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Observation of the Change of Skeletal Muscle Transverse Tension Transmission Caused by Wushu by Transmission Electronics Microscope

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Abstract: Objective: In order to explore how to change the transverse tension transmission of skeletal muscle, a small injury model of skeletal muscle caused by Wushu was established. Methods: 36 healthy Wushu training athletes were randomly assigned to the experimental group (EG, n = 27) and the control group (CG, n = 9). The CG group ate normally and did not do any kind of sports; the EG group let martial arts athletes do sports training, especially for skeletal muscle training. After 30 minutes of training, the skin and muscle tissues of EG group were extracted at 1 h, 48 h and 120 h, respectively, and were used to measure the changes of transverse tension transmission in vivo, and to observe the ultrastructures of skeletal muscle, the structure of extracellular matrix between adjacent cells, and the changes of the junction sites between the small branches of collagen fiber network of myofascicular membrane and myointima and myomembrane. Results: Compared with the control group, the changes of the total transverse tension transfer of EG and CG in the experimental group were larger at 1H, 24h and 48h, showing the trend of first rising, then falling and then rising again; the micro damage of skeletal muscle, collagen area and the number of PJPs in the experimental group were significantly increased and showed the trend of first rising and then falling, which was statistically significant ($P < 0.05$). Conclusion: The micro damage of skeletal muscle caused by martial arts increased, the number of muscle bundle membrane links increased, at the same time, the ability of transverse tension transmission of skeletal muscle increased.

1. Introduction

Wushu has a history of thousands of years in our country. It has been integrated into all walks of life and become one of the core components of Chinese culture [1]. With the establishment of new

China, Wushu has developed into a system. As one of the excellent traditional national sports in China, it has made great achievements in various sports events. After thousands of years of historical screening and tempering, the Chinese martial arts that have been handed down to this day are extensive and profound, with a long history. It contains not only a rigorous and systematic attack and exercise system, but also a series of philosophical thoughts. In addition, many studies have proved that martial arts also have health and practical values, such as strengthening the body, prolonging life and defending against enemies. Therefore, it is in the community the position at the meeting is getting higher and higher. Only through continuous inheritance, innovation and development can martial arts last forever. Since the founding of the People’s Republic of China, especially after the reform and opening up, the eastern and Western cultures have been constantly colliding and exchanging. On this basis, Wushu conforms to the trend and development of the times, gradually extends the classification of Competitive Wushu, and gradually becomes the mainstream. To some extent, it can be said that competitive Wushu is the peak of Modern Wushu. Its development and evolution tend to be high, difficult, beautiful and new, with routine and Sanda as the core.

With the development of Competitive Wushu routines and the continuous improvement of the level of Competitive Wushu athletes, a number of high-level athletes have emerged in China, and the prospect of Competitive Wushu routines is very broad. But at present, the biggest problem we are facing is the injury problem caused by the increase of the difficulty of action in the competitive Wushu routine. In the latest version of "Wushu Routine Competition Rules", the scoring difficulty of Wushu routine is more and more difficult, the competition is more and more fierce, and the incidence of sports injury in training and competition is also higher and higher. After the occurrence of sports injury, it will destroy the system of sports training, affect the training effect and competition results, and bring great physiological and psychological pressure to the athletes. Therefore, how to avoid or reduce the occurrence of sports injuries of Competitive Wushu routine athletes is an urgent problem to be solved in the development of Wushu routine sports. This study attempts to use multi-disciplinary theories and methods, including sports training [2], biomechanics [3], sports anatomy [4], etc., to investigate and study the characteristics of sports injuries of Wushu routine athletes from multiple perspectives and levels, and to provide corresponding preventive countermeasures. It can provide reference for the teaching and training of Wushu routine and the prevention of sports injury in the competition. It can also provide some scientific basis for realizing the scientific training of Wushu routine, tapping the potential of athletes, prolonging the sports life, and promoting the further improvement of Wushu routine level in China.

Zhang Xuelin et al. discussed the mechanism of overuse [5] injury in detail and thought that the overuse injury was caused by the imbalance of skeletal muscle tensegrity complex. Passerieux et al. Studied the structure and function of the extracellular matrix of skeletal muscle, and found that the main line of skeletal muscle is the myofascial membrane, one part is connected with the myointima through the myofascial membrane connecting disc, the other part is connected with the muscular bond through the honeycomb tube, presenting the skeletal muscle as a tensive whole. Ramaswamy et al. Studied the tension transmission mechanism of skeletal muscle ECM, and found that the tension produced by contraction of skeletal muscle sarcomere was transmitted to muscle bond through two ways: longitudinal transmission between sarcomere and sarcomere to muscle bond; transverse transmission to intramuscular intima through rib body on sarcomere, and then to muscle bond through myofascial membrane and extramuscular membrane. The second pathway is called transverse tension transfer pathway, in which dystrophin plays a key role. When there is damage to the sarcomere, the tension cannot be transmitted longitudinally through the sarcomere. At this time, the ability of transverse tension transmission pathway will be increased to protect the injured sarcomere from excessive traction and maintain the functional stability of the skeletal muscle.

Integrin located in the pleura also plays a role in transverse tension transmission, but also has a role in mechanical signal transduction, which can regulate the conversion of mechanical signals and chemical signals inside and outside the muscular membrane, and plays a huge role in stabilizing the structure and function of sarcomere and sarcomere. The magnitude of ECM shear force between adjacent cells determines the sensitivity of dystrophin and mechanical signaling pathway, and the shear force is directly proportional to the compliance of sarcolemma. The greater the shear force, the stronger the compliance of sarcolemma, and the stronger the sensitivity of transverse tension transmission and mechanical signaling pathway. When the damage of over centrifugation training continues to accumulate, the tension of PJPs domain is overloaded, and fibroblasts are over activated to produce type I collagen. This is to increase the ability of muscle cells to resist the damage, but it leads to the weakening of the sensitivity of transverse tension transmission and mechanical signal transmission pathway, which makes the damage of skeletal muscle more serious. Based on the above research results, the review part will elaborate from the following three aspects: first, to explain the terms in the paper; second, to measure the change of transverse tension transfer in vivo and observe the ultrastructure of skeletal muscle with transmission electron microscope; third, the structure of extracellular matrix between adjacent cells of bone and the small branches of collagen fiber network of muscle bundle membrane, the inner membrane and the inner membrane The change of junction site of sarcolemma. In order to explore the changes of skeletal muscle transverse tension transmission caused by Wushu.

2. The Relationship Between Transverse Tension Transmission and Skeletal Muscle Function

2.1 Perspective Electron Microscope

Transmission electron microscope [6] has been widely used in many related fields, such as materials, physics, chemistry and biology. The working principle is that by applying a certain bias voltage and using the electron gun as the light source, the electron will be excited between the cathode and the anode of the electron gun, and the electron will be accelerated through the accelerating tube, so that it has a higher incident speed. Because the electron energy is very high and the wavelength is very short, for example, for a $200\ \mathrm{kV}$ transmission electron microscope, the wavelength of the electron will reach 6.8×10^{-2} input, so the electron optical resolution can reach the angstroms or even sub angstroms by using electronic imaging, and the distance between atoms is usually about 0.1A. At this time, the electron beam emitted by the electron gun will pass through the sample in the form of parallel electron beam after the convergence correction of the condenser, so as to obtain the crystal structure and other information of the sample. The traditional electron microscope will convert the electronic signal after penetrating the sample into the photoelectric signal, so that the digital display system CCD can directly image the sample. In the proper projection direction, we can record the shape, diffraction structure, atomic image and other information of the sample, and realize the characterization and analysis of the structure and performance of the material. In addition, the whole TEM system needs a high energy electron beam, so the TEM should work in the ultra-high vacuum of $10^{-8} - 10^{-13}$ atm to prevent the ionization and breakdown of high energy electrons and gas molecules.

In this experiment, we used FEI TECNAI G2 T20 and Titan^{TM} G2 60-300 transmission electron microscopy to analyze the micro area morphology and structure of the samples. Tecnai G2 T20 is produced by Fei company in the United States. The accessories include the Gatanlk×lk CCD camera and EDAX x X-ray spectrometer. The electron gun adopts LaB$_6$, and the magnification range is $25 \times \sim 1030\mathrm{K} \times$. It is a large angle tilt function transmission electron microscope, which can carry out $\mathrm{A}: \pm 300, \mathrm{B}: \pm 70$. Large angle tilt is a powerful tool for cell structure analysis.

Titan^{TM} G2 60-300 is an analysis TEM / stem transmission electron microscope with focusing lens spherical aberration correction and super-x spectrum as its outstanding functional features. The acceleration voltage is 300 kV, the point resolution is 0.2nm, and the TEM magnification range is $50 - 1\,000000 \times$, The equipment combines EDX energy spectrum analysis and electron energy loss spectrum of Infinium, which can cover the range of chemical analysis from light elements to heavy elements.

2.2 The Root of the Concept of "Tension"

The term "tension" was put forward [7], which was a professional term in physics at the earliest time. It refers to the pull force of equal size and opposite direction perpendicular to the section on both sides of any section inside the object when the object is stretched and deformed. The word "tension" is also a common verb in physics. For example, tension exists in objects such as taut ropes, rubber bands, full bows and arrows or compressed springs. The analysis of tension from physics has the following characteristics: first, it is produced in static or relatively static things; second, it has interactive forces, such as the forces produced by the two directions of front and back, left and right, up and down; but later, the word "tension" was transplanted and extended by other fields. In addition to the application of tension in physics, this concept was first put forward by Alan dent, a representative of British and American new criticism, who was created to sum up the common characteristics of excellent poetry. It is a theoretical term for new critics to explain the structural characteristics of text semantics and an important aesthetic standard to measure "good poetry". In 1937, in the book on the tension of poetry, Allen Turner believed that the meaning of poetry refers to its tension, that is, the organic whole of all the outspread and inner package that can be found in poetry." At present, it is believed that "where there are opposing and interrelated forces, impulses or meaningful places, there is tension." In essence, tension is a kind of dynamic balance formed by the interdependence and restriction of two or more forces. These two forces are the tension of the subject's aesthetic tension and the object's aesthetic attribute, but they are not to achieve a grim balance, but to achieve agreement and harmony.

The concept of "movement" includes three kinds: physical, visual and auditory; it is both physical and sound, both subject and object, sculpture and architecture. From the sociological point of view, "the tension of movement" is like the compression and abstraction of a huge construction site, which condenses the intensity, noise and danger of tense construction. Therefore, it can also be regarded as a metaphor of contemporary China in rapid development and change.

The concept of "transverse tension transfer" was first put forward by street et al. Through studying the tension transfer between muscle fibers and sarcolemma of frog Semitendinosus, they found that the tension of sarcomere can be transferred both vertically and horizontally. Later, Huijing et al. Found that there are two pathways involved in the transfer of the tension generated by the contraction of skeletal muscle sarcomere to the muscular Bond: one is through the longitudinal transfer between sarcomere and sarcomere to the muscular bond; the other is through the transverse transfer of the rib body on the sarcomere to the sarcomere, and then through the sarcomere and fascicular membrane to the muscular bond. The latter is called transverse tension transfer. Some studies show that the longitudinal tension transfer accounts for only 20-30% of the tension produced by sarcomere contraction, and the transverse tension transfer accounts for more than 70%, which plays an important role in maintaining the functional stability of skeletal muscle. Zhang et al. Also confirmed this point of view. It is believed that since most muscle fibers in vertebrate skeletal muscle do not directly connect to the two ends of the muscle bond, but terminate on the muscle bundle membrane, the tension generated by muscle fibers must be transmitted to the muscle bond through extracellular matrix laterally.

2.3 Transverse Tension Transmission Mechanism

The concept of "transverse tension transfer" was first put forward by street et al. Through studying the tension transfer between muscle fibers and sarcolemma of frog hemibond muscle, they found that the tension of sarcomere can be transferred both vertically and horizontally. Later, Huijing et al. Found that there are two pathways involved in the transfer of the tension generated by the contraction of skeletal muscle sarcomere to the muscular Bond: one is through the longitudinal transfer between sarcomere and sarcomere to the muscular bond; the other is through the transverse transfer of the rib body on the sarcomere to the sarcomere, and then through the sarcomere and fascicular membrane to the muscular bond. The latter is called transverse tension transfer. Some studies show that the longitudinal tension transfer accounts for only 20-30% of the tension produced by sarcomere contraction, and the transverse tension transfer accounts for more than 70%, which plays an important role in maintaining the functional stability of skeletal muscle. Zhang et al. Also confirmed this point of view. It is believed that since most muscle fibers in vertebrate skeletal muscle do not directly connect to the two ends of the muscle bond, but terminate on the muscle bundle membrane, the tension generated by muscle fibers must be transmitted to the muscle bond through extracellular matrix laterally.

The structure of transverse tension transfer is based on rib. Skeletal muscle is mainly composed of cells and extracellular matrix. Intercostals, which are located on the sarcolemma of skeletal muscle and connected with Z disk, are the bridge between intracellular myofibrils and extracellular matrix. They were first found by Pardo et al. The costal body mainly consists of two protein complexes, i.e. DGC complex, integrin related trampoline protein and rudimentary spot protein complex. DGC is mainly composed of dystrophin, dystrophin glycoprotein complex and sarcan protein complex. F-actin and laminin are connected in the cell and outside the cell. Integrins in skeletal muscle are mainly in the form of α7β1integrin. α7β1integrin is linked to DGC by myolongin. Integrin is mainly connected with actin through alpha actin, adhesion spot protein and naked protein in the cell, and interacts with extracellular matrix through adhesion layer protein and fibronectin outside the cell. As a transmembrane protein, the pleura, on the one hand, combines with extracellular matrix to form a network of cells, cytoskeleton and extracellular matrix, and mediates cell signal transmission; on the other hand, it combines with intramuscular sarcomere to transfer the tension produced by sarcomere contraction to extracellular matrix, which plays a key role in the function of stabilizing cell structure and transverse tension transfer. Ramaswamy et al. Found that skeletal muscle sarcomere tension can be transmitted to extracellular matrix through DGC complex, and finally to muscle bond. Changes in the number or type of DGC complex will affect the ability of skeletal muscle transverse tension transmission, which indicates that DGC complex is of great significance to skeletal muscle transverse tension transmission. In addition, it was found that there is a significant difference between there was no significant difference in the protein content of beta dystrophin, indicating that the loss of dystrophin alone was enough to cause the decrease of transverse tension transmission. Welser et al. Studied the changes of skeletal muscle in human skin tissue after being knocked out by alpha7integrin, and found that the membrane integrity of human skin tissue was destroyed in a large area four weeks later, and the muscle was atrophic and necrotic, which indicated that DGC and integrin were jointly responsible for maintaining the function of skeletal muscle and transverse tension transmission.

2.4 The Relationship between the Structure of Collagen Fiber and the Change of Transverse Tension Transmission in Skeletal Muscle

Extracellular matrix is the basic element of the mechanical structure of skeletal muscle. When the structure of extracellular matrix and its interaction with muscle fibers change, the mechanical properties of the whole muscle will be changed. A large number of studies have shown that the sarcomere tension of skeletal muscle is transmitted to the intima laterally, and then to the muscular bond through the intima and myofascicular membrane, indicating that extracellular matrix is of great significance to the process of transverse tension transmission of skeletal muscle. Extracellular matrix hardness provides important information for sensing cell changes and responding to mechanical environment. The hardness of extracellular matrix affects the structure and function of rib body and sarcomere and is involved in the regulation of cell contraction and the maintenance of calcium homeostasis. Bove et al. Found that the proliferation and deposition of extracellular matrix collagen fibers, and then fibrosis, will lead to the increase of extracellular matrix hardness, affect the mechanical transmission of extracellular matrix, and reduce the overall function of skeletal muscle.

Passerieux et al. Studied the structure and function of skeletal muscle ECM [8], and found that skeletal muscle is mainly composed of myofascial membrane, on the one hand, PJPs is used to connect with myointima, on the other hand, honeycomb tube is used to connect with muscle bond to form a tensegrity, which is of great significance to the process of skeletal muscle tensegrity transmission, especially transverse tensegrity transmission. PJPs, as the junction site between the myointima and the myofascicular membrane, attaches the small branches of collagen network of each myofascicular membrane to the surface of the myointima, which may participate in the transverse tension transmission of skeletal muscle. In addition to the structural and mechanical properties of muscle fibers, the ability of transverse tension transmission is also affected by extracellular matrix. Further study found that the efficiency of skeletal muscle transverse tension transfer depends on the shear force between two adjacent muscle fibers, that is, the compliance of the inner muscle, the greater the compliance, the greater the ability of skeletal muscle transverse tension transfer. In addition, it was found that integrin was connected with collagen in extracellular matrix, and continuous mechanical stimulation changed the structure of extracellular matrix through integrin, resulting in the proliferation and fibrosis of collagen fibers in extracellular matrix. Integrin, as a two-way signal hub of mechanical transduction, affected the ability of transverse tension transmission of skeletal muscle, suggesting that the structure and transverse tension transmission of collagen fibers in skeletal muscle changed Guan. Zhang et al. Studied the effect of aging on the transverse tension transmission of skeletal muscle and found that the ability of transverse tension transmission of old human skin tissue was significantly lower than that of young human skin tissue. They believed that aging led to the increase of extracellular matrix, especially the thickness of myofascicular membrane. Further study found that the rib body is the main cause of the change of skeletal muscle transverse tension transmission ability. As the intercellular matrix is connected with the rib, the increase of the thickness of the extracellular matrix results in the change of the spatial density and mechanical properties of the rib, and the decrease of the ability of transverse tension transfer. In addition, it was found that the increase of type I collagen concentration resulted in the increase of myofascicular membrane thickness, which hindered the repair ability of skeletal muscle injury. Myofascicular membrane, as the hinge of skeletal muscle tension transfer, suggests that the structural change of extracellular matrix of skeletal muscle may affect the functional stability of skeletal muscle through the change of transverse tension transfer.

3. Experimental Materials and Methods

3.1 Subjects and Conditions

36 healthy martial arts athletes, SPF level, weight (165 ± 23.6 kg), martial arts athletes carry out

the usual training for one week, during which they do not carry out the training that may cause slight damage to the skeletal muscle, after one week, they take the training for the skeletal muscle, and the intensity is moderate.

3.2 Personnel Grouping and Experiment Scheme

Sports conditions: carry out martial arts training for skeletal muscle (see Table 1).

Experimental group: 36 healthy Wushu athletes were randomly assigned to experimental group (EG, n = 27) and control group (CG, n = 9).

Table 1. Personnel grouping

Group	1h	48h	120h
Experience group (EG)		9	
Control group (CG)	9	9	9

3.3 Specimen Collection and Processing

One hour, 48 hours and 120 hours after Wushu training. The skin and muscle tissues of athletes were used to measure the transverse tension transmission of skeletal muscle in vivo (n = 9). After weighing the athletes, 2% Pentobarbital Sodium ($65\mathrm{mg}\cdot\mathrm{kg}^{-1}$) was injected into the legs for anesthesia. The skin and muscle tissues of the left legs of the athletes were fixed in the ice bath with 3% glutaraldehyde (0.1mol phosphate buffer dilution, pH 7.4) for transmission electron microscope observation. The skin muscle tissue of the right leg of each athlete was used to measure the transverse tension transmission in vivo. The skin tissues of left and right legs were separated, EDL was exposed, free EDL was obtained with glass minute needle, and redundant tissues around EDL were removed as much as possible with ophthalmic scissors. During the experiment, the scalpel was not used to avoid scratches. From the proximal leg of EDL to the distal leg of EDL, the skin on the tissue surface was gently pulled by tweezers, and the distal leg of EDL was separated and exposed by ophthalmic scissors and glass split needle. During the separation, the connective tissue between the blood vessel and the leg of EDL was avoided as much as possible. The surgical line is attached to the proximal end of EDL, and the proximal surgical line is connected to the force measuring sensor to measure the transverse tension transmission. After the measurement of EDL transverse tension transfer, 5 ml blood was taken from the abdominal aorta of human skin tissue. After standing at 4 ℃ for 1 h, the serum was separated by centrifugation at$3000\mathrm{r}\cdot\mathrm{nim}^{-1}$. The serum was stored at 80 ℃ after repacking.

In this experiment, we use EDL to measure the transverse tension transmission of Wushu Athletes' skeletal muscle, which is based on the special physiological structure of EDL muscle bond. The distal end of EDL is divided into four muscle bond heads, which end at the phalanges of the 2nd to 5th toes in turn. The proximal end of EDL is closely connected with the bond membrane, while the distal end is relatively independent of the bond membrane. The results show that the distal bond and bond membrane of EDL are relatively separated, and the obvious changes of muscle leg tension can be observed after key cutting and myotomy.

3.4 Measurement of Skeletal Muscle Transverse Tension Transfer

Refer to Zhang et al. [9] for the experimental method of transverse tension transfer test of skeletal muscle, but the experiment is slightly modified. The order of muscle leg cutting is carried out in order, and the specific method is as follows:

(1) After weighing, pentobarbital sodium maintained the deep anesthesia state of Wushu Athletes'

legs on the constant temperature platform. ($65\mathrm{mg} \cdot \mathrm{kg}^{-1}$) intraperitoneal injection anesthesia. Pentobarbital sodium was added during the experiment to prevent response to tactile stimulation. After anesthesia, the leg skin tissue was extracted and fixed on a 37 ℃ constant temperature table.

(2) Skin tissue was separated, EDL was exposed, distal muscle bond was separated carefully with glass minute needle, and connective tissue between blood vessel and muscle leg was avoided as much as possible.

(3) The surgical line was attached to the proximal end of EDL, and the muscle bond of the proximal end of EDL was cut. Connect the surgical line to the force measuring sensor so that the muscle is on the same level with the surgical line and the connection part of the force measuring sensor. During the experiment, Ringer's solution was added to maintain the excitability of muscle and skin tissue.

(4) Use the stimulation electrode for stimulation. After the stimulation, the biological function experimental system automatically detects and collects the experimental data. Under the 6 V stimulation intensity, change the stimulation frequency, stimulate the muscle to produce the maximum tetanic contraction tension, record the intensity and frequency of the contraction stimulation at this time, measure the maximum tetanic contraction tension of EDL, and record it asF_0.

(5) Remove the EDL proximal surgical line from the load cell. First, the head V of the muscle bond was cut off, and the proximal surgical line was reconnected to the force sensor to give the same electrical stimulation to the muscle. At this time, the longitudinal force transmission channel of the muscle key head V is cut off, and the measured tension is recorded as $\grave{\mathrm{F}}_2$. The contraction interval was 5 minutes. Remove the EDL proximal surgical line from the load cell, and cut off the ECM between the head IV and V of the leg to separate the leg IV and V. At this time, the longitudinal and transverse force transmission of the head V of the muscle leg is cut off, and the tension produced by the head V of the EDL muscle key at this time is recorded as F2. For each tension measurement, three groups of contraction tests were carried out, each contraction interval was 5 minutes, and the average value was calculated. As mentioned above, key amputation and myotomy were performed on the head IV and III of the muscle key-respectively, which were recorded as F3 ', F3, F4. And F4. During the experiment, any distal key amputation should be as close to the corresponding muscle abdomen as possible, excluding the influence of mechanical / mechanical interaction between adjacent muscle keys.

(6) If there is a difference between F_0 and F_2, it is recorded as $\mathrm{F}_0 - F_2$, at this time, the generation of tension comes from the head V of the muscle bond; the difference between F_0 and $\grave{\mathrm{F}}_2$ is recorded as $\mathrm{F}_0 - \grave{\mathrm{F}}_2$, and the generation of force comes from the head V of the muscle bond, that is, the longitudinal tension transmission; the difference between $\grave{\mathrm{F}}_2$ and F_2 is recorded as $\grave{\mathrm{F}}_2 - \mathrm{F}_2$, and the generation of force comes from the head V of the muscle bond, and the ECM transverse transmission between the head IV and V of the muscle bond, that is, the transverse tension transmission.

(7) In order to reduce the geometric difference between EDLs, it is necessary to standardize the maximum tension of each group of measurements, F_0, Namely $\alpha = F_i/F_0\,(\mathrm{i} = 2{,}3{,}4), \grave{\alpha}_2 = \grave{F}_i/F_0\,(\mathrm{i} = 2{,}3{,}4)$.The function of each muscle bond head in the whole tension is recorded as θ_i,Namely $\theta_i = (F_{i-1} - F_i)/F_0\,(i = 2{,}3{,}4, F_1 = F_0)$.The force produced by the head of each muscle key $F_{i-1} - F_i$(i=2, 3, 4, $F_1 = F_0$),It is divided into two parts, i.e. the transmission of transverse force $\grave{F}_i - F_i$ and the transmission of longitudinal force $F_{i-1} - \grave{F}_i$, The respective ratio is calculated as the lateral force $\beta_i = (\grave{F}_i - F_i)/((F_{i-1} - F_i)$(i=2,3,4, $F_1 = F_0$), Formula of total transverse tension of human skin $\sum_{i=2}^{4} \grave{\alpha}_i - \alpha_i$ Calculated.

3.5 Transmission Electron Microscope Observation of Skeletal Muscle Ultrastructure

The ultrastructural changes of skeletal muscle were observed by transmission electron microscopy (TEM), and the ultrastructural analysis and test center was used to make sections, sections and transmission electron microscopy [10]. The fixed extensor digitorum longus muscle was cut into $1\ mm^3$, fixed for 2 hours before 4 ℃ with 3% glutaraldehyde, then rinsed for 4 times with 0.1 mol / L phosphoric acid buffer (pH 7.2), each time for 10 minutes. After that, then double distilled water was used to wash it for 3 times, each time for 10 minutes, and then 30%, 50%, 70%, 90% ethanol was used successively for dehydration, each time for 10 minutes, and finally 100% ethanol was used for 2 times, each time for ingenious minutes. After that, 100% acetone was replaced for three times, each time for 10 minutes, and then the embedding agent (resin) was incubated at 1:1 room temperature for 1h, then the embedding agent (resin) was incubated at 1:2 room temperature for 3h, and then the pure embedding agent was soaked at room temperature for 2h. After that, the tissue block was embedded again. The tissue block was picked into the baked plate with a toothpick and placed in the center of the plate, then the embedding agent was added. The embedded plate was put into a 35% incubator for polymerization for 12 hours, then moved to a 45 ℃ incubator for polymerization for 12 hours, polymerized in a 60 ℃ incubator for 48 hours to repair the block, and made a semi thin section, stained with azure methylene blue, and observed under the light microscope. Leicauc6i microtome was used to cut ultra-thin sections, copper mesh was used to remove the sections, and uranyl acetate was used to dye the sections. JEM-1400 electron microscope was used to observe the ultrastructural changes of skeletal muscle, including the structure of extracellular matrix between adjacent cells and the change of PJPs between the small branches of collagen fiber network of myofasciculus membrane and myointima and myomembrane. Image J (NIH) software was used to quantify the transmission electron microscope images.

4. Results and Discussions

4.1 Changes of Extensor Digitorum Longus Tension α_i and $\alpha_i^{\cdot}$ Caused by Martial Arts Intervention

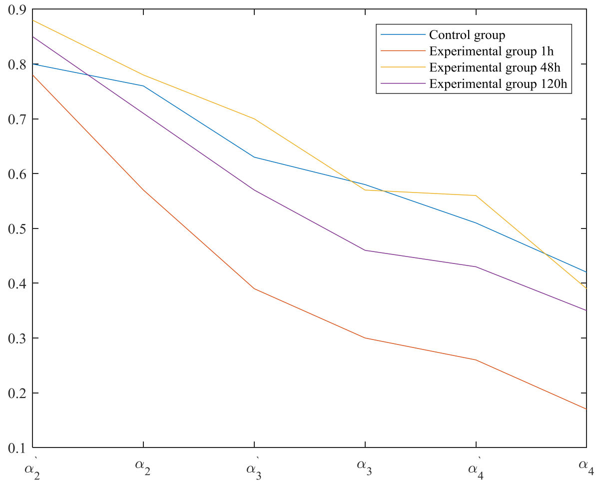

Figure 1. Changes of extensor digitorum longus tension α_i *and* $\alpha_i^{\cdot}$ *caused by martial arts intervention*

After statistical analysis (see Figure 1), alpha 3 and α 3 · in the control group decreased but had no statistical significance ($P > 0.05$); in the experimental group, α_i and $\alpha_{\dot{i}}$ were significantly lower than each other at 1 h, 48 h and 120 h ($P < 0.01$); in the control group, α_i and $\alpha_{\dot{i}}$ were significantly lower ($P < 0.05$).

4.2 Changes of Transverse Force β_4 of Skeletal Muscle Key III after Martial Arts Intervention

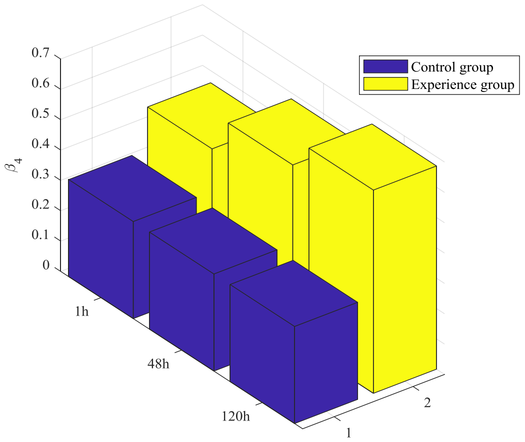

Figure 2. The change of the transverse force β_4 of the skeletal muscle joint III after the intervention of martial arts

According to the statistical analysis (see Figure 2), the change of muscle bond III transverse force β_4 was: compared with the control group, the experimental group increased for 1h, but there was no significant difference, 48 h, 120 h was very significant increase ($P < 0.01$); compared with the different periods in the group, the E group increased for 48h, 120h, but there was no significant difference.

4.3 Changes of Total Transverse Tension Transmission of Skeletal Muscle by Martial Arts Intervention

Table2. The effect of martial arts intervention on the transfer of total transverse tension of skeletal muscle

Group	1h	48h	120h
Control group		0.963	
Experience group	2.526	2.461	2.406

Calculation formula of total transverse tension: $\sum_{i=2}^{4}\alpha_{\grave{i}} - \alpha_i$.

According to the calculation formula of transverse tension, the change of total transverse tension transmission of skeletal muscle is as follows (see Table 2): compared with the control group, the experimental group increased by 184%, 127%, 158% respectively in 1H, 48h, 120h; compared with 1H, the experimental group decreased by 4%, 2%, 120h and 48h respectively in each phase, and increased by 3%,48 hE $<$ 120 h E $<$ 1 hE.

4.4 The Change of Collagen Area of Extensor Muscle in the Intervention of Martial Arts

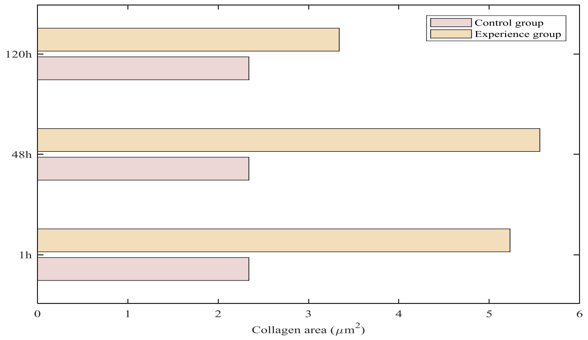

Figure 3. The changes of collagen area of extensor muscle in the intervention of martial arts

According to the statistical analysis (see Figure 3), the changes of collagen area of extensor digitorum longus muscle were as follows: compared with the control group, the collagen area of experimental group increased significantly at 1 h, 48 h ($P < 0.001$), and 120 h ($P < 0.05$); compared with different periods in the group, the collagen area of experimental group reached the peak at 48 h, 120 h and 1 h, Compared with 48 hours, the difference was very significant ($P < 0.01$) and extremely significant ($P < 0.001$).

4.5 The Changes of PJPs in Skeletal Muscle after Martial Arts Intervention

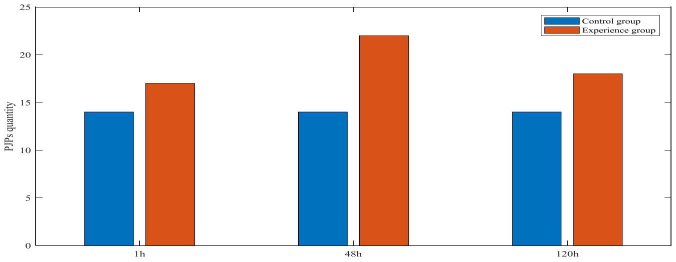

Figure 4. The change of pjps quantity of extensor digitorum longus by Wushu simulation training intervention

According to the statistical analysis (see Figure 4), the number of PJPs in skeletal muscle in the experimental group increased significantly at 1 h, 120 h ($P < 0.01$) and 48 h ($P < 0.01$) compared with that in the control group; the number of PJPs in the experimental group peaked at 48 h and increased significantly at 1 h ($P < 0.01$) compared with that in the control group, Compared with 48 hours, 120 hours decreased significantly ($P < 0.05$). In the experimental group, the number of PJPs in human skeletal muscle increased first and then decreased, and the peak value appeared in 48 hours. The results showed that Wushu significantly increased the number of PJPs in human skeletal muscle.

5. Conclusion

A large number of studies have shown that martial arts cause changes in the ultrastructure of skeletal muscle, resulting in muscle strength decline, DOMS and other symptoms of micro injury peak in 24 hours to 48 hours. In this experiment, EDL was used to measure skeletal muscle transverse tension transmission caused by martial arts. The research basis was based on the special physiological structure of EDL muscle bond. The distal end of EDL is divided into four muscle bond heads, which end at the phalanges of the 2nd to 5th toes in turn, while the proximal muscle bond and bond membrane are closely connected with the distal leg and leg membrane, which are relatively independent. This study found that martial arts caused a significant increase in the total transverse tension transmission and the content of skeletal muscle α7β1integrin. In addition, integrin plays an important role in maintaining skeletal muscle structure, functional integrity and transverse tension transmission by mediating two-way signal molecular pathways inside and outside the muscle membrane. Therefore, the increase of total transverse tension transmission after martial arts may be related to the increase of integrin content on the muscle membrane. It can also be concluded that the increase of skeletal muscle transverse tension transmission is helpful to stabilize the sarcomere structure and maintain muscle strength and promote the stable maintenance of skeletal muscle function. Whether it is nonintervention or martial arts exercise intervention, the transverse tension transmission of skeletal muscle is related to the degree of injury. That is to say, the greater the degree of injury, the greater the ability of transverse tension transmission. It is suggested that the transverse tension transmission of skeletal muscle can be used as an index for skeletal muscle to adapt to exercise intensity, and also as an index for sports injury rehabilitation, which is of great theoretical significance and practical work Use.

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