Original Article

Study on the effect of whey protein on the physical fitness of athletes receiving resistance training

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Abstract. *Objective:* This paper aims to understand the effect of whey protein on athletes' physical fitness during resistance training. *Methods:* Sixty professional athletes from the Department of Physical Education of Beijing University of Chinese Medicine were randomly divided into three groups: a blank group (con group), a placebo-resistance training group (pla group), and a whey protein-resistance training group (pro group). After four weeks of resistance training, the athletes' body composition and physical quality were compared. *Results:* Before the experiment, there were no significant differences in body composition and physical quality of different groups, and the indicators of the con group did not change significantly before and after the experiment. After the experiment, the body mass index (BMI) and body fat percentage (BF%) of pla and pro groups decreased significantly, and the basal metabolic rate increased ($p < 0.05$ compared with the pre-experiment and $p < 0.05$ in the comparison between the two groups). After the experiment, pla and pro groups showed significant improvement in physical qualities, and the performance of the pro group was significantly different from the pre-experimental performance and the pla group. *Conclusion:* Whey protein can effectively improve the body composition of athletes in resistance training, enhance physical quality, and improve the training effect.

Key words: resistance training, whey protein, physical fitness, athletes, body composition

Introduction

With the development of society and economy, sports are becoming increasingly important in people's lives, and sports competition has received more and more widespread attention (1). Athletes must work hard to improve their competitive level to get excellent performance in events. Both nutritional supplementation and exercise training have a role in improving athletes' physical fitness and athletic performance. Nutritional supplementation can meet the body's needs timely (2) and improve athletic performance (3). Whey protein is an excellent protein supplement, which has been extensively applied in the sports population. Exercise training can improve human body quality and help people familiarize athletic skills. Both nutritional supplementation and exercise training have received extensive attention from researchers. Chang et al. (4) found that a three-month whole-body vibration training was effective in improving skeletal muscle mass index and living quality in the elderly. Hassan et al. (5) studied 30 senior athletes and found that the intervention group that received suspension training showed significant changes in speed, agility, and balance, demonstrating the benefits of suspension training for athletes. Huang et al. (6) carried out a five-week study on 12 male track and field athletes and found through experiments that the group of athletes supplemented with whey protein showed better endurance performance, increased muscle mass, and relieved sports injuries. Li et al. (7) studied 36 soccer players and found that the athletes supplemented with whey protein had more significant erythrocyte function and better physical performance test results.

Resistance training (8) refers to the training means to improve the strength, speed, etc. of the body through multiple groups of weight training with the assistance of equipment. Grgic et al. (9) studied the effect of resistance training with different frequencies on muscle strength gain. A review and analysis of the existing literature found that resistance training frequency had a significant effect on upper limb strength gain ($p = 0.004$) but had no effect on lower limb strength gain ($p = 0.070$) and that younger people responded more positively to high resistance training frequencies than older people. Nagaia et al. (10) found through a randomized controlled trial that after six months of resistance training, participants had a significant increase in lower limb muscle strength, demonstrating that resistance training is beneficial for improving mobility in older people. This paper proposed improving athletes' physical fitness of by providing whey protein and resistance training. It was hypothesized that whey protein positively affect the physical fitness of athletes in resistance training. The accuracy of the hypothesis was proved by experimental analysis, which provides theoretical support for the further application of whey protein and resistance training in sports.

Research subjects and methods

Research subjects

Sixty professional athletes from the Department of Physical Education of Beijing University of Chinese Medicine were subjects. All subjects were in good health and mental condition and had no physical injuries in the past year, no bad habits (smoking and alcohol), no recent history of medication, no contraindications to exercise such as cardiovascular diseases, and no strenuous exercise 24 h before the experiment. All of them understood the purpose and process of the study and signed the informed consent form. The subjects were randomly divided into three groups, the blank group (con group) that did not receive resistance training nor whey protein, the pro group using whey protein as a nutritional supplement, and the pla group using placebo. The comparison of the general information between the subjects is shown in Table 1.

2.1 Research methodology

2.1.1 Experimental protocol

Three groups of subjects were tested for four weeks. The arrangement of every group is as follows.

The con group had no nutritional supplementation or exercise training except for daily diet and activity.

In the pla group, the subject did one hour of resistance training in the afternoon of Monday, Wednesday, and Friday every week, including 10-min warm-up preparation, 40-min resistance training, and 10-min stretching and relaxation; they took 180 ml of pure water as a placebo within half an hour after every training session.

In the pro group, the training program was the same as in the pla group. The subject took 30 g of whey protein powder (Competitor brand) along with 180 ml of pure water within half an hour after every training session.

The resistance training protocols for the pla and Pro groups are shown in Table 2. The training intensity was 70 % of the individual's maximum weight. The subjects rested for 2 min after one group of training.

2.2 Test index

2.2.1 Body composition testing

Instrument: TEZEWAT620 body composition analyzer

Table 1. Comparison of general information

	Con group (n=20)	Pla group (n=20)	Pro group (n=20)
Age/year	22.12±1.11	21.36±1.21	22.07±1.08
Height/cm	178.84±6.27	179.93±5.64	178.62±6.16
Body weight/kg	82.77±14.96	82.33±15.12	81.67±16.07
Training time/year	7.12±1.21	7.33±0.87	6.54±1.09

Table 2. Resistance training program

Time	Training movement	Training volume	Movement specification
Monday	Flat bench press	10RM×3	Hold the barbell with two hands slightly wider than the shoulder width, tighten the hips and tense the abdomen, inhale, move the barbell to just above the collarbone, adjust breathing, and bring the barbell down slowly.
	Seated dumbbell alternate press	10RM×3	Sit in a chair with the back straight, hold the dumbbells with double hands, and push the dumbbells upwards with the left hand and then the right hand until the elbows are straight.
	Prone dumbbell row	10RM×3	Keep the legs apart, bend over about 90°, hold the dumbbells with both hands, pull them up to the sides of the abdomen, and slowly lower them to the starting position.
	Dumbbell curl	12RM×3	Stand, lift the chest, tighten the belly, hold the dumbbells with both hands, keep the arms close to the body, bend the arms to lift the dumbbells close to the chest, pause for a moment, and unload to drop them to the starting position.
Wednesday	Barbell deadlift	10RM×3	Keep double feet as wide as the shoulder, keep the shoulders directly above the barbell, thrust against the ground with the heels, pull up the barbell, tighten the hips and stand straight after passing the knees, move the barbell close to the thighs and calves, pull the barbell up, retract the shoulder blades, keep the back straight, squat down, and drop the barbell back to the ground.
	Prone lift	15RM×3	Lie on the mat with the hands on the ears, push the body upward to the highest point, and return to the starting position.
	Supine alternate leg lift	15RM×3	Lie on the back on a yoga mat with two legs straight, hook the toes, and alternate lifting and dropping.
	Standing side bend	20RM×3	Stand, lift the chest, tighten the belly, lift the arms over the head, keep the palms face to face, bend the body to one side, return to the starting position after a short pause, and then bend the body to the other side.
Friday	Barbell front squat	10RM×3	Stand with double feet slightly wider than the shoulder width, keep the back straight, place the barbell on the shoulders, hook the fingers on the barbell, slowly squat down until the thighs are parallel to the ground, and get up.
	Lunge stretch	12RM×3	Stand, step forward on one leg to make a bow step, stretch the arms before the body and upward until the limit, return to the starting state, and change the leg for the next extension.
	Barbell deadlift	10RM×3	Keep double feet as wide as the shoulder, keep the shoulders directly above the barbell, thrust against the ground with the heels, pull up the barbell, tighten the hips and stand straight after passing the knees, move the barbell close to the thighs and calves, pull the barbell up, retract the shoulder blades, keep the back straight, squat down, and drop the barbell back to the ground.
	Resistance band squat	10RM×3	Keep the two feet and arms apart and as wide as the shoulder, put one side of the resistance band under the foot, bend the elbows, palm up to hold the other side of the resistance band before the neck, squat until the thighs parallel to the ground, and stand up.

Time: The day before the experiment starts and the day after it ends

Test method: After removing outer clothing, footwear, and metal objects, the subject stood on the analyzer, held the electric shock bar, relaxed physically and mentally, and outstretched both arms.

Test index: body mass index (BMI); body fat percentage (BF%); basal metabolic rate (BMR).

2.2.2 Physical fitness test

Instruments: whistle, stopwatch, and tape measure

Time: the day before the experiment started and the day after it ended

Test content is as follows.

(1) Strength (standing long jump): athletes stood behind the starting line with legs slightly divided,

leaned their bodies forward, swung their two arms, and jumped from the standing position. Skip-step was not allowed. The most excellent performance was taken.

(2) Endurance (800 m): athletes started running after the whistle on the track and field blew. Timing stopped after passing the finish line. The time was recorded.

(3) Agility (10 × 4 fold run): markers were set up on the track and field as the starting and fold points. Athletes made four round trips between the starting point and the fold point. The time was recorded.

(4) Speed (100 m): athletes started after the whistle on the track and field blew. Timing stopped after passing the finish line. It was repeated three times, and the best performance was taken as the final performance.

(5) Flexibility (sit and reach): after calibrating the apparatus, athletes straightened their legs, heeled together, stepped on the vertical instrument board, and pushed the cursor with the fingertips of both hands until they could not continue. It was repeated three times, and the best performance was taken.

2.3 Statistical analysis

The experimental data were recorded and organized in an Excel sheet and statistically analyzed in SPSS 23.0. The results were expressed as mean ± standard deviation () and tested by t-test. The significance level was 0.05.

Experimental results

3.1 Changes in body composition

Changes in BMI in different groups before and after the experiment are shown in Figure 1.

It was seen from Figure 1 that the con group did not show significant changes in BMI before and after the experiment, while both the pla and pro groups had significantly smaller BMIs after the experiment than before the experiment ($p < 0.05$). Before the experiment, the BMIs of the pla and pro groups were 26.77 ± 5.07 and 25.46 ± 5.33, respectively, while after the experiment, the BMIs of the two groups were 23.21 ± 5.11 and 22.17 ± 5.03, respectively. The BMI of the pro group was smaller after the experiment, and $p < 0.05$ when compared to the pla group.

Changes in BF% in different groups before and after the experiment are shown in Figure 2.

It was seen from Figure 2 that before the experiment, the difference in BF% between different groups was not significant ($p > 0.05$), and the BF% of the con group did not show significant changes after the experiment. After the experiment, the BF% of the pla group decreased from 22.36 ± 5.17% to 20.87 ± 4.41%, and the BF% after the experiment was significantly different from that before the experiment ($p < 0.05$). The BF% of the pro group before the experiment (22.41 ± 4.86%) was not significantly different from that of both the con and pla groups; after the experiment, the BF% of the pro group decreased to 19.46 ± 4.56%,

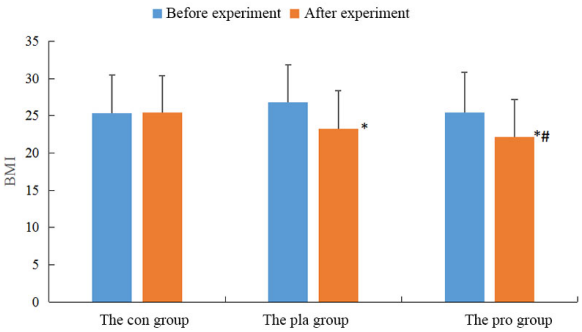

Figure 1. Changes in BMI in different groups before and after the experiment
*: $p < 0.05$ compared to pre-experiment
#: $p < 0.05$ compared to the pla group

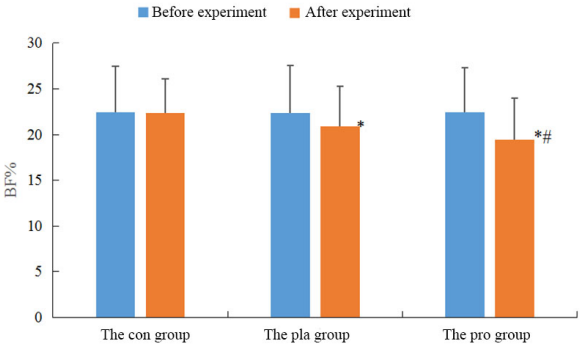

Figure 2. Changes in BF% of different groups before and after the experiment
*: $p < 0.05$ compared to pre-experiment
#: $p < 0.05$ compared to the pla group

which was significantly different from that before the experiment and that of the pla group ($p < 0.05$).

Changes in BMR in different groups before and after the experiment are shown in Figure 3.

It was seen from Figure 3 that the BMR of the con group did not show significant changes before and after the experiment. The BMR of the pla group before and after the experiment was 1765.44 ± 251.26kcal and 1815.67 ± 249.47kcal, respectively; the BMR significantly improved after the experiment ($p < 0.05$). After the experiment, the BMR of the pro group rose to 1835.76 ± 312.52 kcal, which was significantly different from that before the experiment and that of the pla group ($p < 0.05$).

3.2 Physical fitness changes

Changes in agility (10 × 4 fold run) and speed (100 m) qualities of different groups before and after the experiment are shown in Figure 4.

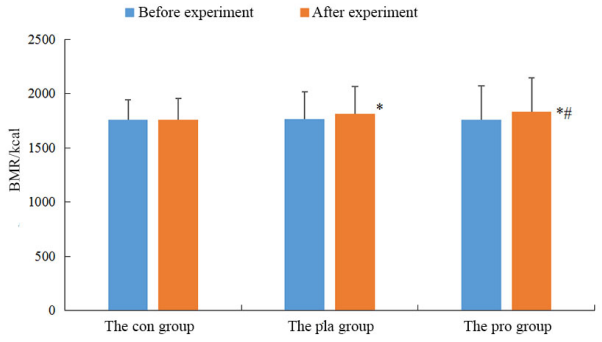

Figure 3. Changes in BMR in different groups before and after the experiment

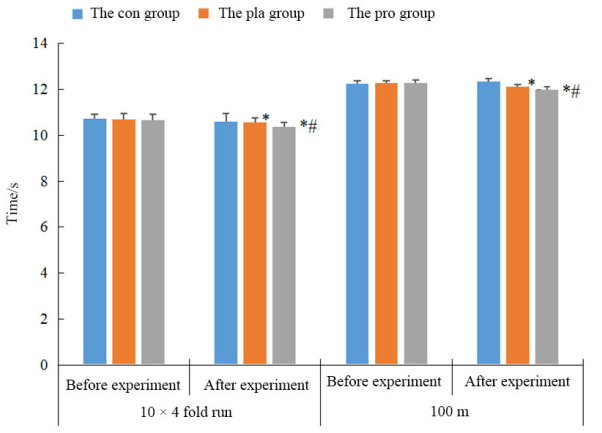

Figure 4. Changes in agility and speed qualities

It was seen from Figure 4 that before the experiment, the agility (10 × 4 fold run) performance of the groups did not show a significant difference ($p > 0.05$); after the experiment, the performance of the con group did not show a significant change ($p > 0.05$ compared with the pre-experiment), the performance of the pla group was 10.56 ± 0.18 s ($p < 0.05$ compared with the pre-experiment), and the performance of the pro group was 10.36 ± 0.19 s ($p < 0.05$ compared with the pre-experiment and the pla group. Before the experiment, the speed (100 m) performance of the three groups did not indicate significant differences; after the experiment, the performance of the con group did not show significant differences ($p > 0.05$ compared with the pre-experiment, the performance of the pla group was 12.11 ± 0.09 s ($p < 0.05$ compared with the pre-experiment), and the performance of the pro group was 11.98 ± 0.14 s ($p < 0.05$ compared to the pre-experiment and the pla group). These results demonstrated that whey protein could enhance agility and speed.

Changes in strength, endurance, and flexibility qualities of different groups before and after the experiment are shown in Table 3.

It was noticed in Table 3 that before the experiment, there was no significant difference in the physical quality between all the groups. The performance of the con group before and after the experiment was all known, and $p > 0.05$ when comparing the pre-experimental performance with the performance after the experiment. After the experiment, the force (standing long jump) performance of the pla group was 2.48 ± 0.03 m ($p < 0.05$ compared with the pre-experiment). After the experiment, the endurance (800 m) performance of the pla group was around 2 minutes and 31 seconds ($p < 0.05$ compared with the pre-experiment), and the performance of the Pro group was around 2 minutes and 29 seconds ($p < 0.05$ compared with the pre-experiment and the pla group). After the experiment, the flexibility (sit and reach) performance of the pla group was 22.31 ± 0.67 cm ($p < 0.05$ compared with the pre-experiment), and the flexibility performance of the pro group was 23.29 ± 0.64 m ($p < 0.05$ compared with the pre-experiment and the pla group). These results indicated that whey protein could improve athletes' qualities in resistance training.

Table 3. Changes in strength, endurance, and flexibility in different groups

		Force/m	Endurance/min·second	Flexibility/cm
The con group	Pre-experiment	2.42±0.01	2.33±0.01	21.77±0.51
	After the experiment	2.43±0.02	2.32±0.02	22.07±0.49
The pla group	Pre-experiment	2.44±0.02	2.33±0.01	22.15±0.52
	After the experiment	2.48±0.03*	2.31±0.01*	22.31±0.67*
The pro group	Pre-experiment	2.42±0.02	2.32±0.01	22.54±0.48
	After the experiment	2.52±0.04*#	2.29±0.01*#	23.29±0.64*#

Discussion

Resistance training is beneficial to improving the muscle strength of the body (11) and stimulating muscle growth (12). Combining whey protein with resistance training can further strengthen the training effect and relieve exercise fatigue. In order to understand the effect of nutritional supplementation on resistance training better, this paper conducted a specific experimental analysis and recorded and sorted the results.

After four weeks of resistance training, the body composition of the pla group showed significant changes, reflected in decreased BMI and BF% and increased BMR. For the pro group that received whey protein in addition to resistance training, athletes' body composition changes were more significant. It was seen from Figures 1 ~ 3 that the BMI, BF%, and BMR of the pro group after the experiment were significantly different from those before the experiment and the pla group ($p < 0.05$). Moreover, after four weeks of resistance training, the physical quality of the pla group was significantly improved, and the performance of multiple indexes was significantly improved ($p < 0.05$ compared with the pre-experiment). In addition to the resistance training, the pro group was also supplemented with whey protein, so the improvement of physical quality was more significant ($p < 0.05$ compared with the pre-experiment and the pla group).

It is concluded from the results that resistance training has a significant effect on consuming body fat and improving metabolic level, which can effectively improve body composition and reduce fat content, thus increasing basal metabolic level, and the combination with whey protein, i.e., whey protein, can further improve athletes' body composition. Resistance training promotes protein synthesis, while whey protein supplementation enhances the effect of resistance training and improves athletes' recovery. During resistance training, muscle fibers may be damaged under the effect of high-intensity exercise, and whey protein supplementation not only facilitates the reconstruction of damaged muscle fibers but also promotes the enrichment of energy reserves, bringing better training results.

Conclusion

This paper studied the effect of whey protein on the physical fitness of athletes in resistance training. Through the comparison and analysis of 60 athletes, it was found that through whey protein, the BMI and BF% significantly decreased, and the BMR significantly improved ($p < 0.05$ compared with the pre-experiment and the athletes without whey protein); the physical quality significantly improved, and the speed and endurance significantly improved, and $p < 0.05$ compared with the pre-experiment and the athletes without whey protein.

The experimental results verify the correctness of the hypothesis. Whey protein significantly affects the physical quality of athletes in resistance training and can improve the effect of resistance training. Nutritional supplementation can be further promoted and applied in actual sports training. However, this paper has some shortcomings, such as the small sample size and the lack of comparison and analysis of different populations. A more scientific and comprehensive exploration of the effects of whey protein supplementation is needed in future work.

Conflicts of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

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