular physical exercise , consuming a balanced diet maintains skeletal protein mass because the cumulative rate of skeletal muscle protein synthesis (SMPS) equals the cumulative rate of skeletal muscle protein breakdown (SMPB) .[3] Hypertrophy or an increase in skeletal muscle mass , occurs when rates of SMPS exceeds those of SMPB over time. Resistance training stimulates SMPS to a greater extent than SMPB. [4,5] Protein recommendation for endurance and strength trained athletes ranges from 1.2 to 2g/kg/day [6] some recent researches suggested potential benefits from a higher amount 1.6 to 2.2 g/kg/day .[7]Phillips et al. [8] reports that 3 hours post resistance training the rate of SMPS and SMPB increases , 11.2% to 31% respectively. When resistance exercise is followed by increased amino acid availability the rate of SMPS is enhanced more than that observed when either resistance training or amino acid alone.[9-11] Hence an anabolic window exists within the first 3 hours after resistance training . This is the reason , why weight training combined with protein intake during anabolic window leads to significant increase in lean body mass, compared to failure in gaining lean body mass and loss of muscle protein, in the case of delayed protein intake.

There are various types of protein sources available in the market. Animal protein such as (whey,casein, egg, beef ,fish) and plant protein sources such as (Isolated soy protein , pea, rice, hemp), differing in various qualities such as presence of different allergens (casein, soy), cholesterol content, saturated fat content, rate of amino acid digestibility (fast , intermittent , slow absorption of amino acids), relative presence of individual essential amino acids. [12]

This review aims to find out the differential effects of animal and plant protein supplements in muscle hypertrophy.

Digestibility Rate of Protein Sources Influencing SMPS:

Whey protein is rapidly digested which leads to rapid rise in plasma amino acid level, hence it is referred as “fast protein”. [13] Isolated soy protein (ISP) is termed as an “intermediate protein” in respect of protein digestibility and amino acid peak and casein protein is referred as “slow protein” because the rise in amino acid concentration is moderate and prolonged.[13]Previous research showed that results in increase of SMPS was comparable in both ISP and whey protein supplements when fed immediately post exercise [14] suggesting the ability of ISP to act similarly to a “fast protein” in stimulating SMPS.

Effect of Individual Amino Acids on SMPS :

Dietary protein quality is assessed based on essential amino acid content and the ability of protein to be digested, absorbed and retained by the body . [15] The Protein Digested Corrected Amino Acid Score (PDCAAS) is a composite indicator of protein quality used to assess the ability of dietary protein to meet the body’s amino acid requirement. [16] Apart from soy protein isolates, the plant based protein sources are characterized by a PDCASS below 100% , therefore lower than animal protein .[17] Out of the nine essential amino acids Branched Chain Amino Acids (BCAA) valine, isoleucine and leucine are of great interest in case of muscle protein synthesis. When short term glycogen stores get exhausted during exercise, muscle oxidizes BCAA to provide energy. The role of leucine in the stimulation of SMPS is of real interest to strength athletes. Leucine activates mechanistic target of rapamycin (mTOR) signalling pathway that turns on the translational machinery for SMPS in both rodent and human muscle. [18-20] Lysosomal availability of mTOR initiate cellular protein synthesis. Resistance Exercise Training (RET) stimulates association of mTOR and Rheb (GTP) , targeting mTOR to lysosome and stimulate protein synthesis . Post exercise BCAA availability specially leucine augment this process. [21] Whey protein has higher leucine and total BCAA content than casein and ISP. To optimize muscle hypertrophy in conjunction with resistance training a daily protein intake of 1.6 g/kg body weight/day with 6-15 g essential amino acids and 1.7 to 3.5g leucine per serving plays a pivotal role. [22-23]

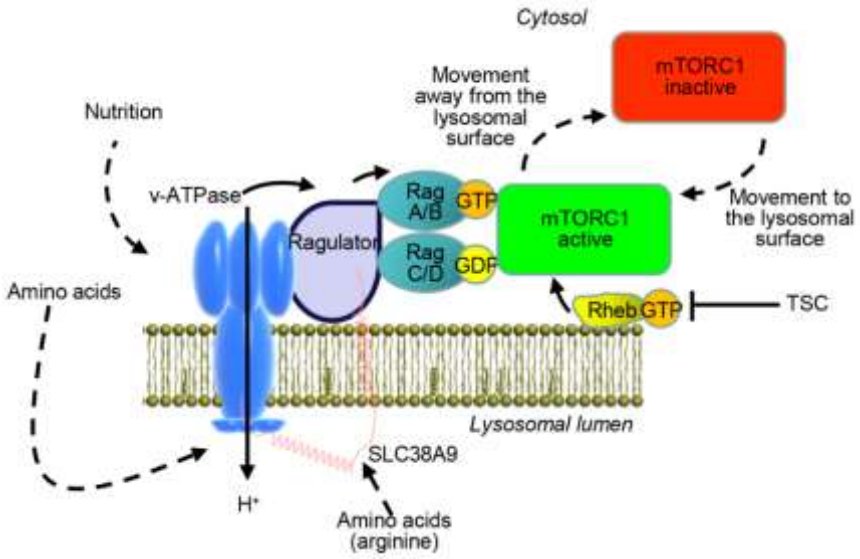

Figure 1.[24] Mammalian target of rapamycin (mTOR) signaling at the lysosomal surface. Nutriton , amino acids promoting this condition, Rag (Ras-related GTPases) and Rheb (Ras homolog enriched in brain) Activated GTP bound Rag and Rheb bind to mTORC1 complex leads to activation of mTORC1 complex and entry of mTORC1 into the lysosomal surface. Loss of these inputs leads to blockade of mTORC1. TSC: Tuberous sclerosis complex; v-ATPase: vacuolar-type H^+-ATPase.

Table 1:[25] Leucine content of some common protein sources per 100 g

Protein Source	Leucine (g)
Brown rice	4.08
Whole wheat	3.78
Peas	3.87
Soyabean	4.59
Milk	6.20
Egg	7.95

Review :

Teixeria et al. (2022) [26] conducted a study on 50 male futsal players ,with no experience of resistance training in the age group of 18 to 35 years. The participants were divided in two groups, one on novel plant based protein powder supplement (pea protein, yeast protein) and the other were on whey protein powder concentrate. They were followed up for 8 weeks. Maximal isometric hand grip strength, aerobic and anaerobic performance were measure at baseline and after 8 weeks of intervention. 40 athletes were analyses in the final result. In the final analysis no difference were observed between two groups at base line or after 8 weeks supplementation. A time effect was only observed in fat mass reduction. The result of the study suggests that whey protein does not possess any unique anabolic properties over and above those of plant based protein when equated for essential amino acid profile. Furthermore when consuming daily protein greater than 1.6g/kg/BW/day additional protein supplements does not affect body composition or performance regardless the supplement type. Similar findings were observed in the study by Lynch M. Heidi et al. (2020). [27], where sixty one untrained men (n= 19) and women (n= 41) aged (18 to35 year) were enrolled for the study. All candidates were given resistance training for 3 days /week, and they were fed 19 gm whey protein isolate or 26 g ISP, both containing 2 gm leucine. All participants were followed for 12 weeks. Both groups significantly increased total body mass, lean body mass and reduced body fat percent, but no significant difference was noticed between both groups. The results also indicated that increased in lean mass and strength in untrained participants are similar when strength training, with either soy or whey supplements containing equal amount of leucine.

Different results were found by Hratman et al. (2007)[28] , where young men (18-30 year) were recruited for a 12week intervention study. All the participants were on a 5day/week resistance training. The subjects were divided into three groups, the control group (n = 19) were fed a flavoured fluid containing 9% maltodextrin which was isocaloric to the milk and soy group, the milk fluid group (n = 19) were given 500 ml fat free milk and the third group (n=18) were fed 500 ml soy milk fluid that was isocaloric and isonitrogenous and macronutrient matched (protein, carbohydrate, fat) to that of the milk fluid. The supplements were given to the subjects 1 hour post resistance training. Fat loss were higher in the milk supplement group than control or soy group. Increase in lean body mass (LBM) was significantly higher in milk group.

The result of the study by Joy.J.M et al. (2013)[29] were consistent with the result of Teixeria et al. (2022) [26] and M. Heidi et al. (2020)[27] . In this study 24 male (18-25 years), who had a background of resistance training were enrolled. All the participants were on a diet consisting of 50% carbohydrate,

25% protein and 25 % fat and they were on 3days/week resistance training programme. The subjects were divided into two groups. One was fed 48 g rice protein supplement and other 48 g whey isolate post exercise. They were followed up for 8 weeks. Though the leucine content was high in whey isolate by 1.7 g but both protein supplement met the recommended leucine dose of (1.7 to 3.5 gm/meal) for muscle protein synthesis. The result reported that LBM significantly increased in both groups from baseline, bicep and quadricep size increased in both groups and body fat significantly decreased in both groups. In the rice protein group LBM increase by 2.5 kg and in whey isolate group by 3.2 kg but the difference was not statistically significant. Joly. M. J et al. (2013) [29] hypothesised that higher dose of rice protein (48g) will be comparable to equally high dose of whey protein on skeletal muscle hypertrophy and training induced adaptation.

Discussion :

Recent data shows that, when put on a resistance exercise training (RET) schedule, skeletal muscle hypertrophy occurs in untrained individuals irrespective of the type of protein supplements , due to the fact that protein supplementation is overwhelmed by the robust effect of RET in novice weight lifters. Reidy et al. (2016)[30] also reported , that there was no difference in lean body mass gains after chronic resistance exercise between whey and soy-dairy blend supplementation. A slightly different study was done by Volek S Jeff et al. (2013)[31], where the researchers investigated long term (9 months) effect of whey, soy and carbohydrate supplements on LBM gain after resistance training in 63 male and female. The results showed that LBM gain was significantly higher in whey protein group (3.3 ± 1.5 kg) than carb (2.3 ± 1.7 kg) and soy (1.8 ± 1.6 kg). This study was different than the previously mention studies, as it tested chronic effect of different protein sources on skeletal muscle hypertrophy and also in this study carbohydrate supplementation on skeletal muscle hypertrophy was also tested. Here LBM gain was significantly greater in whey protein group, one of the reasons also can be that the whey group subjects were on a diet consisting 1.4 g/kg/BW of protein, whereas the carbohydrate group were on relatively lower protein diet 1.1g/kg/BW. One of the reasons of greater LBM gain in whey group than soy group can be due to the fact that leucine content differed greatly in both groups (whey 2.2g& soy 1.4 g).

In a meta analysis by Messina M et al. (2018)[32] , they reported the rate of LBM gain and gain in grip strength was comparable for soy with not only whey supplements but also with all other protein supplements of animal origin. Banaszek et al. (2019) [33] also observed that there was no difference in LBM gain between pea protein and whey protein when matched for leucine content (2.1-2.2g/dose). Study by Mobley B C et al. (2017) [34] also observed that the effect of protein supplementation was overwhelmed by RET in untrained individuals. In the aforementioned study young untrained college aged males were recruited and put on 12week RET. They were divided into placebo maltodextrin, L-leucin supplement, whey concentrate, whey isolate and soy concentrate groups. This is one of the few studies were the effect of isolated L- leucine was investigated on skeletal muscle hypertrophy, strength and body composition. The researchers concluded that though the supplements were varying in protein content , yet there was no significant difference in the muscle protein indices due to the reason that all the participant were on a extensive RET programme, which outshined the effect of protein supplementation and also the fact that all the subjects belonging to different test groups were on a progressive calorie increase and 1.1 to 1.3 g/kg/day protein diet throughout the training period which created the anabolic environment needed for muscle growth . Farup .J et al .(2014)[35] concluded in their study that muscle protein synthesis and muscle protein hypertrophy is less dependent on different methods of muscle concentration exercises and more on timed protein ingestion . Babault etal . (2015)[36] also observed similar results . They found almost similar effect of whey and pea protein on muscle hypertrophy, while the subjects were kept on RET for 12 weeks. The researchers attributed the similar effects of pea and whey supplementation to the fact that both supplementation were rich in BCAA. They also reported an interesting finding that beyond 6 weeks of training, only the groups on supplementation either on whey or pea saw an increase in muscle thickness than the placebo group. This particular finding indicates that protein supplementation plays a pivotal role on muscle hypertrophy specially in longer training periods. Ahtiainen et al . (2003)[37] and V et al . (2010) [38] came to a consensus that greater increase in muscle thickness is observed in untrained individuals than previously trained subjects. They concluded that the effect of supplementation and training adaptation depends on initial training status. Novice, untrained individuals will experience greater effect of protein supplementation on muscle hypertrophy irrespective of protein quality.

Conclusion:

The differential effect of protein sources on physical activity and it's influence on athletic performance is one of the expanding research area now a days. Resistance exercise training(RET) along with timed protein ingestion proved to be important stimulus for skeletal muscle hypertrophy. Branched chain amino acid particularly have a pivotal role to play in skeletal muscle synthesis. It has been observed, when matched with leucine content, animal protein and plant protein sources have similar effect on muscle hypertrophy. Several studies also suggested that in individuals with no exercise background will have muscle growth as a result of comprehensive RET with adequate protein intake having all essential amino acids irrespective of any special protein supplementations. Few studies also indicated that difference of protein composition is of less importance when protein is consumed in high amount throughout RET. In future detailed studies on the effect of different protein supplements on skeletal muscle hypertrophy including subjects belonging from different age groups and gender and having different exercise background will give a better understanding of this topic.

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