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Molecular & Cellular Biomechanics 2024, 21(2), 159.
https://doi.org/10.62617/mcb.v21i2.159

Article

Research on motion control strategy of athlete muscle training based on blockchain and visual image analysis

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CITATION

Zhou X. Research on motion control strategy of athlete muscle training based on blockchain and visual image analysis. Molecular & Cellular Biomechanics. 2024; 21(2): 159. https://doi.org/10.62617/mcb.v21i2.159

ARTICLE INFO

Received: 24 May 2024
Accepted: 11 July 2024
Available online: 5 November 2024

Abstract: Muscle training is an important part of athletes' physical training. Its goal is to keep athletes in high intensity and improve sports performance in physical training. With the continuous improvement of the level of competitive sports, there are still many problems in the training of competitive athletes. The research on the control strategies of some technical movements in the process of athletes' muscle development would help to improve the efficiency and effect of athletes' training. By analyzing and quant description of muscle movement control process based on blockchain and visual image processing technology, the muscle movement control rule is discussed and then a complete movement database is constructed. At the same time, combined with the sports experiment method and cognitive behavioral theory, this paper analyzed the exercise load, exercise time allocation, muscle training time allocation methods and the corresponding muscle training strategy selection methods under different muscle states, providing theoretical basis for athletes to conduct muscle strength training scientifically and efficiently. This paper first analyzed the importance of athletes' muscle training action control. After that, the research was mainly carried out from the following two aspects. The first is to analyze the motion control strategy of athlete muscle training based on blockchain and visual image, and summarize its characteristics. The second is to use electronic imaging technology to analyze the data related to posture control in athletes' muscle training, and explore the characteristics and changes of muscle posture. At last, this paper put forward relevant algorithms about visual images and conducted experimental research on athletes' physical indicators and performance under different muscle training according to the research in this paper. It was concluded that the score ratio of athletes' performance after muscle training action control was 7.39% higher than that of general muscle training. Therefore, it is very important to strengthen the research of movement technology in muscle training and analyze the influence of some training control strategies on the development of athletes' muscles in training.

Keywords: muscle training; action control; electronic imaging; image information processing; vision system

1. Introduction

The human body is a complex sports system, involving many muscles. Therefore, it is of great significance for athletes to study the sports ability, muscle strength and endurance of the human body. As the most important structure in the body, the sports system is the whole body in which various joints and muscles cooperate with each other to carry out various sports [1]. As the largest and most important muscle in the body, skeletal muscle not only plays a role in supporting the body and maintaining joint stability, but also is an organ in the body where various sports organs and tissues (including muscles, tendons, ligaments, etc.) cooperate with each other to carry out various specific sports behaviors [2,3]. These muscles move in different positions to jointly complete various movements corresponding to strength and speed: during speed training, they can be used to balance the body's center of gravity; when doing stretching exercises, it can maintain joint stability and reduce unnecessary energy consumption; when doing various strength exercises, it is mainly used to support the upper and lower limbs (below the knee joint). In the past decades, the training methods of human muscle strength training have made great progress, but there are still some problems: the training methods of human muscle strength training are only applicable to a single sports skill or ability; human muscles need to overcome many obstacles in the process of strength enhancement; in addition, human muscles need to constantly strengthen and adapt during the process of strength enhancement. Therefore, in order to improve the athletes' action control ability, and make them obtain better fitness effect and sports ability, it is necessary to optimize and improve the existing athletes' training methods.

In recent years, research achievements related to athlete' muscle training have emerged constantly. Blazevich Anthony J has proved through experiments that high load and heavy load are the best exercise mode when the strength level is low and high [4]. Pires Telma Filipa found that the way of less resistance or less weight bearing should be selected for muscle training during strength training [5]. Hartz Charlini S has proved through experiments that when the strength level is low, low resistance or heavy load should be selected for exercise [6]. Pareja-Blanco Fernando can realize motion control and training effect prediction by using EMG (electromyogram) signal and biofeedback technology [7]. Suchomel Timothy J found that there was a significant positive correlation between the range and speed of joint flexion and extension when the athletes squatted and bent their upper body backward, and between the angle and range of knee joint when they bent their upper body forward [8]. The above research results have important guiding significance for reasonable and effective training of athletes.

With the development of computer technology, the research results related to image processing and analysis of athletes' muscle training action control continue to emerge. Sheng Zhiyu analyzed and studied the athletes' muscle training action control through modern scientific and technological means and methods [9]. Alonso-Fernandez D analyzed the characteristics of human muscle movement and the law of muscle strength change from the perspective of muscle strength. He also believed that the range of joint flexion and extension and the frequency of upper body forward flexion during upper body backward flexion of deep squatting were the key factors affecting the angle from squatting to knee joint and the change of flexor force value, as well as the angle and range from upper body backward flexion of deep squatting to knee joint [10]. Bruschetta Daniele used visual image features to systematically analyze the biomechanical characteristics of athletes' skeletal muscles under different training levels by using static biomechanical models in view of the impact of high-intensity interval training on the morphological structure of the musculoskeletal system of competitive athletes [11]. Pedrosa Gustavo F, based on the research of human biomechanics model, found that the main factor of the strength of the upper back flexor muscle in deep squatting is the combined effect of the strength of the extensor muscle group and the contractile muscle group, in which the synergistic effect of the strength of the extensor muscle group and the contractile muscle group has a significant impact on the range of joint activity in deep squatting [12]. Franchi Martino V's research showed that the range of motion of the joint during upper body flexion in squatting is positively related to the bending angle of the joint during upper body forward flexion, while there is no significant relationship between the angle from joint forward flexion to knee joint and the bending angle of the joint during upper body forward extension [13]. Using image processing technology to analyze the control of muscle training of athletes has a positive impact on the improvement of athletes' sports effect and efficiency.

To sum up, muscle training is one of the important contents for athletes to carry out physical training, and its purpose is to enable athletes to maintain a higher level of strength and better sports performance in physical training. Muscle injury seriously affects the physical health and sports ability of athletes, even endangers life. Therefore, it is very important to strengthen the research of movement techniques in muscle training and analyze the influence of some control strategies of technical movements in the development of athletes' muscles. This paper discusses the motion control strategy of athlete muscle training based on blockchain and visual image and carries out research from many aspects. Through experiments, the motion control effect of athlete muscle training is obtained, which provides some reference value for the research of muscle training movement control in the future.

2. Importance of athletes' muscle training action control

In competitive sports, the body shape of athletes is indispensable, and the body shape depends on the effect of muscle training. Many sports experts believe that the human body is a whole, which can transmit its power to other athletes. Once problems occur, the entire sports chain would be completely paralyzed. Therefore, it needs a whole strength to make its various parts perfectly coordinated, especially in the body and lower limbs [14]. Generally speaking, the core muscle of the body is a cylinder, which gathers the strength of the whole body, while the spine and pelvis need the middle muscle group to support them [15]. The central muscle of exercise and movement is the central muscle, which is the center of the whole sports chain. It can enhance the strength of the central muscle group, so as to improve the ability of the upper and lower limbs' sports chain. The movement process is divided into two parts: the first is the stage from the static state to the start of the movement; the second is the whole movement process from the start to the completion (as shown in **Figure 1**). The importance of muscle training for athletes is as follows:

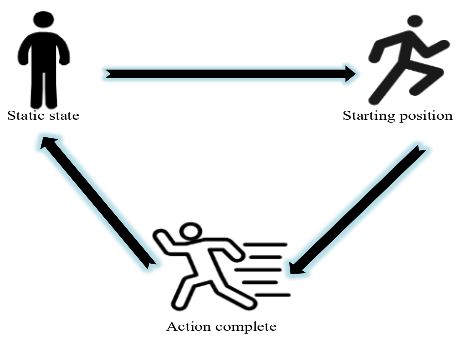

Figure 1. Movement process.

(1) Avoiding injury to athletes

In sports training, if people can't control the action effectively, it would lead to sports injury. Injuries of ankle joint, knee, psoas, thigh and other parts are common [16]. Because many sports events would constantly adjust their center of gravity, it requires coordination between various parts of the body, as well as coordination of muscles in various parts. To stabilize the trunk, people need to rely on the deep small muscle group, which is very useful for positioning the limbs, because the body must bear a certain amount of pressure during exercise, and the role of the core force is to reduce the burden on the body.

(2) Faster growing muscles

Athletes in muscle training, would lead to slow muscle growth, and even some muscle atrophy. Many athletes feel uncomfortable, laborious, not smooth and uncoordinated when doing movements, which means that no reasonable muscle training is carried out, and unreasonable muscle training would make joints worse. Reasonable muscle training action control can make the body develop better [17–19].

(3) Improving the stability of athletes

In sports, all movements are based on the stability of movements [20]. The core muscles of the human body are like this. The stability of many kinds of muscles is achieved by the core muscles. Without sufficient strength, the core muscles cannot guarantee the balance and stability of the body. A strong core muscle can improve the balance of athletes. Many actions should have a good sense of balance. Therefore, correct and reasonable exercise control can effectively improve the physical stability of athletes.

(4) Improving muscle agility and coordination

With the increase of core strength, the reaction speed of the body would be greatly reduced, and the flexibility and coordination of muscles would also be increased, thus improving the adaptability of athletes in sports training [21]. In many sports, athletes would complete a movement when they lose balance. For example, in a football match, when they lose balance, they must maintain enough center of gravity to ensure their body's stability and accuracy in midair. To change the posture of the body, strong core muscles are needed to adjust, and the function of stabilizing muscles is deeper muscle groups. Through the cooperation of both sides, the athletes' movements are accurate and complete smooth technical movements.

In a word, athletes' muscle training action control can avoid injuries, make muscles grow faster, improve athletes' stability, and improve muscle agility and coordination (as shown in **Figure 2**). Improving the control ability of athletes' muscle training actions based on visual image analysis can improve the standardization and scientificity of athletes' muscle training actions, and then make athletes maintain a higher level of strength and better sports performance in physical exercise.

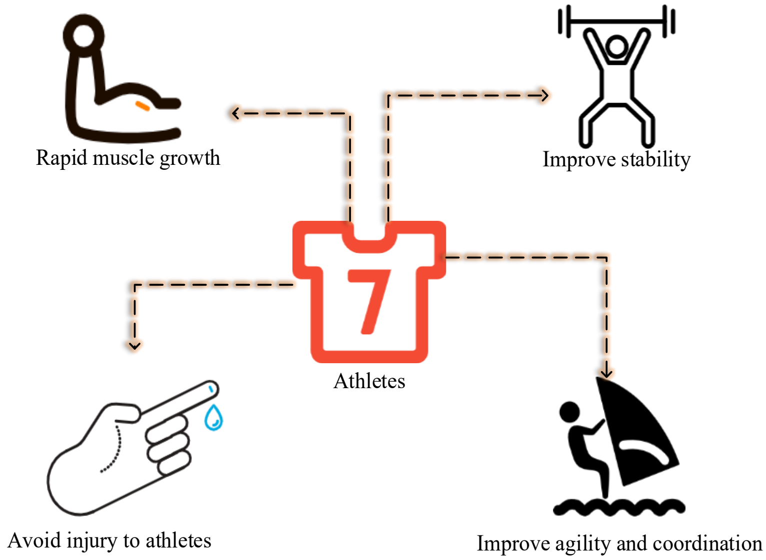

Figure 2. Advantages of athletes' muscle training action control.

3. Training action control method based on image processing

(1) Visual image processing and analysis

A. Visual image processing

First, the athletes are photographed in the right position, and then the image data of the athletes are imported into the computer vision system. Then, the static and dynamic image data of athletes are extracted in the computer vision system (as shown in **Figure 3**). Before feature extraction of EMG, the image is normalized. In order to get the best result, the skeletal muscle image of athletes is converted into discrete data points. Because skeletal muscle is the most important muscle tissue of human body, the image conversion process of skeletal muscle is particularly important. The normalized data is imported into the computer vision system. Then the motion attitude is analyzed: firstly, the acceleration and angular velocity of the motion attitude are calculated, and then these data are converted into digital sequences. Then the corresponding eigenvalues are obtained by the least square method, which are the posture characteristics of the athletes' muscle training actions. Finally, according to the feature values and the characteristics of athletes' muscle training actions, appropriate classifiers are selected for classification and recognition.

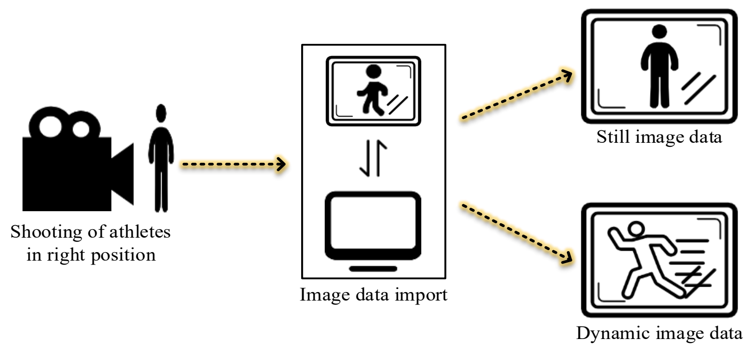

Figure 3. Visual image processing steps.

B. Feature extraction and analysis

In the obtained data, the athletes' training actions are taken as samples, and image preprocessing technology is adopted. The image preprocessing process includes: denoising: removing noise and other non-target information, and retaining important details of the image; removing redundancy: to avoid redundant information in the image.

Adjusting color saturation: the contrast and saturation are adjusted for best results; adjusting the non-uniformity of color distribution: the image contrast is adjusted to make it uniform, so as to obtain better results; smoothing and de-noising the image: the noise through smooth filtering and threshold segmentation are removed to obtain better results; increasing brightness and contrast: the contrast by changing the gray level is adjusted to make it more bright, and the saturation by gray scale shrinkage is adjusted to make it more saturated; image color balance processing after filtering: in order to achieve the effect of color stability and no distortion, the saturation in the original data needs to be properly adjusted; defogging: the bright and dark areas of the image in a contrast way are removed to make them clearer.

C. Parameter processing

Firstly, the training image is thresholded based on the maximum and minimum method to obtain effective motion parameters; secondly, the maximum and minimum method is used to extract the motion parameters, and some methods are used to construct three different local threshold functions; finally, the threshold value of the segmented data is modified to extract the motion parameters. Mean value method: the number of objects within the target range are calculated according to the position of the training image in the gray domain and the mean value of the local area. Smoothing elimination algorithm: the redundant noise is eliminated by median filtering on all pixels of the image, and the unnecessary details in the excessive gray scale domain are eliminated by smoothing processing technology; finally, two methods, mean filtering and threshold correction, are used to correct the distribution of the number of objects. Denoising result: the de-noising result is determined according to the change of distance between the center point of pixel points in different regions and adjacent pixel points in gray scale domain; for the noise difference between different regions, median filtering is used for denoising to obtain the denoised data. Median filtering algorithm: combining the mean filtering and denoising results, the corresponding noise distribution range in each gray domain is divided into several intervals; then, all images in each interval are denoised using the maximum minimum method, gradient, median and mean methods respectively. Edge detection: the edge of the data is extracted by median filtering and the edge contour is calculated; then the area inside the contour line is merged with the surrounding area. Threshold correction: the threshold is set according to the motion parameters after image segmentation to achieve effective control of actions after training.

(2) Application of electronic imaging technology

Muscle is the "mechanical part" of human body, and its structure and shape have an important impact on sports performance. The muscle tissue of each part of the human body is very different in shape, structure and function.

The muscle movement and stress of athletes during exercise are shown in **Figure 4**.

Figure 4. Muscle movement and stress analysis diagram.

The different colors in **Figure 4** represent different muscle groups. Colored arrows and curves indicate the path of movement and the direction of power transfer when an athlete performs a certain action, such as a jump or a start. The direction and length of the arrows show the direction and magnitude of the force, and the curves show the dynamic process of the force transfer. The diagram at the bottom left shows the force distribution and moment diagram in relation to the stress on the athlete's muscles. The force distribution diagram shows the change of muscle stress during exercise, and the moment diagram reflects the stress state of the joint. The small figure on the right shows the athlete's posture during various movements, including jumps, starts, and stretches.

The pectoralis major and deltoid muscles play the main role in the athlete's arm swing. The pectoralis major muscles are responsible for the extension and adduction of the arm, while the deltoids assist in lifting the arm.

The biceps are mainly responsible for the flexion of the arm, while the triceps is responsible for the extension of the arm. During a start or arm swing, these two sets of muscles work in concert.

During the athlete's squat and jump movements, the rectus abdominis and external obliques act as the stabilizing core, providing power transmission and maintaining body balance. Latissimus dorsi plays a major role in arm pull-downs and back extensions, helping athletes maintain upper body stability during exercise.

The quadriceps (front of thigh) is responsible for knee extension, while the hamstring (back of thigh) is responsible for knee flexion. These two groups of muscles are the main source of power during jumps and starts. The gluteus maximus plays a key role in hip extension, providing strong momentum for athletes' jumps and sprints.

The gastrocnemius and soleus muscles, located in the lower leg, are responsible for flexion of the ankle joint and help push the body forward or up during jumping and running.

At present, electronic imaging technology can conduct real-time detection and analysis of human motion control at different levels. Electronic imaging technology is mainly applied to the study of muscle movement morphology. With the continuous development of electronic imaging technology, sports biomechanics has also been developed rapidly. It has been widely used in the research of skeletal muscle and myocardial microstructure. The electromyography recording technology under the electronic imaging technology is a technology that uses high-frequency weak electric field to conduct real-time detection and recording of muscle electrical signals. It mainly detects, records and analyzes the low-frequency components of human muscle electrical signals, studies the rules of neural electrical activities, and reveals the relationship between muscle contraction and the formation and control of motor skills. High resolution multiphoton ionization imaging technology can directly observe the cell structure and growth process without disturbing the cell components by using charged particles such as X-rays and Y-rays, to study the internal structure and morphology of muscle fibers and understand the dynamic changes of cells during exercise. At the same time, the indexes of muscle contraction function, muscle fiber contraction speed, strength and movement completion are analyzed. First of all, in the research of the relationship between human muscle morphology and physiological function, electronic imaging technology can accurately reflect the changes in morphology and structure caused by mechanical stimuli such as muscle contraction and traction. Secondly, electronic imaging technology can obtain the morphological change data of athletes' skeletal muscle microstructure in real time, and process and analyze the data through computers to form a neural network and extract the physiological parameters and related indicators of skeletal muscle movement [22]. Thirdly, electronic imaging technology can directly detect a number of muscle training related indicators. Finally, the study and analysis of the changes in muscle tissue morphology during skeletal muscle contraction would help to reveal the relationship between skeletal muscle contraction and morphological and structural indicators.

To sum up, as an advanced technical means and tool, electronic imaging technology can judge people's motion posture from different levels. The data information obtained from electronic imaging can directly reflect the changes in the physiological activity patterns of athletes after the changes in the morphological structure of muscle tissue, and thus have a guiding significance for the formulation of training programs, the improvement of strength levels and the formation of motor skills.

(3) Research on blockchain technology in athletes' training and management

Blockchain technology will provide a new management mode for athletes' contract management, whose main features can be summarized as decentralized, intelligent, efficient, accurate and low cost [23,24]. At present, the management of athletes mainly adopts the contract system, but there are some problems in the contract management of athletes, such as non-standard signing procedures, invalid contract content, and many disputes in the execution process, which hinder the improvement of athletes' competitive level. To block chain smart contract technology characteristics and application choice to analyze the present situation of athletes contract management, the block chain smart contract applied to athletes contract management, block chain smart contract athletes contract management mode, simplify fraud prevention, reduce costs, accurate setting, promote the development of athletes themselves, clear the main body of the chain positioning design application layered framework and implementation process.

The application of blockchain technology in motion control analysis ensures the integrity and traceability of motion control data, as the data is recorded on the blockchain and cannot be tampered with. Smart contracts automate preset data analysis and feedback processes that automatically trigger adjustments to training schedules and medical interventions when specific exercise metrics reach set thresholds.

The integration of blockchain technology shows significant practical impact and broad scalability in athlete training and management. Through its decentralized nature, blockchain ensures that data and transaction records are immutable, thus increasing transparency and trust, simplifying contract signing and enforcement processes, reducing fraud, and reducing administrative costs. At the same time, blockchain's encryption technology enhances data security, protecting athletes' personal information and training data. In terms of scalability, blockchain technology can adapt to different sports and training needs, support technology upgrades, cross-field applications, and promote the construction of an open ecosystem, attract multi-stakeholder participation, and jointly promote the standardization and intelligence of athlete training and management.

4. Image processing related algorithms

(1) Wavelet change processing for noise reduction

The dyadic wavelet is obtained by discretizing the scale parameter c of wavelet according to binary form $c_l = 2^{-l}$, while the dyadic wavelet transform of function or signal is the value of continuous wavelet transform when the scale parameter c is only $c_l = 2^{-l}$.

If wavelet function $\Phi(k)$ meets the stability condition:

$$C \le \sum_{i=-\infty}^{+\infty} |\Phi(\alpha)|^2 \le D, i. \alpha \in R \tag{1}$$

Then $\Phi(k)$ is called dyadic wavelet. For any integer m, it is recorded as:

$$\Phi_{(2^{-m},d)}(k) = 2^{m/2}\Phi(2^m(k-d)) \tag{2}$$

$Q_p^l(d)$ is used to represent the binary discrete wavelet transform of function p(k), which is defined as follows:

$$Q_p^l(d) = Q_p(2^{-l}, d) = \int_R p(k)\overline{\Phi(2^{-l}, d)}(k)dx \tag{3}$$

This is equivalent to that in wavelet transform, when the scale parameter c is binary discrete value $c_l = 2^{-l}$, its value is $Q_p(c, d)$. In this case, the inversion expression of dyadic wavelet is:

$$p(k) = \sum_{l=-\infty}^{+\infty} 2^l \int_R Q_p^l(d) \times g_{(2^{-l},d)}(x)d \tag{4}$$

In the formula, function p(k) satisfies:

$$\sum_{l=-\infty}^{+\infty} \Phi(2^l\alpha)\, G(2^l\alpha) = 1, i, \alpha \in R \tag{5}$$

(2) Median filtering algorithm

If there is a one-dimensional sequence as follows: $t_1, t_2, \cdots, t_n$. The median filtering processing is carried out, that is, the odd point sliding window is adopted [25,26]. At the same time, the filtering window is assumed to correspond to a certain length, and its function is expressed as M = 2X + 1. The *M* numbers conforming to the functional formula are arranged based on the numerical value, and their serial numbers are taken as the values at the center point (the values are named as filtered output). The number of *M* is extracted, and then the above number of *M* is arranged based on size. Its serial number is taken as the value at the center point. This number is the filtered output. The functional expression is as follows:

$$Q_n = median[t_{n-x}, \cdots, t_n, \cdots, t_{n+x}](n \in Z) \tag{6}$$

In Equation (6), medium [*] represents the intermediate value in the sequence, and *Z* represents the set of all natural numbers. For example, if there is a single sequence {1, 2, 4, 0, 6}, then there is media [1, 2, 4, 0, 6] = 1.

A single finite length sequence is $t_1, t_2, \cdots, t_n, \cdots, t_K$. If the length function of the filtering window is M = 2X + 1, in order to ensure that the length of the output signal is equal to the length of the input signal, *X* signals must be expanded on both sides of the input signal before filtering. The expansion methods are as follows:

The *x* signal values expanded on each side are equal to the signal values at both ends, as shown in Equation (7):

$$\left.\begin{aligned} t_{-x+1} = t_{-x+2} = \cdots = t_0 = t_m \\ t_{K+1} = t_{K+2} = \cdots = t_{K+x} = t_K \end{aligned}\right\} \tag{7}$$

After its extension, the sequence becomes {1, 1, 2, 4, 1, 6, 6}.

The expanded *x* signal values on each side are configured with the signal values on both sides, as shown in Equation (8):

$$\left.\begin{aligned} t_{1-n} = t_n, n \in [1, x] \\ t_{K+n} = t_{K+m-n}, n \in [1, x] \end{aligned}\right\} \tag{8}$$

After its extension, the sequence becomes {2, 1, 1, 2, 4, 0, 6, 6, 1}.

5. Experimental evaluation on athletes' muscle training action control

In this paper, visual image was used to analyze athletes' muscle training action control, and a reasonable and scientific muscle training method was proposed [27–29]. In order to verify that the athletes' muscle training proposed in this paper can improve the efficiency and effect of athletes' training, two athletes, A and B, were selected to enable Athlete A to implement the muscle training action control method mentioned in this paper, and Athlete B to implement the traditional muscle training action control method [30,31]. Before the start of the experiment, athletes A and B were evaluated in detail to understand their physical conditions, sports experience, training goals and basic indicators. Based on the results of the initial evaluation, a personalized training plan is developed for each athlete to ensure that the content and intensity of training matches their actual situation. A If the athlete is weak in muscle flexibility, increase the proportion of flexibility training in his training plan; B Athletes in the muscle explosiveness is weak, then increase the frequency of high-intensity interval training. The physical indicators of athletes during the same exercise were counted [32].

In the experiment of muscle explosive force, the explosive force of athletes A and B was tested (as shown in **Figure 5**):

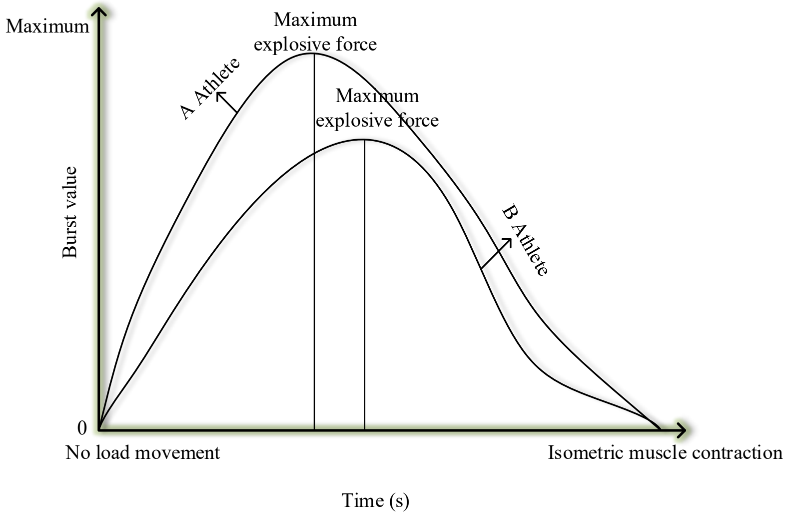

Figure 5. Comparison of sports explosiveness.

It can be seen from **Figure 5** that the explosive power of Athlete A was faster and higher than that of Athlete B.

When testing the endurance value of muscle contraction speed, Athletes A and B were tested (as shown in **Figure 6**):

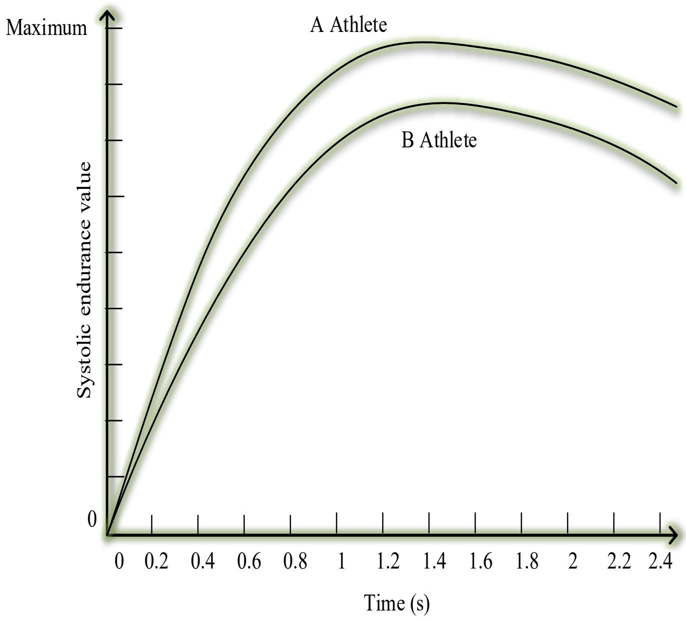

Figure 6. Comparison of muscle contraction tolerance values.

It can be seen from **Figure 6** that the endurance value of muscle contraction speed of Athlete A was greater than that of Athlete B.

In the experiment of muscle contraction rate, Athletes A and B were tested (as shown in **Figure 7**):

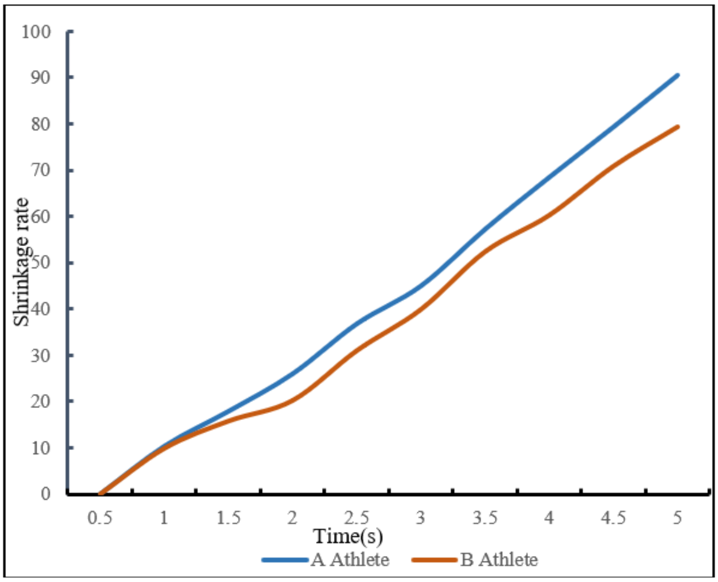

Figure 7. Comparison of muscle contraction rate.

It can be seen from **Figure 7** that the muscle contraction rate of Athlete A was higher than that of Athlete B.

It can be seen from **Figures 5–7** that the visual image analysis of athletes' muscle training action control strategy adopted in this paper can enable athletes to conduct muscle training scientifically and effectively, thus improving the efficiency and effect of athletes' training.

Muscle training, as one of the important contents of athletes' physical training, aims to improve the efficiency and effect of athletes' training in physical training, and further enable athletes to maintain a higher level of strength and better sports performance. In order to verify the effect of the muscle training action control strategy proposed in this paper based on visual images, this paper selects basketball players' Group 1 and Group 2 (10 members in each group), respectively, to carry out the muscle training and traditional muscle training methods mentioned in this paper for one month, and then test the strength level and sports performance of Group 1 and Group 2.

The first is the strength level test (as shown in **Figure 8**):

It can be seen from **Figure 8** that the overall strength level of Group 1 was higher than that of Group 2.

In the basketball performance test of each group, the number of ten goals scored by each of them was selected, and then the scores were scored according to the number of goals scored by each player (as shown in **Figure 9**):

It can be seen from **Figure 9** that the average sports performance of Group 1 students was 6 points higher than that of Group 2 students, and the score ratio was 7.39% higher. Therefore, the muscle training action control strategy based on visual images proposed in this paper can enable athletes to maintain a higher strength level and better sports performance.

T-test was used to conduct statistical analysis on the data in **Figures 8** and **9**, as shown in **Table 1**.

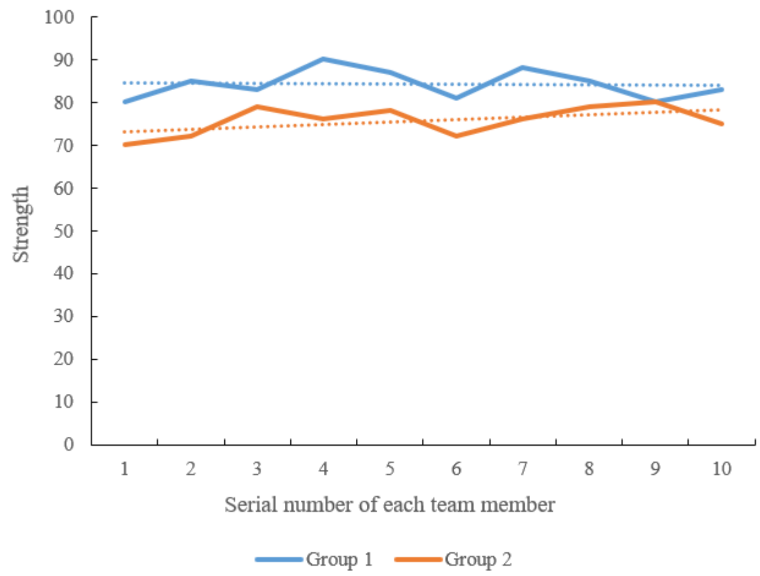

Figure 8. Comparison of strength levels.

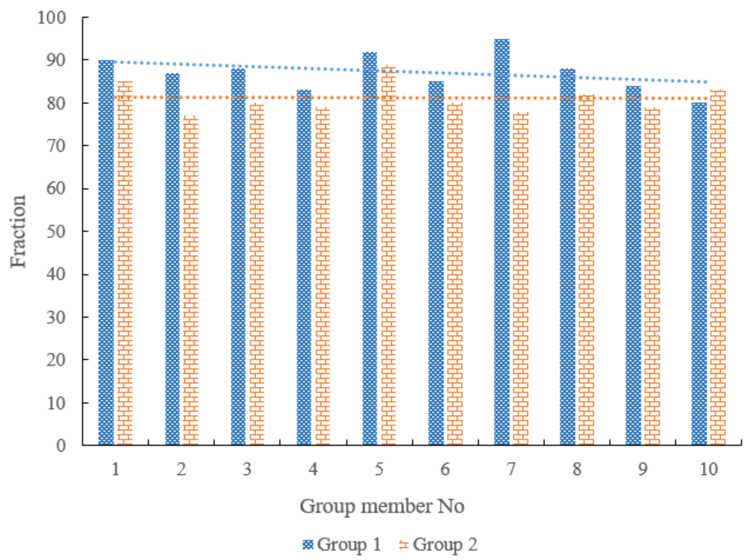

Figure 9. Comparison of sports results.

Table 1. *T*-test results of the data.

Data	*T*_statistic	*P*_value
Strength levels	3.1234	0.0056
Sports results	2.5678	0.0182

Table 1 shows the results of the statistical analysis of the data in **Figures 8** and **9** based on the *T*-test. For the strength level test, the *T*-value was 3.1234 and the *P*-value was 0.0056, indicating that the difference in strength level between group 1 and group 2 was significant ($p < 0.05$). This suggests that the blockchain-based and visual image analysis-based motion control strategy for muscle training proposed in this paper can significantly improve the strength level of athletes. For the sports performance test, the *T*-value was 2.5678 and the *P*-value was 0.0182, which also showed a significant difference between the two groups ($p < 0.05$). This further

verifies that the training strategy proposed in this paper can not only improve the strength level, but also significantly improve the athletic performance.

In order to further verify the reliability of the experimental results, this paper expanded the sample size to 500 people and re-conducted the experiment and analysis. Two groups of 500 basketball players were selected for one month to carry out the muscle training mentioned in this paper and the traditional muscle training methods.

The experimental content and test method were consistent with the preliminary experiment, and the strength level and basketball performance of each athlete were recorded respectively. Average the recorded data, as shown in **Figure 10**.

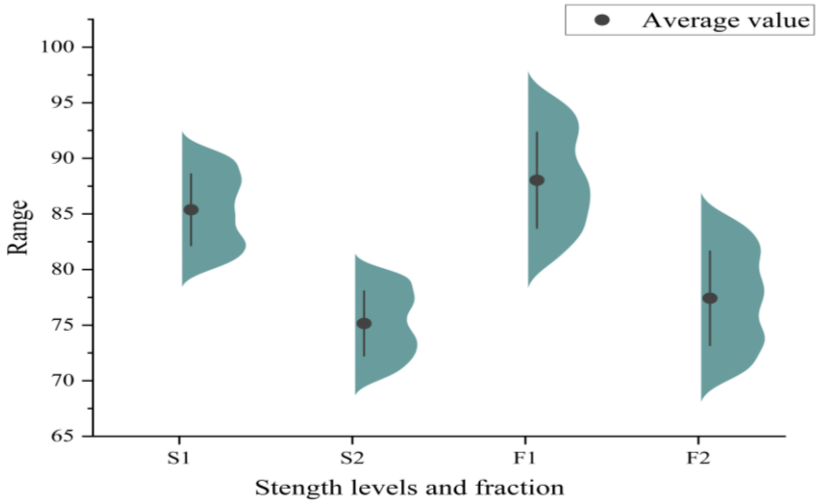

Figure 10. Comparison of strength levels and sports results.

In **Figure 10**, S1 and S2 refer to the strength levels of Group 1 and Group 2 respectively, while F1 and F2 refer to the exercise scores of Group 1 and Group 2 respectively. It is obvious that both the strength level and the exercise score of the first group are stronger than those of the second group, which further verifies the effectiveness of the method presented in this paper.

6. Conclusions

In this paper, we mainly studied the motion control strategy of athlete muscle training based on blockchain and visual image analysis. Through the analysis of the importance of muscle control, it was concluded that reasonable and scientific muscle training has many advantages. Then it proposed the control strategy of muscle training action through image processing technology and electronic imaging technology. Through research, it was found that the demand for muscle coordination ability in sports training is getting higher and higher. Finally, in order to verify the effect of the control strategy of athletes' muscle training based on visual image analysis proposed in this paper, a series of related experiments were carried out. By means of visual image method and data analysis, this paper conducted an experimental study on the physical indicators and sports performance of athletes under different muscle training, and concluded that the muscle training action control strategy in this paper can enable athletes to maintain a higher strength level and improve sports performance, which provided a certain value for future athletes in muscle training action control.

Ethical approval: Not applicable.

Conflict of interest: The author declares no conflict of interest.

References

1. Alouini S, Memic S, Couillandre A. Pelvic Floor Muscle Training for Urinary Incontinence with or without Biofeedback or Electrostimulation in Women: A Systematic Review. International Journal of Environmental Research and Public Health. 2022; 19(5): 2789. doi: 10.3390/ijerph19052789
2. Saeterbakken AH, Stien N, Andersen V, et al. The Effects of Trunk Muscle Training on Physical Fitness and Sport-Specific Performance in Young and Adult Athletes: A Systematic Review and Meta-Analysis. Sports Medicine. 2022; 52(7): 1599–1622. doi: 10.1007/s40279-021-01637-0
3. del Corral T, Fabero-Garrido R, Plaza-Manzano G, et al. Home-based respiratory muscle training on quality of life and exercise tolerance in long-term post-COVID-19: Randomized controlled trial. Annals of Physical and Rehabilitation Medicine. 2023; 66(1): 101709. doi: 10.1016/j.rehab.2022.101709
4. Blazevich AJ, Wilson CJ, Alcaraz PE, et al. Effects of Resistance Training Movement Pattern and Velocity on Isometric Muscular Rate of Force Development: A Systematic Review with Meta-analysis and Meta-regression. Sports Medicine. 2020; 50(5): 943–963. doi: 10.1007/s40279-019-01239-x
5. Pires TF, Pires PM, Moreira MH, et al. Pelvic Floor Muscle Training in Female Athletes: A Randomized Controlled Pilot Study. International Journal of Sports Medicine. 2020; 41(04): 264–270. doi: 10.1055/a-1073-7977
6. Hartz CS, Sindorf MAG, Lopes CR, et al. Effect of Inspiratory Muscle Training on Performance of Handball Athletes. Journal of Human Kinetics. 2018; 63(1): 43–51. doi: 10.2478/hukin-2018-0005
7. Pareja-Blanco F, Rodríguez-Rosell D, Sánchez-Medina L, et al. Effects of velocity loss during resistance training on athletic performance, strength gains and muscle adaptations. Scandinavian Journal of Medicine & Science in Sports. 2016; 27(7): 724–735. doi: 10.1111/sms.12678
8. Suchomel TJ, Nimphius S, Bellon CR, et al. The Importance of Muscular Strength: Training Considerations. Sports Medicine. 2018; 48(4): 765–785. doi: 10.1007/s40279-018-0862-z
9. Sheng Z, Sharma N, Kim K. Quantitative Assessment of Changes in Muscle Contractility Due to Fatigue During NMES: An Ultrasound Imaging Approach. IEEE Transactions on Biomedical Engineering. 2020; 67(3): 832–841. doi: 10.1109/tbme.2019.2921754
10. Alonso-Fernandez D, Docampo-Blanco P, Martinez-Fernandez J. Changes in muscle architecture of biceps femoris induced by eccentric strength training with nordic hamstring exercise. Scandinavian Journal of Medicine & Science in Sports. 2017; 28(1): 88–94. doi: 10.1111/sms.12877
11. Bruschetta D, Anastasi G, Andronaco V, et al. Human calf muscles changes after strength training as revealed by diffusion tensor imaging. The Journal of Sports Medicine and Physical Fitness. 2019; 59(5). doi: 10.23736/s0022-4707.18.08759-5
12. Pedrosa GF, Lima FV, Schoenfeld BJ, et al. Partial range of motion training elicits favorable improvements in muscular adaptations when carried out at long muscle lengths. European Journal of Sport Science. 2021; 22(8): 1250–1260. doi: 10.1080/17461391.2021.1927199
13. Franchi MV, Raiteri BJ, Longo S, et al. Muscle Architecture Assessment: Strengths, Shortcomings and New Frontiers of in Vivo Imaging Techniques. Ultrasound in Medicine & Biology. 2018; 44(12): 2492–2504. doi: 10.1016/j.ultrasmedbio.2018.07.010
14. Sasaki S, Tsuda E, Yamamoto Y, et al. Core-Muscle Training and Neuromuscular Control of the Lower Limb and Trunk. Journal of Athletic Training. 2019; 54(9): 959–969. doi: 10.4085/1062-6050-113-17
15. Lee S, Park M, Lee K, et al. Scalable muscle-actuated human simulation and control. ACM Transactions on Graphics. 2019; 38(4): 1–13. doi: 10.1145/3306346.3322972
16. Hislop MD, Stokes KA, Williams S, et al. Reducing musculoskeletal injury and concussion risk in schoolboy rugby players with a pre-activity movement control exercise programme: a cluster randomised controlled trial. British Journal of Sports Medicine. 2017; 51(15): 1140–1146. doi: 10.1136/bjsports-2016-097434

17. Weng K, Huo W, Li Y, et al. Fiber characteristics and meat quality of different muscular tissues from slow- and fast-growing broilers. Poultry Science. 2022; 101(1): 101537. doi: 10.1016/j.psj.2021.101537
18. Huo W, Weng K, Li Y, et al. Comparison of muscle fiber characteristics and glycolytic potential between slow- and fast-growing broilers. Poultry Science. 2022; 101(3): 101649. doi: 10.1016/j.psj.2021.101649
19. Soglia F, Bordini M, Mazzoni M, et al. The evolution of vimentin and desmin in Pectoralis major muscles of broiler chickens supports their essential role in muscle regeneration. Frontiers in Physiology. 2022; 13. doi: 10.3389/fphys.2022.970034
20. Bagherian S, Ghasempoor K, Rahnama N, et al. The Effect of Core Stability Training on Functional Movement Patterns in College Athletes. Journal of Sport Rehabilitation. 2019; 28(5): 444–449. doi: 10.1123/jsr.2017-0107
21. Sessa F, Messina G, Valenzano A, et al. Sports training and adaptive changes. Sport Sciences for Health. 2018; 14(3): 705–708. doi: 10.1007/s11332-018-0464-z
22. Jin KH, McCann MT, Froustey E, et al. Deep Convolutional Neural Network for Inverse Problems in Imaging. IEEE Transactions on Image Processing. 2017; 26(9): 4509–4522. doi: 10.1109/tip.2017.2713099
23. Gad AG, Mosa DT, Abualigah L, et al. Emerging Trends in Blockchain Technology and Applications: A Review and Outlook. Journal of King Saud University—Computer and Information Sciences. 2022; 34(9): 6719–6742. doi: 10.1016/j.jksuci.2022.03.007
24. Habib G, Sharma S, Ibrahim S, et al. Blockchain Technology: Benefits, Challenges, Applications, and Integration of Blockchain Technology with Cloud Computing. Future Internet. 2022; 14(11): 341. doi: 10.3390/fi14110341
25. Shah A, Bangash JI, Khan AW, et al. Comparative analysis of median filter and its variants for removal of impulse noise from gray scale images. Journal of King Saud University—Computer and Information Sciences. 2022; 34(3): 505–519. doi: 10.1016/j.jksuci.2020.03.007
26. Balasamy K, Shamia D. Feature Extraction-based Medical Image Watermarking Using Fuzzy-based Median Filter. IETE Journal of Research. 2021; 69(1): 83–91. doi: 10.1080/03772063.2021.1893231
27. Rodríguez Macías M, Giménez Fuentes-Guerra FJ, Abad Robles MT. The Sport Training Process of Para-Athletes: A Systematic Review. International Journal of Environmental Research and Public Health. 2022; 19(12): 7242. doi: 10.3390/ijerph19127242
28. Stone MH, Hornsby WG, Suarez DG, et al. Training Specificity for Athletes: Emphasis on Strength-Power Training: A Narrative Review. Journal of Functional Morphology and Kinesiology. 2022; 7(4): 102. doi: 10.3390/jfmk7040102
29. Tuychiyev A, Farrukh K. The basics of building a training session for young athletes. Conferencea. 2023; 55–65.
30. Washif JA. Training during the COVID-19 lockdown: knowledge, beliefs, and practices of 12,526 athletes from 142 countries and six continents. Sports Medicine.2022; 52(4): 933–948.
31. McNamara A, Harris R, Minahan C. ‘That time of the month’ … for the biggest event of your career! Perception of menstrual cycle on performance of Australian athletes training for the 2020 Olympic and Paralympic Games. BMJ Open Sport & Exercise Medicine. 2022; 8(2): e001300. doi: 10.1136/bmjsem-2021-001300
32. Sofyan D, Budiman IA. Basketball jump shot technique design for high school athletes: Training method development. Journal Sport Area. 2022; 7(1): 47–58.