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Article

Cell biological mechanisms of muscle fiber type transformation and athletic performance enhancement by martial arts exercise

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Abstract: Wushu, as a type of exercise nurtured in traditional Chinese culture, not only has profound cultural significance, but also possesses the physiological role of exercise. In order to investigate the effects of wushu exercise on human muscle fiber types and athletic ability, the study was based on the effects of exercise on skeletal muscle, and the cell biological mechanisms of skeletal muscle contraction during wushu exercise were investigated. The experimental subjects were modeled and grouped by designing experiments. The muscle fiber ratio, the ratio of fast and slow muscle fibers of gastrocnemius muscle and the cross-sectional area were collected by polyacrylamide gel electrophoresis, immunofluorescence staining and protein blotting in order to analyze the changes in the muscle fiber types of the subjects before and after the wushu exercise. Then, the effectiveness of martial arts exercise in enhancing athletic ability was investigated by comparing the intergroup and intragroup athletic ability before and after the experiment between the experimental group and the control group. Wushu exercise had an interaction effect on the ratio of fast and slow muscle fibers, the expression of PGC1α4 and PGC1α2/3, the expression of PPARδ, PDK4, and the protein expression of mitochondrial complex, and it did not have an interaction effect on the protein expression of P38MAPK/P38MAPK and P-AMPKα/AMPKα. Before the experiment, the motor ability of the experimental group and the control group was at the same level ($P > 0.05$), and after the experiment, the motor ability of the experimental group was much higher than that of the control group, and the P value of each dimension was less than 0.05. After the wushu experiment, the motor ability of the experimental group was greatly improved, and the P value of each dimension was less than 0.05, while the control group stayed at the same place, and the P value of each dimension was greater than 0.05. Wushu exercise could effectively improve the subject's motor ability.

Keywords: wushu exercise; muscle fiber type; athletic ability; cell biology; independent samples *t*-test

1. Introduction

Muscles are important biological tissues that support the movement of all parts of the body. The motor unit is the smallest functional unit of the muscle and one motor neuron axon controls one motor unit [1,2]. Motor units follow the principle of consistency of action; when a nerve impulse is delivered, all nerve fibers of the motor unit contract almost simultaneously [3,4]. The difference in the number of nerve fibers contained in a motor unit causes a large difference in the function of the muscle in which it is located. Generally, motor units in muscles that require fine manipulation contain fewer fibers, and motor units in muscles that require rough action are relatively large and contain more muscle fibers [5–8]. When the body is subjected to a large load, the structure of its muscle fibers changes accordingly, thus showing different degrees of functional status [9,10]. By effectively assessing and diagnosing the exercise state

of muscles in an objective and scientific way, trainers are able to reasonably adjust the intensity of training and the state of moderate fatigue, which can enable muscles to achieve a better fatigue state, which is conducive to achieving a better effect of exercise training [11–13].

Boxing theory and techniques in Chinese martial arts can be explained in terms of cell biological mechanisms. Taking taijiquan as an example, "loosening" is a subtle aspect of traditional Chinese martial arts, which aims to elongate and relax the muscle fibers so as to enhance the maximum explosive force when striking [14,15]. In taijiquan, it is the loosening of the joints, the loosening of the joints, the loosening of the joints from the tightening of the pulling, stretching and rotating, which brings about the relaxation of the whole body, the lightness of spirit, the multiplication of strength, and the reduction of athletic injuries [16–18]. With the stretching of the muscle fibers, the blood vessels attached to the muscles are also stretched at the same time and do elastic movement, so that the cardiovascular get a real exercise, which is the most precious treasure of martial arts dedicated to human health.

In this paper, in order to investigate the effect of martial arts exercise on human muscle fiber type and exercise capacity, the cell biological mechanism of skeletal muscle contraction in exercise and the effect of exercise on skeletal muscle are analyzed in depth. On the basis of theoretical analysis, the research hypothesis is proposed, the experimental subjects are selected and then the experimental subjects are modeled and grouped, and the test indexes such as the proportion of oxidized type I muscle fibers of gastrocnemius muscle, the proportion of fast and slow muscle fibers of gastrocnemius muscle, and the cross-sectional area of the subjects are collected by polyacrylamide gel electrophoresis, etc., which are used as the basis for the study of the transformation of the muscle fiber types. The muscle fiber type change and muscle fiber transformation related protein expression were studied in depth. Finally, the effect of wushu running on athletic ability enhancement was analyzed by intergroup and intragroup comparisons between the experimental group and the control group.

2. Cell biological mechanisms of skeletal muscle contraction in martial arts exercise

2.1. Martial arts sports

Traditional Chinese culture gave birth to the Chinese Wushu, and with thousands of years of continuous development, a complete system of Wushu culture has been formed today. Wushu is different from other sports in that it carries the culture and spirit of the Chinese nation and embodies the sports ideology of a country and nation. "Virtue" is an important connotation of martial arts culture and martial arts spirit. As the saying goes, "those who practice martial arts first practice virtue", the true meaning of martial arts sports is to cultivate martial arts virtue, martial arts virtues, so martial arts sports training to a certain extent can also be corrected in the human heart, to promote the sportsman to have a correct outlook on the world, outlook on life, values. Therefore, this paper defines Wushu as a martial arts sport program that is adapted to the ever-changing survival needs of human beings and formed on the basis of the distinctive characteristics of the Chinese nation and its long history and culture, which

implies “Wudu” and “Chongdao”.

Wushu exercise can comprehensively improve the physical quality of exercisers, which helps to strengthen body resistance, prevent diseases and improve the quality of life [19]. At the same time, wushu training requires perseverance and long-term commitment, which develops perseverance and patience, and also promotes the development of a healthy lifestyle, such as regular exercise, a balanced diet and good sleeping habits. It should also be emphasized that Wushu emphasizes practicality, teaches exercisers self-protection skills, improves their ability to cope with emergencies, enhances safety awareness, and effectively prevents accidental injuries. To sum up, wushu has a comprehensive and far-reaching value in promoting the health of exercisers, which is not only related to physical health, but also involves the overall development of the psychological, behavioral and social dimensions.

2.2. Effects of exercise on skeletal muscle

It is well known that exercise enhances physical performance and this brings many health benefits. A single bout of exercise changes the expression of molecules in skeletal muscle. Whereas, if the skeletal muscle undergoes regular contractions and the duration and frequency of contractions are ensured, specific signaling mechanisms will take place in the skeletal muscle, adapting it to the demands of physical activity [20–21]. During exercise, the levels of circulating inflammatory markers, growth factors, and adrenergic compounds increase, and exercise induces phenotypic changes in the muscle, including an increase in cross-sectional area, an increase in capillary density, a shift in fiber type, and an enhancement of mitochondrial function. Skeletal muscle anabolic and catabolic pathways are largely influenced by physical exercise, and regular training improves muscle mass and strength by increasing protein synthesis, myogenic fiber number, and fiber cross-sectional area. Exercise increases IGF-1 levels and subsequently induces mTOR activation to increase protein synthesis. In addition, exercise increases myofibrillar protein through activation of satellite cells and decreases muscle fat infiltration. Exercise also inhibits protein degradation, an effect that may be caused by lower levels of oxidative stress after training. Exercise induces autophagy in skeletal muscle, and the intensity of autophagy regulation induced depends on fiber type and training duration and intensity. Aerobic training slows aging-induced muscle loss by reducing muscle growth inhibitor and FoxO, and the reduction of muscle growth inhibitor inhibits atrogene transcription and therefore protein degradation.

Changes in autophagy during exercise were first identified in the 1980s, and increases in the number and size of autophagic vesicles were observed in the liver and skeletal muscle of animals following exercise. In 2011, Grumati et al. showed that autophagy was induced in skeletal muscle during exercise, and that animals deficient in collagen VI (a model of impaired autophagy) were exercise intolerant. In addition, these mice showed a worsening of the dystrophic phenotype during acute and chronic exercise, suggesting that functional autophagy is required in an appropriate response to exercise. Increased expression of autophagy genes as well as increased autophagy proteins after exercise has been demonstrated in humans and rodents, and increased autophagy after exercise has been observed in several metabolism-related organs, such

as skeletal muscle, liver, heart, pancreas, and adipose tissue, and activation of autophagy after exercise has even been observed in the brain.

Skeletal muscle is low in mitochondria under basal conditions, but exercise initiates signaling of compensatory responses, leading to improved mitochondrial biogenesis and organelle function. Exercise also promotes degradation of dysfunctional mitochondria (i.e., mitochondrial autophagy), which accelerates mitochondrial renewal and preserves healthy organelles. As mitochondrial function declines with age, exercise maintains mitochondrial and systemic metabolic health. Many signaling pathways activated by exercise are involved in initiating mitochondrial biogenesis; the most common pathways include an increase in intracellular sarcoplasmic reticulum calcium levels with exercise and changes in adenosine triphosphate (ATP) leading to an increase in adenosine monophosphate (AMP) and activation of AMPK. Earlier studies applied calcium ion carriers to cultured myotubes and found elevated mitochondrial enzyme activity and increased expression of specific genes associated with mitochondrial biosynthesis.

2.3. Cytologic mechanisms of skeletal muscle contraction

Modern physiological studies have suggested the following process of contraction by excitation of the myocyte membrane leading to gliding of the myofilaments.

2.3.1. Excitation-contraction coupling

Firstly, the excitation (action potential) of the myocyte membrane propagates along the myocyte membrane in the form of a local current, which is transmitted along the transverse tubular system of the myocyte into the deeper part of the myocyte, resulting in the excitation of the triple tubules, which increases the permeability of the terminal pools of the longitudinal tubular system to Ca^{2+}, and the release of Ca^{2+} from the terminal pools into the cytoplasm, which results in the instantaneous increase of 100-fold in the cytoplasmic Ca^{2+} concentration (from 10^{-7}M to 10^{-5}M), Ca^{2+} diffuses and binds to troponin in the thin filaments, the spatial conformation of the troponin molecule changes and loses its immobilization, causing the protomyosin in the thin filaments to move away from its obstructing position, thereby exposing the binding site of the cross-bridge on the actin molecule in the thin filaments, causing the cross-bridge to bind to the actin, and triggering the cross-bridge to oscillate.

2.3.2. Cross-bridge oscillations cause thick and thin myofilaments of myotomes to glide over each other

The cross-bridge cycle consists of the following four steps of polymerization:

(1) Binding (into $90°$) of energized myosin cross-bridges on thick myofilaments ($M\times$) to actin (A):

$$A + M \times ADP \times Pi \rightarrow A \times M \times ADP \times i \quad (1)$$

(2) This binding triggers the release of energy stored in myosin, resulting in the generation of an angular motion for each cross-bridge (into $45°$):

$$A \times M \times ADP \times Pi \rightarrow A \times M + ADP + Pi \quad (2)$$

(3) ATP binds to myosin, breaking the bond between actin and myosin and

allowing the cross-bridge to dissociate from actin:

$$A \times M + ATP \rightarrow A + M \times ATP \quad (3)$$

(4) ATP bound to myosin transfers energy to the cross-bridge of myosin through endogenous catabolism, producing an energy-acquiring cross-bridge (into $90°$):

$$M \times ATP \rightarrow M \times ADP \times Pi \quad (4)$$

The above cycle is repeated continuously, resulting in the constant gliding of thick and thin muscle filaments in the myotome, causing the muscle to contract, and the cross-bridge activity shortens the myotome by 1% per cycle.

2.3.3. Diastole of contracted muscles

Stimulation of the muscle is terminated, the myocyte membrane potential returns to its resting potential, and the terminal pool of the longitudinal tubular system becomes less permeable to Ca^{2+}, while the Ca^{2+} pump on the terminal pool is activated, relying on ATP partitioning to pump Ca^{2+} from the cell plasma back into the terminal pool, so that the Ca^{2+} energy in the cell plasma is reduced, leading to dissociation of troponin from Ca^{2+}, and the troponin re-anchors the protomyosin on the above the binding site of the cross-bridge on actin, blocking the binding of the cross-bridge to actin and leading to muscle diastole.

3. Study design

3.1. Research hypotheses

Through the above research review and the previous research of our group, this paper proposes two hypotheses:

(1) Wushu exercise can cause transformation of skeletal muscle fiber types.

(2) Wushu exercise can realize the improvement of athletic ability.

3.2. Subject modeling and grouping

School D was chosen as the experimental site, and the subjects were collected and screened by soliciting experimental volunteers. Finally, 20 male college students aged 18–20 years old were screened as experimental subjects, and the experiment was conducted under the preliminary assurance that the subjects' body weight, body fat, and exercise and fitness experience (basically non-exercise or no exercise habit) were basically the same. The subjects will be randomly assigned into experimental group (EG) and control group (CG), 10 people in each group, the experimental group subjects will receive twice a week martial arts exercise training, the control group will maintain the original exercise habits.

3.3. Test indicators and methods

3.3.1. Basic indicators

Proportion of oxidized type I muscle fibers, proportion of fast and slow muscle fibers and cross-sectional area of gastrocnemius muscle.

3.3.2. Polyacrylamide gel electrophoresis

The percentage content of major histocompatibility complex (MHC) isoforms in

the gastrocnemius muscle of the subjects was determined. The protein concentration of the homogenized supernatant was determined according to the BCA kit, and separating and concentrating gels were prepared by taking 20 μg of each group of proteins, adding the same volume of buffer, and denaturing them for 3–6 min in a boiling water bath at 100 °C. The gels were electrophoresed at 4 °C and a constant pressure of 70 V for 38 h. After electrophoresis, the gel was stained in Kaomas blue staining solution at 37 °C for 1 h. The color was removed from the destaining solution at the end until the blue background of the gel faded and the protein bands were clear. After the gel was decolorized, the gray values and percentages of each MHC isoform were calculated using the Tanon Gel Image Acquisition System.

3.3.3. Immunofluorescence staining

Immunofluorescence staining of the subject gastrocnemius muscle was performed as follows: after the tissue was cut into sections on routinely deparaffinized hydrated paraffin, the sections were thermally repaired with citric acid antigenic repair agent in a water bath at 98 °C with a pH of 6 for 30 min. After the repair was completed, the sections were allowed to cool, washed three times with polybutylene succinate (PBS) for 1 min each time, and then immunohistochemical circles were drawn around the tissues with a special pen, then goat serum was dropped in, and the tissues were sealed for 20 min at room temperature. The goat serum on the tissue was shaken off, and then mixed with 100ul of primary antibody working solution, and incubated at 37 °C for 1 h, after which it was washed with PBS 3 times for 1 min each time, and after the washing was completed, immunofluorescent secondary antibody working solution (1:500) was added dropwise to the tissue, and the incubation was continued for 45 min at 37 °C in an environment protected from light, and these procedures were in accordance with the MHCI and MHCII antibody concentration Instructions. After incubation, the sections were washed three times using PBS for a total of 2 min each time. Finally, the sections were removed, the liquid around the dried tissues was added dropwise with 100 uL of prepared DAPI (4',6-diamidino-2-phenylindole) working solution, waited for 5 min, rinsed the sections with DDH2O 3 times for 2 min each time, sealed the sections with anti-quencher, and examined the sections under a fluorescence microscope in a light-protected environment. The stained sections were subjected to image acquisition and calculation of the percentage of fast and slow muscle fiber area by selecting meaningful fields of view under a Lycra microscope, and the muscle fibers showed green fluorescence.

3.3.4. Protein Blots

The protein expression levels of PPARδ and PGC-1α were detected by Western blot technique as follows:

(1) Protein extraction of skeletal muscle tissue. Skeletal muscle tissue lysates were extracted with protease inhibitor containing EDTA (100×) and enhanced RIPA lysate, flounder muscle was lifted and placed in EP tubes to break up the samples by ultrasonication, and placed on ice for 30 min and then centrifuged at 13,000 r/min for 5 min at 4 °C, and the extracted supernatant was frozen and deposited in a −20 °C refrigerator.

(2) Measure protein concentration. The BCA concentration test method was used to measure the protein concentration of the supernatant of each group, and the standard

curve was plotted to derive the primary function of concentration and absorbance (the closer the R^2 is to 1 the more accurate it is), and the absorbance value was substituted into the primary function to derive the specific concentration value of each group of proteins, and finally the volume of samples in each group was calculated.

(3) Gel preparation and electrophoresis. Configure the separation gel (10%) and the concentrated gel (4%) according to the composition table on the kit manual. After successful gel making, pull out the comb and pour in the electrophoresis solution for protein up-sampling, the concentrated gel was electrophoresed with 85V for 10–15 min, and the separated gel was run with 120V until the bottom end of the gel was stopped.

(4) Membrane transfer. According to the actual number of detected proteins cut the corresponding PDVF membrane in advance and place it in methanol for soaking, put the sponge and filter paper into the membrane transfer solution for soaking, and perform the membrane transfer after the end of electrophoresis, put two layers of sponge-two layers of filter paper-gel-two layers of filter paper-two layers of sponge in order on the plastic clip, and then clip it up to carry out the membrane transfer on the ice for 1–1.5 h, and set the current of the membrane transfer to 250 mA.

(5) Confinement and primary antibody incubation. The protein was closed with a sealer containing 0.05% Tween-20 and incubated for 2 h on a shaking bed. The primary antibody was diluted according to the ratio of the desired antibody, and after completion of the closure, the PDVF film was loaded into the prepared antibody and incubated overnight at 4 °C in a freezer.

(6) Secondary antibody and developing exposure. 4 °C freezer took out the strip cassette to recover at room temperature for 10 min, after which the film was washed with prepared TBST four times for 8 min each time. Take the primary antibody and secondary antibody dilution solution to dilute the secondary antibody proportionally. After the secondary antibody was diluted, the membrane and the secondary antibody (corresponding to the primary antibody species source) were allowed to fully bind on a shaker for about 2 h (incubation). Finally, TBST was added to the PVDF membrane and washed 4 times for 8 min each time, and the liquid was poured off after each wash to leave the membrane behind. Ultrasensitive ECL chemiluminescent solution (Ultra Signal, tetrazolium cypress) was added dropwise to 80 mL each of Liquid A and Liquid B in a dimly lit hut, mixed, and then developed, after which the exposure was imaged with the VisionWorks system.

(7) Data analysis. The protein bands analyzed by Image J software were analyzed for relative quantification according to the formula.

4. Empirical analysis

4.1. Analysis of muscle fiber type transition

In this subsection, a regular aerobic exercise group (AG) is introduced to compare with the experimental (martial arts exercise group) and control (no exercise group) groups set up in the previous section.

Before comparing the exercise ability of the experimental group and the control group by using the independent sample *t* test method, it is necessary to conduct a normal distribution test on the measured data before and after the samples. The test

results showed that the measured data of the experimental group and the control group were all subject to Gaussian normal distribution, and the independent sample *T*-test method could be used for follow-up analysis in the follow-up study.

4.1.1. Changes in muscle fiber types

Before and after the experiment, the gastrocnemius fiber data of the subjects in each group were collected by immunofluorescence staining of the gastrocnemius muscle for comparison, and the changes in the fast and slow muscle fiber types of the gastrocnemius muscle of the subjects in each group were shown in **Figure 1**, with **Figure 1a** showing the proportion of the fast and slow muscles, and **Figure 1b** showing the average area of the fast and slow muscle fibers.

As shown in **Figure 1**, compared with the subjects in the control group, the proportion of slow muscle fibers of the gastrocnemius muscle in the aerobic exercise group was significantly increased ($P < 0.05$), and the proportion of slow muscle fibers of the gastrocnemius muscle in the experimental group was significantly decreased ($P < 0.01$); the change in the proportion of fast muscle fibers was opposite to the change in the proportion of slow muscle fibers. Compared with the control group, there was no significant change in the area of fast and slow muscle fibers of the gastrocnemius muscle of the subjects in the aerobic exercise group ($P > 0.05$), and there was a significant decrease in the area of fast ($P < 0.05$) and slow ($P < 0.01$) muscle fibers in the experimental group. Both fast ($P < 0.05$) and slow ($P < 0.01$) muscle fiber areas in the experimental group showed a significant decrease compared to the aerobic exercise group. By ANOVA, martial arts exercise had an interaction effect ($P < 0.01$) on the fast and slow muscle fiber ratio.

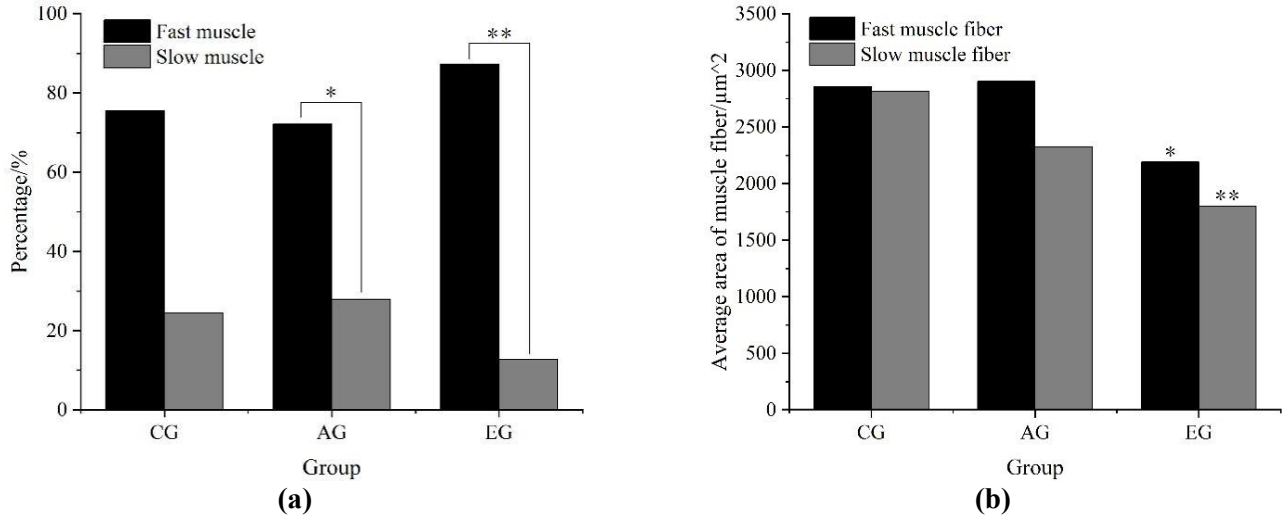

Figure 1. Fast, slow muscle type change of three groups: **(a)** Fast and slow muscle percentage; **(b)** Average area of fast and slow muscle fiber.

4.1.2. Expression of proteins related to muscle fiber transformation

Before and after the experiment, polyacrylamide gel electrophoresis and protein blotting were used to obtain the protein expression data in the fibrous transformation of subjects' gastrocnemius muscle, and the gastrocnemius muscle protein data of subjects from each group were compared, and the changes in the protein expression of

the different isoforms of the subjects' gastrocnemius muscle P-P38MAPK, and P-AMPKα in each group are shown in **Figure 2**. As can be seen in **Figure 2**, the protein expression of PP38MAPK/P38MAPK ($P < 0.01$) and P-AMPKα/AMPKα ($P < 0.05$) in gastrocnemius muscle of the subjects in the aerobic exercise group were significantly increased compared with the subjects in the control group, and there was no significant change in the protein expression of P-P38MAPK/P38MAPK in the experimental group, and the P-AMPKα/AMPKα protein expression were all significantly increased ($P < 0.05$). By analysis, martial arts exercise did not have an interaction effect on the protein expression of P38MAPK/P38MAPK and P-AMPKα/AMPKα ($P > 0.05$).

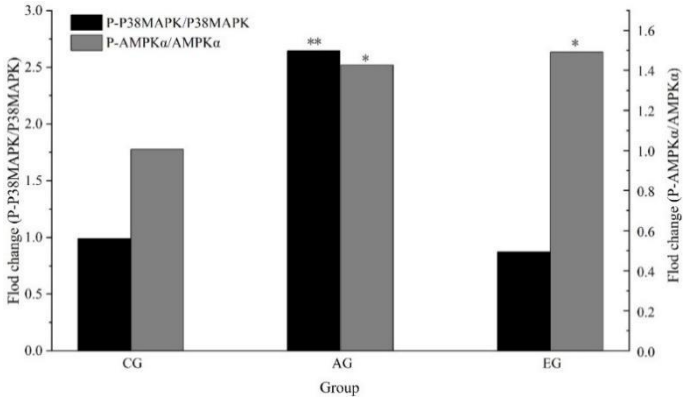

Figure 2. Changes in the expression of P38MAPK, P-AMPKα different subtypes of three groups.

Changes in protein expression of different isoforms of PGC1α in gastrocnemius muscle of subjects in each group are shown in **Figure 3**. As can be seen from **Figure 3**, compared with the subjects in the control group, the protein expression of PGC1α1 in the gastrocnemius muscle of the subjects in the aerobic exercise group was significantly increased ($P < 0.05$), and there was no significant change in the protein expression of PGC1α2/3 and PGC1α4 ($P > 0.05$), and the PGC1α1 ($P < 0.01$) and PGC1α2/3 were significantly increased ($P < 0.05$) in the experimental group, and the the expression of PGC1α4 was significantly decreased ($P < 0.01$). By analysis, martial arts exercise had an interactive effect on the expression of PGC1α4 and PGC1α2/3 ($P < 0.05$).

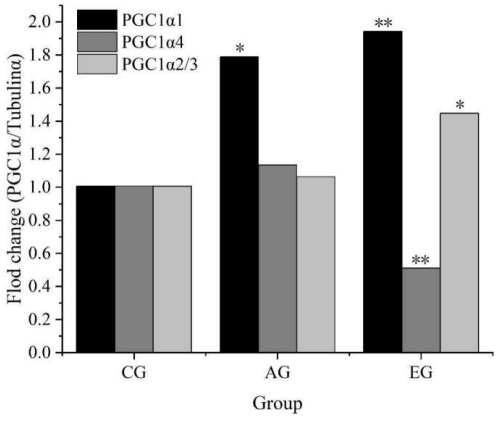

Figure 3. Changes in the expression of PGC1α different subtypes of three groups.

Changes in protein expression of PPARδ, MEF2C, PDK4, and MSTN in gastrocnemius muscle of subjects in each group are shown in **Figure 4**. As seen in **Figure 4**, compared with the control group, there was no significant change in MSTN of gastrocnemius muscle of the subjects in the aerobic exercise group ($P > 0.05$), the protein expression of MEF2C and PDK4 was significantly increased ($P < 0.05$), the protein expression of PPARδ was significantly increased ($P < 0.01$), and there was no significant change in the expression of all proteins in the experimental group ($P > 0.05$). By ANOVA, the expression of PPARδ and PDK4 in martial arts exercise had an interaction effect ($P < 0.01$).

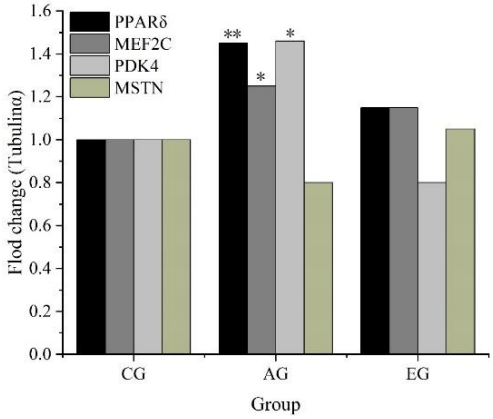

Figure 4. PPARδ, MEF2C, PDK4, MSTN protein expression changes of three groups.

The mitochondrial respiratory chain complex protein expression in the gastrocnemius muscle of the subjects in each group is shown in **Figure 5**. Observation of **Figure 5** reveals that compared with the control group, the mitochondrial complexes I, III, IV and V of the subjects' gastrocnemius muscle in the aerobic exercise group were significantly increased ($P < 0.01$), and there was no significant change in the protein expression of the mitochondrial complexes I, III, and IV in the experimental group ($P > 0.05$), and there was a significant increase in the protein expression of complex V ($P < 0.05$). By ANOVA, martial arts exercise had an interaction effect on the protein expression of mitochondrial complexes ($P < 0.01$).

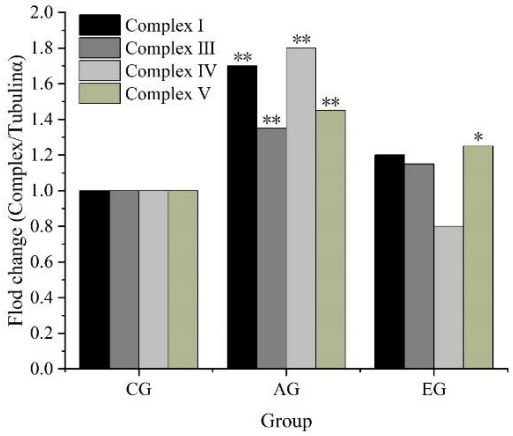

Figure 5. Protein expression of muscle mitochondrial respiratory chain complex of 3 groups.

4.2. Analysis of the improvement of athletic capacity

The athletic ability of the experimental group and the control group before and after the experiment was tested by dimensions, including 100 m sprint, 1500 m long-distance running, push-ups, deep squats, and pull-ups. The scores were assigned and calculated from the test data of each dimension, and the effects of martial arts exercise on the subjects' athletic ability were explored through the between-group and within-group comparisons of the scores of the two groups.

4.2.1. Comparison between groups

The independent samples *t*-test was conducted on the exercise ability of the two groups before the experiment, and the results are shown in **Table 1**. Observation of **Table 1** shows that before the beginning of the experiment, the difference between the mean values of the experimental group and the control group in the five items of 100 m sprint, 1500 m long-distance running, push-ups, deep squats and pull-ups is not more than 1 point, and the *P* value is greater than 0.05, which indicates that there is no significant difference in the athletic ability of the two groups, and that the experimental group and the control group's athletic ability is at the same level. The experimental group and the control group are at the same level. They meet the requirements of the experiment and can continue to carry out the next experiment.

Table 1. Independent sample *T* test of pre-test athletic ability.

Athletic ability	Group	M ± SD	*T*	*P*
100m	Experimental group	10.56 ± 3.05	−0.354	0.613
	Control group	10.63 ± 2.85		
1500m	Experimental group	8.95 ± 2.69	0.694	0.584
	Control group	8.53 ± 2.84		
Push-ups	Experimental group	9.12 ± 2.78	0.218	0.489
	Control group	9.06 ± 2.94		
Deep squat	Experimental group	11.32 ± 3.42	1.021	0.581
	Control group	10.98 ± 3.18		
Lead up	Experimental group	8.62 ± 2.34	−0.321	0.649
	Control group	8.74 ± 2.47		

The athletic ability data of the experimental group and the control group after the experiment were again subjected to independent samples *t*-test, and the test results are shown in **Table 2**. As can be seen from the data in **Table 2**, after the experimental group experienced the wushu exercise experiment, the scores of 100 m sprint, 1500 m long-distance running, push-ups, deep squats, and pull-ups opened up a gap with the control group, and the experimental group scored 17.86, 15.62, 16.09, 18.64, and 15.98 points on the five items, while the control group's scores were 10.69, 8.47, 9.68, 11.26, and 8.59 points, and the difference between the two groups was 7.17, 7.15, 6.41, 7.38, and 7.39 points, respectively, and the *P*-value of all dimensions of the two groups was 0.000 ($P < 0.05$), which indicated that the athletic ability of the experimental group and the control group had produced significant differences.

Table 2. Independent sample *T* test of post-test athletic ability.

Athletic ability	Group	M ± SD	*T*	*P*
100 m	Experimental group	17.86 ± 5.42	5.642	0.000
	Control group	10.69 ± 3.02		
1500 m	Experimental group	15.62 ± 4.87	5.384	0.000
	Control group	8.47 ± 2.53		
Push-ups	Experimental group	16.09 ± 4.95	4.628	0.000
	Control group	9.68 ± 3.08		
Deep squat	Experimental group	18.64 ± 5.72	5.068	0.000
	Control group	11.26 ± 4.39		
Lead up	Experimental group	15.98 ± 5.26	4.916	0.000
	Control group	8.59 ± 2.27		

4.2.2 Within-group comparisons.

Further comparison of the experimental group's athletic ability before and after the experiment, the results of the comparison of the experimental group's pre- and post-test athletic ability are shown in **Table 3**. The data comparison in **Table 3** shows that the experimental group's scores of 100 m sprint, 1500 m long-distance running, push-ups, deep squats, and pull-ups after the wushu exercise experiment improved by 7.30, 7.67, 6.97, 7.32, and 7.36 points respectively compared with the pre-experiment, and the *P*-value of each dimension is less than 0.05, and the pre- and post-tested athletic ability shows a significant gap.

Table 3. Comparison of pre-test and post-test athletic ability of experimental group.

Athletic ability	Pre/post-test	M ± SD	*T*	*P*
100 m	Pre-test	10.56 ± 3.05	−5.152	0.000
	Post-test	17.86 ± 5.42		
1500 m	Pre-test	8.95 ± 2.69	−5.384	0.000
	Post-test	15.62 ± 4.87		
Push-ups	Pre-test	9.12 ± 2.78	−4.895	0.000
	Post-test	16.09 ± 4.95		
Deep squat	Pre-test	11.32 ± 3.42	−4.692	0.000
	Post-test	18.64 ± 5.72		
Lead up	Pre-test	8.62 ± 2.34	−5.267	0.000
	Post-test	15.98 ± 5.26		

The results of the pre- and post-test motor ability comparison of the control group are shown in **Table 4**. Comparison of the motor ability scores of the control group before and after the experiment revealed that the difference between the pre- and post-test scores of the control group in the five dimensions of motor ability was no more than 1 point, and the *p*-values were all greater than 0.05, which did not show a significant difference and maintained the same level as before the experiment.

Table 4. Comparison of pre-test and post-test athletic ability of control group.

Athletic ability	Pre/post-test	M ± SD	*T*	*P*
100m	Pre-test	10.63 ± 2.85	−0.185	0.458
	Post-test	10.69 ± 3.02		
1500m	Pre-test	8.53 ± 2.84	0.251	0.655
	Post-test	8.47 ± 2.53		
Push-ups	Pre-test	9.06 ± 2.94	−0.542	0.548
	Post-test	9.68 ± 3.08		
Deep squat	Pre-test	10.98 ± 3.18	−0.478	0.495
	Post-test	11.26 ± 4.39		
Lead up	Pre-test	8.74 ± 2.47	0.428	0.543
	Post-test	8.59 ± 2.27		

5. Conclusion

The article dissects the cell biological mechanism of human skeletal muscle in wushu exercise and the effect of exercise on skeletal muscle, and designs relevant experiments to deeply study the role of wushu exercise on the transformation of muscle fiber type and the enhancement of athletic ability of athletes.

(1) Wushu exercise had an interaction effect on the ratio of fast and slow muscle fibers, the expression of PPARδ, PDK4, and the protein expression of mitochondrial complex, with the P value less than 0.01. Wushu exercise had an interaction effect on the expression of PGC1α4 and PGC1α2/3, ($P < 0.05$). Martial arts exercise did not have an interaction effect on the protein expression of P38MAPK/P38MAPK and P-AMPKα/AMPKα ($P > 0.05$).

(2) The motor ability of the experimental and control groups before the experiment was the same, and the P-value was greater than 0.05. After the experiment, the experimental group was higher than the control group by 7.17, 7.15, 6.41, 7.38, 7.39 points in five items respectively, and the P-value of all the dimensions was less than 0.05, which produced a significant difference in the motor ability of the two groups. Post-experimental motor ability of the experimental group was 7.30, 7.67, 6.97, 7.32, and 7.36 points higher than the pre-experimental one, with p-values less than 0.05 for all dimensions, whereas the control group's post-experimental motor ability remained at the same level as the pre-experimental one. Wushu exercise has a significant positive effect on enhancing the subjects' motor ability.

The research period of this study is short, which can only explain the change of muscle fiber type and movement ability of adolescents during short-term martial arts exercise intervention, but can not reveal the change of muscle fiber type of adolescents under the rule of long-term martial arts exercise. In addition, the selection of exercise mode is single, and only the influence of martial arts on it is studied. In the future, a combination of various sports can be selected to explore and compare its influence on the transformation of muscle fiber types and athletic ability of teenagers.

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