

# Comparison of the Effects of Soy Protein and Whey Protein Supplementation during Exercise: a Systematic Review

## Comparaç o dos Efeitos da Suplementa o de Whey Protein e Prote na de Soja Durante o Exerc cio: uma Revis o Sistem tica

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### Abstract

The interest of the supplementation market for the soy protein consumption to optimize physical and metabolic performance after exercise is increasing. However, evidence suggests that the soy protein ingestion has lower anabolic properties when compared with whey protein. The purpose of this systematic review was to compare the effects of whey protein and soy protein supplementation on the muscle functions maintenance after exercise. This review was performed using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Articles were searched for in the Pubmed database and included studies comparing the effects of soy protein and whey protein consumption on protein synthesis, lean mass gain and oxidative stress reduction in response to endurance or resistance training. Thirteen trials were included in this review. The results showed that the whey protein consumption is superior to that of soy protein with respect to protein synthesis and lean mass gain, but soy protein showed superior results in reducing oxidative stress. Future research comparing both soy and whey protein are needed to define protein source to be used in nutritional interventions to protein synthesis, lean mass gain and oxidative stress in different populations.

**Keywords:** Soybean Proteins. Milk Proteins. Protein Biosynthesis. Hypertrophy.

### Resumo

*O interesse do mercado de suplementa o pelo consumo de prote na de soja para otimizar o desempenho f sico e metab lico ap s o exerc cio est  aumentando. No entanto, evid ncias sugerem que a ingest o da prote na de soja tem propriedades anab licas mais baixas quando comparada   prote na do soro do leite. O objetivo desta revis o sistem tica foi comparar os efeitos da suplementa o com whey protein e prote na de soja na manuten o das fun es musculares ap s o exerc cio. Esta revis o foi realizada usando os Itens de Relat rio Preferidos para Revis es Sistem ticas e Meta-An lises (PRISMA). Os artigos foram pesquisados na base de dados Pubmed e incluíram estudos comparando os efeitos da prote na de soja e do consumo de prote nas do soro na s ntese prot ica, ganho de massa magra e redu o do estresse oxidativo em resposta ao treinamento de resist ncia ou resist ncia. Treze ensaios foram includidos nesta revis o. Os resultados mostraram que o consumo de prote na de soro   superior ao da prote na de soja em rela o   s ntese prot ica e ao ganho de massa magra, mas a prote na de soja apresentou resultados superiores na redu o do estresse oxidativo. Pesquisas futuras comparando a soja e a prote na do soro do leite s o necess rias para definir a fonte prot ica a ser usada em interven es nutricionais para a s ntese prot ica, ganho de massa magra e estresse oxidativo em diferentes popula es.*

**Palavras-chave:** Prote nas de Soja. Prote nas do Leite. Bioss ntese de Prote nas. Hipertrofia.

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## 1 Introduction

Potentiating muscle recovery after exercise is essential to maximize muscle adaptations. The literature indicates the key role of protein intake in the metabolic functions balance after exercise<sup>1</sup>. Protein-based supplements are often used for the rapid delivery of amino acids into the systemic circulation, facilitating protein anabolism in the muscle<sup>2</sup>. The intake of soy protein and whey protein may reduce the oxidative stress caused by intense exercise<sup>3</sup> and reduce the muscle proteins catabolism, which aids in hypertrophic gains<sup>4</sup>.

The use of soy protein and whey protein supplementation stimulates and maintains muscle growth and strength. Whey protein is used by athletes for muscle recovery and hypertrophy<sup>5</sup>,

and the intake of whey protein after exercise was shown to induce hyperaminoacidemia, Mammalian target of rapamycin (mTOR) signaling and muscle protein synthesis<sup>6</sup> as well as having an antioxidant effect<sup>7</sup> and maintaining high levels of hepatic glycogen. Soy protein combined with strength training stimulates muscle protein synthesis (MPS)<sup>8,9</sup>, and it also contains antioxidants and may decrease the deleterious effects of exercise<sup>10</sup>. The purpose of this systematic review was to compare the effects of whey protein and soy protein supplementation on the muscle functions maintenance after exercise.

## 2 Development

### 2.1 Methodology

This systematic review was carried out using explicit

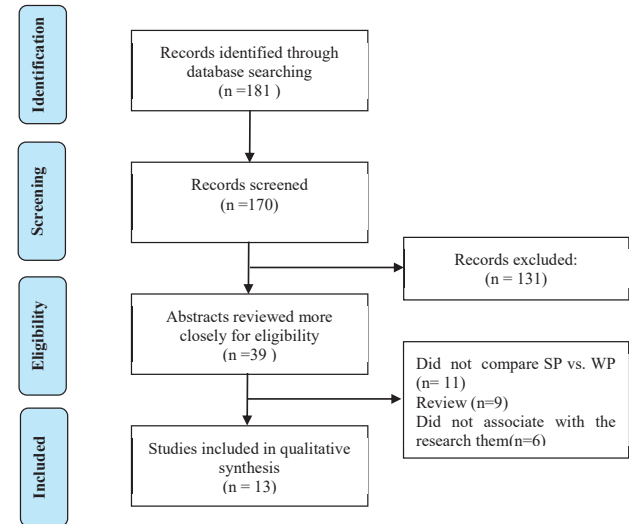
methods that allowed the selection of articles that analyzed the use of whey protein and soy protein supplementation in physical exercise. This systematic review was performed using The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).

The articles research was based on PubMed database until February of 2018. In this search for articles the terms used for soy protein were: “soy”, “soy protein”, “soy proteins”, “soybean”, “soy bean” and “soybean protein”, and the search was carried out using the “OR” operator between the terms. The terms used for whey protein were: “whey”, “whey protein”, “milk protein” and “milk serum protein”, and the search was again carried out using the “OR” operator between the terms. The terms used for exercise: “physical fitness”, “physical performance”, “physical exercise”, “exercise”, “exercise training”, “physical training”, “exercise program”, “exercise performance”, “resistance training” and “resistance exercise”. The search was carried out using the “OR” operator, between the terms. The combination of the terms related to soy protein, whey protein and exercise was carried out using the “AND” operator.

The included studies were English language, randomized, double-blinded, placebo-controlled trials investigating the effects of soy and whey protein supplementation on measures of protein synthesis, lean mass gain and oxidative stress reduction following exercise. In the initial search for the selected terms, 181 potential articles were identified for inclusion in the review. 131 were excluded because they did not contain the combination of terms in the title and abstract. 39 studies were selected which participated of the inclusion and exclusion criteria. Frase: Foram selecionados 39 estudos que participaram dos critérios de inclusão e exclusão.

The exclusion criteria were applied and the following studies were excluded: a) reviews; b) those focusing on research about hormonal changes; c) diseases; d) hepatic glycogen levels e) those that did not directly compare the effects of soy protein and whey protein supplementation on physical exercise. Thirteen trials were included in this review. The study selection diagram and the selection steps are shown in Figure 1.

Figure 1 - Diagram of selected studies.



Source: The authors.

2.2 Findings

Six studies investigated the effects of soy and whey protein supplementation on the lean mass gain after resistance-trained (Table 1). Five studies investigated the effects of soy and whey protein supplementation on the muscle protein synthesis after resistance and endurance exercise (Table 2).

Table 1 - Comparison between the effects of the intake of WP and SP on lean body mass gain after resistance exercise

Authors	Sample	Supplementation/day	Exercise	Methods	Main Findings
Aristizabal et al. <sup>16</sup>	61 men and women (18–35 years)	~0.3g/kg WP or SP	resistance exercise for 36 weeks	DXA	↓ lean body mass
Volek et al. <sup>15</sup>	63 men and women (18–35 years)	~0.3g/kg WP or SP	resistance exercise for 36 weeks	DXA	↓ lean body mass
Mobley et al. <sup>14</sup>	75 men (20-22 years)	~0.35g/kg WP ~0.5g/kg SP	resistance exercise for 12 weeks	DXA	= lean body mass
Kalman et al. <sup>13</sup>	20 men and women (18–40 years)	~0,6g/kg WP or SP	resistance exercise for 12 weeks	DXA	= lean body mass
Candow et al. <sup>11</sup>	27 men and women (18–35 years)	1,2g/kg WP or SP	resistance exercise for 6 weeks	DXA	= lean body mass
Brown et al. <sup>12</sup>	27 men (18–25 years)	~0,4g/kg WP or SP	resistance exercise for 9 weeks	HW	= lean body mass

Subtitle: WP: Whey protein; SP: Soy protein; DXA: dual-energy X-ray absorptiometry metabolic map; HW: hydrostatic weighing; =: no significant differences (SP vs. WP); †: significantly greater (SP vs. WP); ↓: significantly lower (SP vs. WP).

Source: Research data.

**Table 2 - Comparison between the effects of the intake of WP and SP in muscle protein synthesis during exercise**

Authors	Sample	Exercise	Supplementation	Methods	Main Findings
Kanda et al. <sup>20</sup>	190 Rats	swimming (2 hours)	3.1g/kg WP or SP	FSR	↓ FSR = insulin concentration ↓ leucinemia ↓ BCAA
Yang et al. <sup>17</sup>	30 men (66–76 years)	resistance exercise	~0.25g/kg and ~0.5g/kg WP or SP	FSR	~0.25g/kg ↓ FSR = insulin concentration ↓ leucinemia = leucine oxidation, BCAA, EAA, TAA
					~0.5g/kg ↓ FSR = insulin concentration ↓ leucinemia ↑ leucine oxidation ↓ BCAA, EAA, TAA
Tang et al. <sup>19</sup>	18 men (19-25 years)	resistance exercise	~0.3g/kg WP or SP	FSR	↓ FSR = insulin concentration ↓ leucinemia ↓ EAA
Anthony et al. <sup>21</sup>	30 Rats	Running (2 hours)	~0.9g/kg WP or SP	FSR	= FSR ↓ insulin concentration ↓ leucinemia ↓ phosphorylation of mTOR
Mitchell et al. <sup>18</sup>	13 men (60–75 years)	resistance exercise	~0.5g/kg WP or SP	WB	= phosphorylation of P70S6K

**Subtitle:** WP: Whey protein; SP: Soy protein; FSR: fractional rates of protein synthesis; WB: Western Blotting; BCAA: branched- chain amino acids; EAA: essential amino acids; TAA: total of all amino acids; =: no significant differences (SP vs. WP); ↑: significantly greater (SP vs. WP); ↓: significantly lower (SP vs. WP);

**Source:** Research data.

Three studies investigated the effects of soy and whey protein supplementation on oxidative stress after resistance exercise (Table 3). These studies are compiled with details in Tables 1-3 and discussed in this review.

**Table 3- Comparison between the effects of the intake of WP and SP on oxidative stress after resistance exercise**

Authors	N	Sex	Age	Training	Supplementation	Methods	Results
Box et al. <sup>22</sup>	18	F	18-25	4 weeks	33g	TAS e PLP	↑* TAS ↓* PLP values =# TAS =# PLP
Hill et al. <sup>23</sup>	18	M	18-25	4 weeks	40g	PLP	↓* PLP values =# PLP
Brown et al. <sup>12</sup>	27	F/M	19-25	9 weeks	39g	TAS	=* TAS ↓#TAS

**Subtitle:** WP: Whey protein; SP: Soy protein; TAS: Total antioxidant status; PLP: Plasma lipid peroxides. \*: SP vs. Pre exercise; #: WP vs. Pre exercise.

**Source:** Research data.

### 2.3 Whey protein vs. soy protein in increasing lean muscle mass

Six studies investigated the effects of soy and whey protein supplementations on the lean mass gain after resistance-trained in young people. Four of the six studies found a lean mass gain after 6-12 weeks of training<sup>11-13</sup>. Candow et al.<sup>11</sup> supplemented 0.4g/kg WP and SP, 3 times/ day for 6 weeks. Brown et al.<sup>12</sup> supplemented with ~0.13g/kg WP and SP, 3 times/ day for 9 weeks. Kalman et al.<sup>13</sup> supplemented with ~0.3g/kg WP and SP, 2 times/ day for 12 weeks. Mobley et al.<sup>14</sup> supplemented with ~0.4g/kg WP and supplemented with ~0.5g/kg SP for 12 weeks. There were no significant

differences in the increases in lean mass between the groups supplemented with WP and SP. Two of the six studies found a lean mass gain after 36 weeks of training<sup>15,16</sup>. Volek et al.<sup>15</sup> supplemented with ~0.3g/kg WP and SP, per day for 36 weeks. Aristizabal et al.<sup>16</sup> supplemented with ~0.3g/kg WP and SP, per day for 36 weeks. They observed more significant increases in lean mass for WP than SP. Additional studies are required to determine the difference between SP and WP in increasing lean mass.

### 2.4 Whey protein vs. soy protein in muscle protein synthesis

Supplementation with whey protein is superior to that

with soy protein for muscle protein synthesis (MPS). Three experiments compared the effect of WP and SP intake on muscle protein synthesis (MPS), after resistance exercise in humans. Yang et al.<sup>17</sup> supplemented elderly individuals with ~0.25g/kg and ~0.5g/kg of WP and SP. The fractional synthetic rates (FSR) of myofibrillar proteins were calculated. They observed more significant increases in the ability to stimulate protein synthesis in elderly individuals supplemented with WP than in those supplemented with SP in both doses, 1h after exercise. Mitchell et al.<sup>18</sup> supplemented elderly individuals with ~0.5g/kg of WP and SP. It was observed that WP and SP stimulated muscle protein synthesis via p70S6K phosphorylation to a similar degree, 2h after exercise. Tang et al.<sup>19</sup> supplemented 18 young subjects with ~0.3g/kg of WP and SP. The fractional synthetic rates (FSR) of myofibrillar proteins were calculated. It was showed that WP stimulated MPS to a greater degree than SP after resistance exercise.

Two of the five studies compared muscle protein synthesis after 2hrs of endurance exercise in rats. Kanda et al.<sup>20</sup> used supplementation of 3.1g / kg of WP and SP. The fractional synthetic rates (FSR) of myofibrillar proteins were calculated. They found that SP induced less MPS than WP 60 min after ingestion. Anthony et al.<sup>21</sup> used supplementation of ~0.9g/kg of whey or soy protein in a high-carbohydrate diet for rats that took part in a 2h-endurance exercise session. The results were similar for the induction of muscle protein synthesis 1h after consumption of WP and SP, but mTOR phosphorylation was higher in the group that consumed WP than in the one that consumed SP.

Plasma insulin concentration was similar for WP and SP<sup>17,19,20</sup> but one study observed that plasma insulin concentration was higher following WP as compared to SP 1h post-drink<sup>21</sup>. Higher amplitudes in blood leucinemia were achieved following WP as compared to SP<sup>17,19-21</sup>. WP produced significantly higher blood amino acids levels compared with SP<sup>17,19,20</sup>. SP caused a significant increase in leucine oxidation<sup>17</sup>.

## 2.5 Whey protein vs. soy protein in the oxidative stress parameters

Soy protein reduces oxidative stress more than whey protein. Three studies evaluated the effects of WP and SP supplementation on the oxidative stress caused by resistance exercise in young subjects after 4-9 weeks of resistance training. The results indicated that SP was superior to WP in reducing oxidative stress. Box, Hill and DiSilvestro<sup>22</sup> applied strength training and supplemented with SP or WP 40g/day for 4 weeks. Soy protein increased the total antioxidants concentration and prevented increased blood CK activity. In contrast, WP significantly increased serum lipid peroxide values when compared to pre-exercise values. Hill et al.<sup>23</sup> supplemented with 40g/day of SP or WP for 4 weeks and showed that SP significantly reduced the serum values of lipid peroxide after resistance exercise. Brown et al.<sup>12</sup> supplemented

with 33g/day for 9 weeks and found that SP maintained the antioxidant status in the plasma, whereas the consumption of WP significantly decreased the antioxidant status. However, further research is needed to confirm these findings.

## 2.6 Discussion

Regular resistance exercise promotes progressive physiological muscle adaptation. Each exercise session stimulates specific signaling pathways that regulate transcriptional and translational activities in the cell<sup>24</sup>. To achieve lean mass gain, muscle protein synthesis must be greater than muscle protein degradation, resulting in a positive protein balance<sup>25</sup>. Chronic adaptations come from the accumulation of acute effects and are sustained by the regulation of muscle protein synthesis<sup>26</sup>. Supplementation with WP and SP may accentuate these adaptations and promote an increased muscle cross-section, known as muscle hypertrophy. However, the ingestion of soy protein results in lower postprandial MPS rates than the ingestion of whey protein does, results in a lower skeletal muscle hypertrophy when performed chronically.

The supplementation of WP and SP stimulated increases in lean mass to a similar degree after 6-12 weeks, but after 36 weeks of resistance training WP showed superior results in gaining muscle mass than supplementation with soy protein. The supplementation of soy and whey protein after exercise, results in a positive nitrogen balance, stimulating increases in lean mass, however, the WP has better ability to support the muscle protein accretion. In theory, soy and whey protein stimulated the muscular adaptive responses after resistance exercise, promoting, on a long term basis, muscle remodeling, but the soy protein ingestion results in lower stimulation of the skeletal muscle hypertrophy compared with the whey protein. The studies that verified the consumption of whey protein and soy protein on the gain in muscle mass are characterized in Table 1.

Postprandial MPS measurements are used to verify the maintenance or increase of skeletal muscle mass. Changes in MPS are not a quantitative estimate of skeletal muscle remodeling, but indicate hypertrophy when performed chronically<sup>27</sup>. What is known is that mTORC1 activation enhances the MPS. It was verified that increase in MPS activates the protein kinases such as the ribosomal protein of 70-kDa S6 kinase 1 (p70S6K1) and 4E-binding protein-1 (4EBP1) promoting ribosomal binding to mRNA initiating the protein synthesis<sup>28</sup>. In this review, the articles showed that both WP and SP increased MPS, mTOR and p70S6K phosphorylation, but that supplementation with WP obtained better results than SP in both young and elderly population<sup>17,18</sup>. Elderly people are less sensitive to the anabolic effects of diet and exercise. Kumar et al.<sup>29</sup> associated the reduced effects of resistance exercise on muscle protein synthesis in the elderly with the inability to completely activate mTOR. However, studies showed that WP was superior to SP in protein synthesis

in humans.

WP induced increase in insulin levels compared to SP<sup>17,21</sup>. The increase of insulin secretion after exercise, increases the mTOR activity in the muscle<sup>30</sup>. However, two studies showed no significant difference in plasma insulin levels between SP and WP. Therefore, further studies are required to compare the effects of SP and WP in insulin secretion.

Soy protein contains fewer EAAs than WP. The ingestion of an “unbalanced” AAs profile results in less free AA concentrations in the systemic circulation to support the postprandial increase in MPS<sup>31</sup>. Protein supplementation with whey protein and soy protein increases the circulating amino acids, making the protein balance positive. Tang and Phillips<sup>32</sup> found that WP and SP supplementation may increase muscle protein synthesis, but that whey protein was superior to soy protein, since the amino acids contained in this protein were available in larger quantities in the bloodstream, facilitating absorption by the muscle cell. Some articles included in this review found a significantly higher increase in the concentration of AAs after the WP consumption than after the SP consumption<sup>19-21</sup>.

Leucine is an important essential amino acid responsible for the increase in MPS. It is known that BCAAs (branched chain amino acids), particularly leucine, have an important role as metabolic regulators of MPS<sup>33</sup>, activating mRNA translation from the rapamycin target (mTOR)<sup>34</sup>. Lollo et al.<sup>35</sup> stated that leucine was an important amino acid in the mTOR activation and p70S6K pathways. The leucine content of whey protein is higher than that of soy protein (12% in WP and 8% in SP)<sup>17</sup>. The results indicated that WP elevated the plasma leucine levels significantly more than SP<sup>20,21</sup> hence the amount of leucine present in WP partially explains its superior effect on MPS.

The protein digestion rate and absorption kinetics of the ingested protein source after the exercise are important for modulating postprandial MPS. Rapidly digested proteins support increased rates of MPS. WP and SP are relatively rapidly digested proteins<sup>36</sup>. However, the SP ingestion results in higher AAs oxidation rates than WP ingestion does<sup>17</sup>. This suggests that the AAs from SP are directed toward the deamination pathways. Increasing the concentration of amino acids in the bloodstream may potentiate the protein synthesis process<sup>37</sup>. Thus, Soy protein-derived AAs were less available to stimulate MPS when compared with the whey protein-derived AAs. The results suggest that the SP support to less extent MPS than WP due to differences in digestion and absorption kinetics. Further studies comparing the two proteins are needed to elucidate the potentiation of the initiation of protein synthesis and translation.

An increase in oxidative stress after intense exercise is associated with decreased physical performance, muscle fatigue and muscle damage<sup>12</sup>, and an increase in lipid peroxide values indicates oxidative stress. The articles included in this

review suggest that soy protein may promote an antioxidant function during resistance exercise, possibly by the activation of antioxidant enzymes. Soy protein contains antioxidant enzymes such as isoflavones<sup>38</sup> and research has suggested that the antioxidant action of isoflavones can eliminate free radicals, increasing the antioxidant enzymes expression, and inhibiting lipid peroxidation<sup>39</sup> and DNA susceptibility to oxidative stress<sup>40,41</sup>. The studies indicated that SP supplementation reduced oxidative stress after resistance training more than WP.

### 3 Conclusion

Physical activity and protein ingestion has been shown to sensitize skeletal muscle tissue to the anabolic properties. Only a few studies have compared the muscle protein synthesis, lean mass gain and oxidative stress response to the ingestion of soy protein vs. whey protein. The evidence suggests that supplemental doses of soy protein may increase the antioxidant defenses, inhibit lipid peroxidation and reduce oxidative stress. The review of the articles indicated that supplementation with WP stimulated the initiation of muscle protein synthesis and translation to a greater degree when compared to supplementation with soy protein. Therefore, soy protein intake was demonstrated to result in lower lean mass gain rates. The proposed lower muscle anabolic properties of SP as opposed to WP sources may be attributed to differences in amino acid composition, especially leucine, and protein digestion and absorption kinetics. Given the small number of articles that compared WP and SP supplementation, additional research is needed to elucidate the physiological effects and differences between whey protein and soy protein supplementation after endurance or resistance exercise.

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