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Article

Research on the application of sports biomechanics in optimizing the effect of physical training

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Abstract: This paper discusses the application of sports biomechanics in optimizing the effect of sports training, finds out the existing problems through quantitative evaluation of athletes' technical movements, and puts forward improvement suggestions to maximize the training effect. In this study, 12 professional long jumpers were taken as the object, and advanced equipment such as high-speed photography, computer analysis and photoelectric timer were used to record the long jump movements of athletes in all directions, and the biomechanical parameters were analyzed. The results show that after four weeks of personalized training, the key performance indexes of athletes such as take-off speed, horizontal displacement, vertical jump height, landing technique and muscle strength have been significantly improved, and the average long jump performance has been significantly improved. Principal component analysis (PCA) reveals the key biomechanical factors that affect the performance of long jump, including take-off speed, horizontal displacement and vertical jump height. In addition, hierarchical cluster analysis helps to identify the technical characteristics and training needs of different athletes, which provides a basis for making personalized training plans. The results show that the application of sports biomechanics not only improves athletes' performance, but also helps to reduce sports injuries and prolong sports life, and provides scientific training guidance for coaches. This study has important theoretical and practical value for promoting the development of sports science and improving the level of competitive sports.

Keywords: physical training; sports biomechanics; long jumper

1. Introduction

As an important branch in the field of physical education, sports biomechanics provides important theoretical and technical support for competitive sports, mass sports, rehabilitation medicine and ergonomics. In recent years, with the deepening of sports-related research, people began to look at sports from a biological perspective. By analyzing its mechanical changes, they explained the mechanism of human muscles and bones during sports, and provided theoretical support for the application of modern biotechnology in sports [1,2].

In recent years, with the rapid development of science and technology, the research methods and techniques of sports biomechanics are constantly updated and improved. The application of advanced equipment, such as high-speed photography, computer analysis, photoelectric timer, accelerometer, joint angle measurement, electromyography and dynamometer, enables us to capture and analyze various mechanical parameters of athletes in the process of sports more accurately [3,4]. These parameters not only reflect the athletes' sports state, but also reveal the advantages and disadvantages of their sports skills and potential room for improvement.

However, although some achievements have been made in the application of sports biomechanics in the field of sports, its potential in optimizing the effect of sports training still needs to be further explored [5]. At present, many training methods and means are still based on traditional experience and intuitive judgment, lacking scientific basis and systematicness. Therefore, this study intends to quantitatively evaluate athletes' sports skills by means of sports biomechanics analysis, find out the existing problems and deficiencies, and then put forward targeted improvement suggestions in order to maximize the training effect.

The significance of this study is that applying the theory and method of sports biomechanics to sports training practice can not only improve athletes' sports performance, but also reduce the occurrence of sports injuries and prolong their sports life. At the same time, this study can also provide scientific training guidance for coaches and improve their training level and efficiency. Therefore, this study has important theoretical and practical value, and has positive significance for promoting the development of sports science and improving the level of competitive sports.

2. Literature review

2.1. Basic concepts and principles of sports biomechanics

Sports biomechanics is to quantitatively study and analyze the mechanics research of athletes in general sports. It applies mechanics principles and methods to study the external mechanical movement of objects, especially the law of human movement in sports [6]. The movement of human body or general organism is the result of the cooperation of nervous system, muscle system and skeletal system. The task of sports biomechanics is to study the mechanical movement law of human body or general organism under the action of external force and internal controlled muscle strength [7,8].

2.2. The application of sports biomechanics in physical training

As an important branch of sports science, sports biomechanics is widely and deeply applied in sports training, which is embodied in the following aspects:

Analysis and optimization of technical movements is one of the core applications of sports biomechanics in physical training. Through high-precision measuring equipment and advanced data analysis technology, researchers can accurately capture and deeply analyze the key parameters of athletes, such as strength distribution, speed change and action frequency [9]. These data provide valuable feedback for coaches, help them identify the shortcomings of athletes' technical movements, and then make targeted training plans and optimize training methods. For example, in swimming events, sports biomechanics experts use underwater cameras, mechanical sensors and other equipment to analyze the swimmer's body posture, arm stroke path, leg kicking mode, etc., and find the most suitable swimming posture and action mode by comparing the technical models of excellent athletes, thus significantly improving the swimming speed and efficiency [10,11]. This fine adjustment based on data makes the training more scientific and efficient.

The individualized design of strength training is also an important application field of sports biomechanics. Different sports have different demands on athletes' strength, and sports biomechanics can provide athletes with tailor-made strength training programs. By evaluating the athletes' muscle strength, explosive power, endurance and other indicators, combined with the characteristics of the project, a strength training plan is designed that not only conforms to the athletes' personal characteristics but also can effectively improve their sports performance. This personalized strength training can not only improve athletes' sports ability and technical level, but also reduce the risk of sports injury caused by improper training [12].

Preventing sports injuries is another great contribution of sports biomechanics. Sports injury is a great threat to athletes' career, and sports biomechanics reveals the principle and risk factors of sports injury by studying the mechanical mechanism in the process of sports. On this basis, researchers can develop effective preventive measures and rehabilitation programs to help athletes better protect their bodies, avoid or reduce the occurrence of sports injuries, and thus extend the sports life of athletes [13]. For example, by analyzing the parameters such as the reaction force on the ground and the bending angle of the knee joint during running, we can provide suitable running shoes and running posture suggestions for runners and effectively reduce the risk of knee joint injury.

Sports biomechanics also plays an important role in the development and improvement of sports equipment and equipment. With the progress of science and technology, the performance of sports equipment has more and more influence on athletes' sports performance. Sports biomechanics experts can optimize the design of equipment, improve its performance and reduce the risk of sports injury by studying the interaction between athletes and equipment. For example, in the design of running shoes, the principle of sports biomechanics is used to improve the elasticity, support and grip of the sole, so as to provide better cushioning effect and stability, thus reducing the impact on the knee joint and ankle joint during running [14]. In addition, in terms of ball sports equipment and fitness equipment, the application of sports biomechanics has greatly improved the scientific and practical nature of the equipment.

The application of sports biomechanics in sports training is multifaceted, which not only improves the scientificity and efficiency of training, but also provides strong support for the individualized development of athletes, the prevention of sports injuries and the innovation of sports equipment.

2.3. Development trend of research methods of sports biomechanics

In the next few years, the development of sports biomechanics research methods will focus on the improvement of technology and the deepening of application. Specifically, the accuracy of three-dimensional tracking camera and photogrammetry is improved and the automation process is accelerated, and the plantar pressure distribution test is developing to three-dimensional and fast feedback, combined with mathematical and mechanical models and human motion simulation technology [15,16]; at the same time, the comparability of data is enhanced by distinguishing and quantifying the parameters of sensitive and conventional models. In addition, telemetry technology and muscle dynamics measurement technology, including in vitro or in vivo muscle dynamics measurement, will also become the focus of research [17].

The application research of sports biomechanics in optimizing the effect of physical training is of great significance. Through the research on the law of human movement in sports, it can provide scientific training guidance and suggestions for improving technical movements for athletes. At the same time, sports biomechanics is also of great significance in the design and improvement of sports equipment and equipment, which can improve athletes' sports performance and reduce the risk of sports injuries.

3. Research method

3.1. Experimental design

3.1.1. Selection of experimental objects

The research takes 12 professional long jumpers aged from 18 to 30 as subjects, regardless of gender, and requires each athlete to have at least three years of professional training experience and be systematically trained to ensure the stability and representativeness of technical movements. In addition, all participants should have no history of serious sports injuries, and confirm their health through medical examination before the experiment to ensure that their health will not affect the experimental results.

In this study, we strictly follow ethical principles, especially in the aspects of participant consent and data processing. All participating athletes voluntarily signed the informed consent form after fully understanding the research purpose, process, potential risks and their rights. Ensure that the informed consent form is easy to understand, so that participants can make informed decisions. In addition, strict confidentiality measures are taken for all personal and experimental data collected, and the data are stored on a secure server, which can only be accessed by authorized researchers. We promise to comply with all relevant data protection laws and regulations to protect the privacy and data security of participants.

3.1.2. Control of experimental conditions

In order to ensure the accuracy and reliability of the experimental results, this study strictly controls a number of experimental conditions: all tests will be carried out in standardized sports venues to ensure the consistency of venue conditions such as runway materials, wind direction and temperature; Use uniform training equipment, such as springboard and bunker for long jump, to reduce the influence of equipment differences [18,19]; The experiment is arranged in the regular training time of athletes to avoid the interference of biological clock on performance; At the same time, athletes are required to maintain normal diet and rest habits to prevent excessive fatigue or specific food intake from affecting their sports performance.

3.1.3. Arrangement of experimental steps

The experiment is divided into three stages, as shown in **Figure 1**:

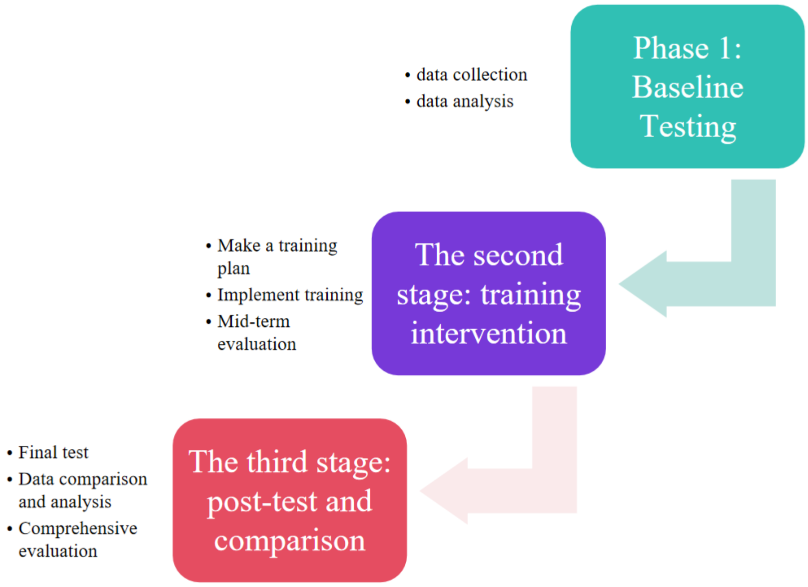

Figure 1. Experimental procedure.

The first stage: using high-speed cameras, dynamometer and other equipment, the long jump movements of each athlete are recorded in an all-round way, including key links such as take-off, air posture and landing. Based on the principle of sports biomechanics, this paper makes a preliminary analysis of the collected data and evaluates the current technical level and existing problems of athletes.

The second stage: according to the results of the baseline test, make a personalized training plan for each athlete, focusing on improving the technical problems found. Under the guidance of the coach, the athletes carry out special training for 4 weeks according to the training plan. In the middle of training (the second week), the athletes' long jump movements were tested again to evaluate the training effect and adjust the training plan.

The third stage: after the end of training (the fourth week), the athletes are given the final long jump test and relevant data are collected. Comparing the final test data with the baseline test data, this paper analyzes the influence and optimization effect of training intervention on athletes' long jump technique [20]. Combined with the self-evaluation of athletes, the observation of coaches and the analysis results of experimental data, the training effect is comprehensively evaluated.

3.2. Testing means

High-resolution high-speed cameras (hundreds to thousands of frames per second) are used to capture the whole process of long jumpers from take-off to landing, especially the dynamic images of key stages such as take-off, flying, spreading and landing (**Figure 2**). The equipment is placed in a position where the complete action can be clearly recorded. After shooting, it is analyzed frame by frame by using professional software to accurately measure the athlete's body posture, motion trajectory and angle changes of each joint, so as to collect detailed data.

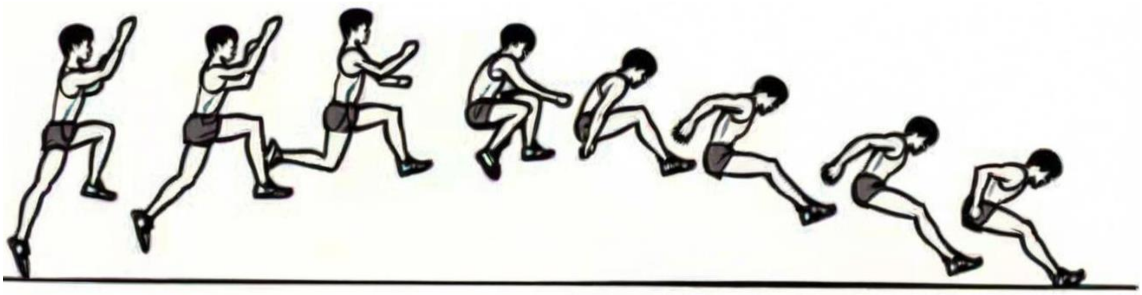

Figure 2. Track of athletes' long jump.

The computer analysis system combines image processing technology and sports biomechanics model to digitally analyze the long jump image obtained by high-speed photography. The system aims to accurately calculate the athletes' kinematic parameters such as speed, acceleration and displacement, as well as dynamic parameters such as joint torque and muscle strength [21]. By importing images into the analysis system, researchers can automatically or manually mark key points and motion trajectories (as shown in **Figure 3**), and then complete detailed data analysis.

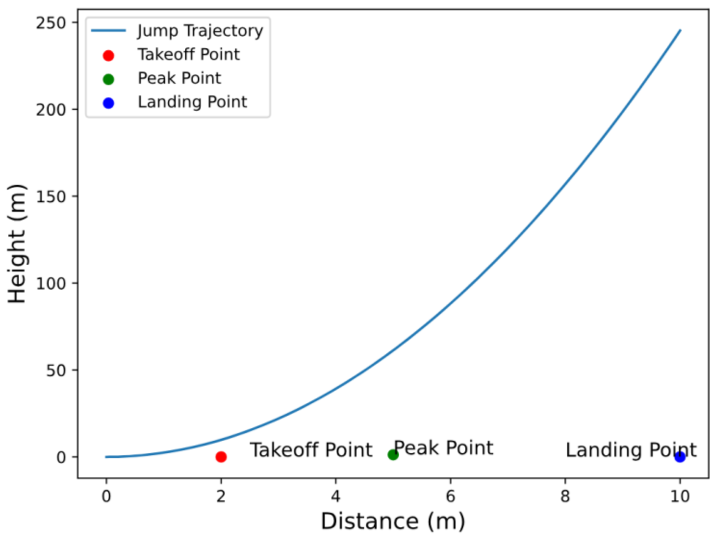

Figure 3. The trajectory of long jumpers (take-off point, highest point and landing point).

Photoelectric timer accurately measures millisecond time, records the total time from take-off to landing, and evaluates the rhythm and efficiency of action. Photoelectric timers are set at the starting line and landing point respectively. Accelerometer is a small and portable sensor worn on athletes, which directly measures the acceleration change during the long jump and reflects the power output and movement dynamics. Based on the optical principle, the joint angle change measuring instrument measures the angle changes of hip, knee, ankle and other joints, analyzes the range of motion and coordination, and the sensor is fixed at the relevant joint parts. The multi-channel system of electromyography records the myoelectric activities of multiple muscles, analyzes the activation sequence, intensity and time, and evaluates the working efficiency and coordination of muscles. Electrodes are attached to the main muscle groups. The high-precision platform of dynamometer measures the ground reaction force and moment in vertical and horizontal directions, evaluates the take-off effect and power output, and places it in the take-off area to ensure complete pedaling.

3.3. Data analysis method

Firstly, the original data collected are preliminarily sorted out and summarized to understand the basic characteristics of the data. This paper analyzes the changes of biomechanical parameters with time in the long jump. Pearson correlation coefficient is used to explore the correlation between biomechanical parameters and the degree of correlation between them and long jump performance. Independent sample *t* test was used to compare whether the mean difference between the two groups was significant. Principal component analysis was carried out on several biomechanical parameters to find out the principal component that can explain most of the data variation. Using hierarchical clustering method, the athletes are grouped according to the similarity of their biomechanical parameters, and the technical characteristics and training needs of athletes in different groups are analyzed.

Among them, PCA is chosen to reduce the dimension of data set, while retaining as many original variations as possible. This method is helpful to identify the main patterns and structures in the data, thus simplifying the subsequent analysis and improving the interpretability of the results. *T*-test is used to compare the mean differences between the two groups to determine whether these differences are statistically significant. In our research, *T*-test is suitable for comparing the effects of different training methods on athletes' performance.

4. Experimental result

4.1. Descriptive statistical analysis

The descriptive statistical analysis results of biomechanical parameters of long jump athletes are shown in **Table 1**. The average speed of athletes is 6.89 m/s, with a standard deviation of 1.35, indicating that there is a certain difference in speed among athletes. The maximum speed is 19.64 m/s, while the minimum speed is 3.27 m/s, which may be due to individual differences in athletes or differences in technical execution. The average acceleration is 8.22 m/s^2, with a standard deviation of 1.79, indicating significant variations in acceleration among athletes. The maximum acceleration is 13.83 m/s^2 and the minimum is 4.70 m/s^2, which reflects the difference in athletes' abilities during takeoff and acceleration phases. The average strength is 7.32 N, with a standard deviation of 1.38, indicating that the athletes are relatively balanced in terms of strength. The maximum strength is 17.92 N, while the minimum strength is 1.28 N, which may indicate that some athletes have an advantage in power output. The average joint angle is 6.86°, with a standard deviation of 2.28, indicating significant differences in joint angles among athletes during long jump movements. The maximum angle is 15.29° and the minimum is 1.35°, which may be related to the athlete's technical style and personal physiological characteristics.

Table 1. Descriptive statistical analysis results of biomechanical parameters of long jumpers.

Parameter	average value	standard deviation	Maximum value	minimum value
Speed (m/s)	6.89	1.35	19.64	3.27
Acceleration (m/s^2)	8.22	1.79	13.83	4.70
Strength (N)	7.32	1.38	17.92	1.28
Joint angle (°)	6.86	2.28	15.29	1.35

As can be seen from **Figure 4**, the take-off strength, flying time and landing angle in the long jump show different trends: the take-off strength gradually decreases after reaching the peak at the moment of take-off, indicating that athletes need to overcome gravity with maximum strength to obtain upward speed and height; The flying time enters a relatively stable stage after take-off, which shows the time for athletes to keep flying, and its length is determined by the take-off speed and angle; The landing angle changes rapidly when approaching the ground, reflecting that athletes adjust their body posture in preparation for landing.

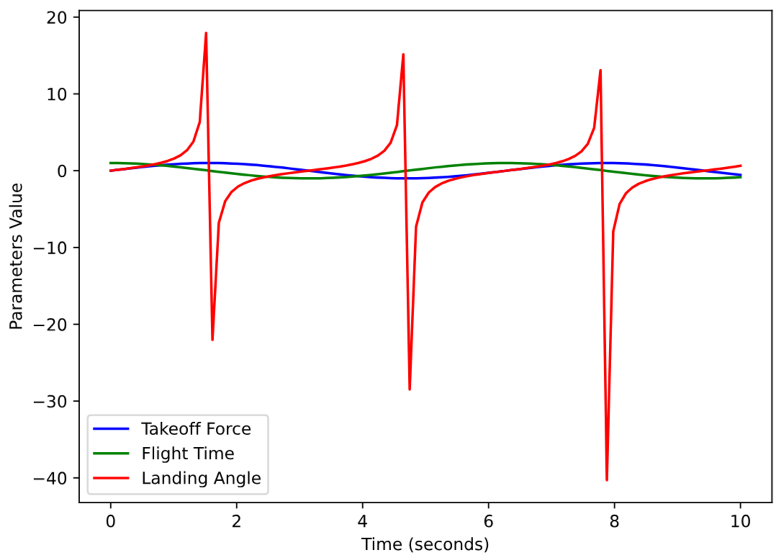

Figure 4. Changes of take-off strength, flying time and landing angle in long jump.

4.2. Correlation analysis

Correlation shows (see **Figure 5**) that there is a moderate positive correlation between speed and acceleration (correlation coefficient is 0.46), indicating that the acceleration tends to increase when the speed increases; The relationship between speed and strength is weak (correlation coefficient 0.24). Speed has little effect on joint angle (correlation 0.11). Although there is a positive correlation between acceleration and strength (correlation coefficient is 0.26), the correlation intensity is low; An increase in acceleration may be accompanied by a decrease in joint angle (correlation −0.23). The change of strength has no significant effect on joint angle (correlation is close to 0). In addition, the correlation between long jump performance and other biomechanical parameters is generally low, the highest is only 0.09 (with joint angle), which shows that these parameters have limited role in predicting long jump performance.

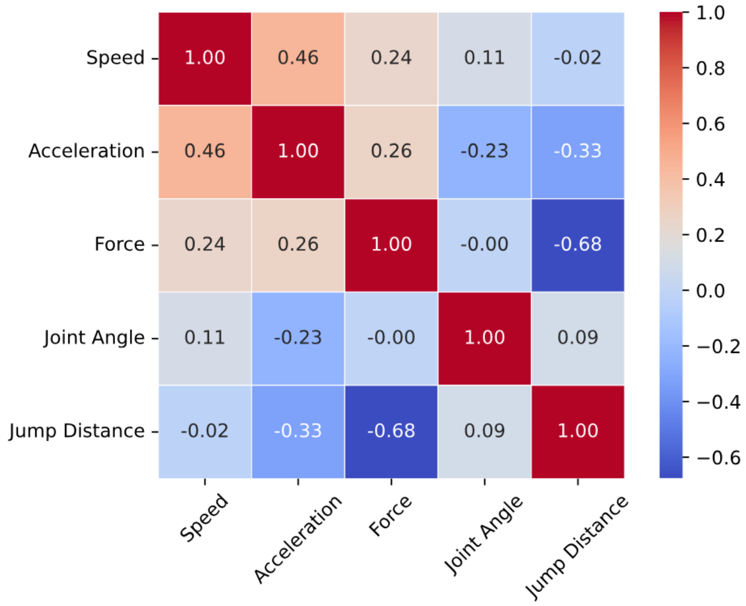

Figure 5. Thermal map of biological characteristic parameters and long jump performance.

4.3. Difference analysis

Table 2 shows the independent sample *T*-test results of various performance indexes of long jumpers before and after training, which shows that training has a significant positive impact on most indexes. After training, the takeoff speed increased from 7.85 m/s to 8.21 m/s ($p = 0.028$), the horizontal displacement increased from 5.92 m to 6.27 m ($p = 0.005$), the vertical jump height increased from 0.48 m to 0.52 m ($p = 0.011$), and the landing buffer time decreased from 0.29 s to 0.26 s. The maximum joint angle increased from 121.4 to 127.6 ($P = 0.023$), and the average muscle strength increased from 1256.3 N to 1312.7 N ($p = 0.008$), all of which were statistically significant. Although the flying time increased, it did not reach a significant level ($p = 0.061$). Generally speaking, the training has significantly improved the athletes' take-off speed, long jump distance, jumping ability, landing technique and muscle strength.

Table 2. *T*-test results of independent samples of performance indexes of long jumpers before and after training.

variable	Baseline test (M ± SD)	Final test (M ± SD)	*T* value	df	*P* value	Cohen's d
Take-off speed (m/s)	7.85 ± 0.63	8.21 ± 0.59	2.34	22	0.028	0.48
Vacation time (s)	0.72 ± 0.08	0.76 ± 0.07	1.97	22	0.061	0.39
Horizontal displacement (m)	5.92 ± 0.45	6.27 ± 0.41	3.11	22	0.005	0.66
Vertical jump height (m)	0.48 ± 0.06	0.52 ± 0.05	2.76	22	0.011	0.57
Landing buffer time (s)	0.29 ± 0.04	0.26 ± 0.03	−2.15	22	0.046	−0.43
Maximum joint angle ()	121.4 ± 8.2	127.6 ± 7.8	2.45	22	0.021	0.51
Average muscle strength (n)	1256.3 ± 104.2	1312.7 ± 98.5	2.83	22	0.008	0.61

4.4. The main biomechanical factors affecting the long jump performance

Principal component analysis (PCA) reveals several key biomechanical factors that affect the performance of long jump (see **Table 3**). First principal component

(PC1) explained the variance of 36.06%, which was mainly related to take-off speed, horizontal displacement and vertical jump height, highlighting the importance of "propulsion" and "flying ability". The second principal component (PC2) explained the variance of 23.71% and accumulated to 59.77%, and emphasized the influence of flying time, landing buffer time and maximum joint angle on attitude control and landing buffer. The third principal component (PC3) contributed 17.41% variance and accumulated to 77.18%, indicating the importance of average muscle strength and acceleration. The fourth principal component (PC4) explained the variance of 10.91%, which accumulated to 88.09%, involving joint flexibility and ground reaction. Finally, the fifth principal component (PC5) explained the variance of 7.14%, which accumulated to 95.23%, reflecting the influence of EMG activity on performance.

Table 3. Results of PCA.

principal constituent	eigenvalue	Variance explanation ratio (%)	Cumulative variance explanation ratio (%)	factor loading
PC1	3.245	36.06	36.06	Takeoff speed: 0.85 Horizontal displacement: 0.81 Vertical jump height: 0.79
PC2	2.134	23.71	59.77	Vacation time: 0.82 Landing buffer time: 0.78 Maximum joint angle: 0.75
PC3	1.557	17.41	77.18	Average muscle strength: 0.84 Acceleration change: 0.76
PC4	0.982	10.91	88.09	Joint angle change: 0.80 Ground reaction force: 0.65
PC5	0.647	7.14	95.23	EMG activity: 0.72

PCA analysis reveals that the performance of long jump is comprehensively influenced by many biomechanical factors, among which take-off speed, horizontal displacement, vertical jump height, flying time, landing buffer time, maximum joint angle, average muscle strength, acceleration change, joint angle change and ground reaction force are the main influencing factors.

Using hierarchical clustering, athletes are grouped according to the similarity of their biomechanical parameters, and the technical characteristics and training needs of athletes in different groups are analyzed. As shown in **Figure 6**, 12 athletes were grouped by hierarchical clustering according to the similarity of their biomechanical parameters. Athletes located in the same branch or with short branch distance are more similar in biomechanical parameters, suggesting that they may have similar technical characteristics and sports performance; On the contrary, athletes who are located in different branches or have a long distance from branches show great parameter differences, indicating that these athletes may need personalized targeted training. Based on this clustering result, coaches and sports scientists can make more personalized training plans to optimize technical movements and improve sports performance.

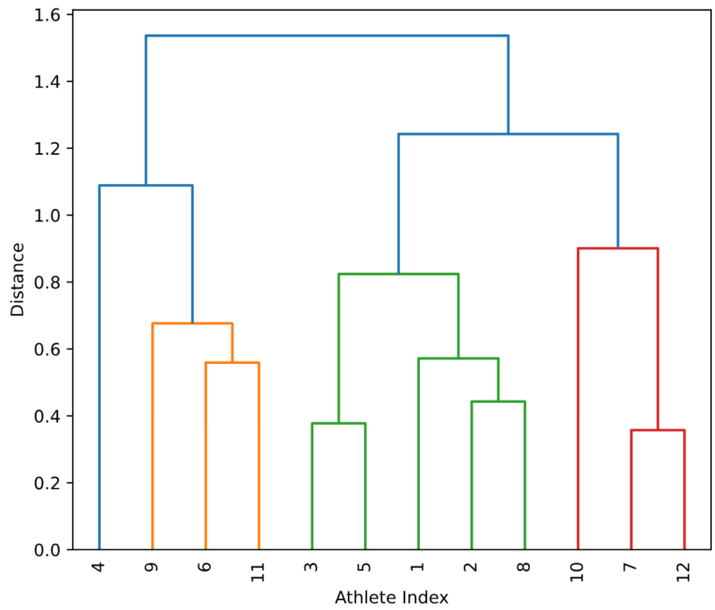

Figure 6. Athletes clustering based on biomechanical parameters.

5. Discussion

The experimental results show that after four weeks of training, the average long jump performance of athletes has improved significantly. The enhancement of take-off strength is one of the key factors to improve the performance of long jump. Through training, the athletes' take-off strength is significantly increased, which helps them to obtain greater initial speed in the take-off stage, thus jumping further. The improvement of flying time and landing angle also contributes to the improvement of long jump performance. Athletes can maintain a better posture in the air, extend the flying time, and land at a more optimized angle, reducing energy loss. The changes of joint angle and EMG activity show that athletes adjust their technical movements during training, which makes muscle activation more coordinated and efficient, thus improving their sports performance.

Through the method of sports biomechanics, this paper deeply analyzes the technical movements and biomechanical parameters of long jumpers, which provides a new perspective for understanding the mechanical mechanism of long jump. It is found that the parameters such as take-off strength, flying time and landing angle have important influence on the performance of long jump, which further enriches the theoretical system of long jump. The formulation and implementation of personalized training plan significantly improved the athletes' long jump performance and proved the effectiveness of this method. This can provide scientific training guidance for coaches and athletes and help them improve their sports performance more effectively. At the same time, the test methods and data analysis methods in this study can also provide reference for other sports research.

Compared with the existing literature [22], this study shows remarkable innovation and uniqueness in the field of biomechanics of long jump, and its academic value and practical significance can not be underestimated, which are embodied in the following aspects, and these innovations will have a far-reaching impact on future research and coaching practice.

First of all, a major innovation of this study is to comprehensively and deeply evaluate the biomechanical characteristics of athletes by combining a variety of advanced testing methods. Previous studies are often limited to a single testing method, such as only using a high-speed camera to analyze the action form, or only relying on a mechanical platform to measure the ground reaction force, which leads to a one-sided and incomplete understanding of the biomechanical characteristics of athletes. In this study, high-speed camera, three-dimensional motion capture system, mechanical sensor and other advanced equipment are integrated to obtain the mechanical and kinematic data of athletes in the process of sports from multiple dimensions at the same time. This comprehensive test method not only improves the accuracy and reliability of the data, but also provides us with the possibility to understand the biomechanical characteristics of long jumpers more comprehensively. This innovation is consistent with the trend of multi-dimensional and comprehensive evaluation emphasized in biomechanical research in recent years [23], which provides new ideas and methods for future research.

Secondly, this study adopted a personalized training plan, and made targeted improvements for each athlete's technical problems. This innovation embodies the concept of precise and individualized training and is a great progress in the field of sports training. Previous research and training practice often adopted a "one size fits all" training method, ignoring the individual differences among athletes. In this study, through in-depth analysis of the biomechanical parameters and technical problems of each athlete, a personalized training plan was tailored for them. This training method not only improves the training effect, but also reduces the risk of sports injury caused by improper training. This discovery is consistent with the trend of individualized training emphasized in the field of sports science in recent years [24], which provides new guidance and reference for coaching practice.

Finally, this study deeply explored the relationship between biomechanical parameters and long jump performance through data analysis. Although previous studies have also discussed the influence of biomechanical parameters on long jump performance, they often stay in descriptive analysis at the surface level, lacking in-depth excavation and discussion. In this study, advanced statistical analysis methods and machine learning algorithms are used to deeply analyze and mine a large number of data, revealing the internal relationship and law between biomechanical parameters and long jump performance. This discovery not only deepens our understanding of the biomechanical mechanism of long jump, but also provides a powerful theoretical support and prediction tool for future research and coaching practice.

For future research, the innovation of this study provides a new research direction and thinking. For example, we can further explore the application of more advanced testing methods in the biomechanical research of long jump to obtain more comprehensive and accurate data; We can deeply study the application effect of personalized training plan in athletes of different events and levels to verify its universality and effectiveness. The relationship between biomechanical parameters and other sports performance indexes can be further explored to build a more perfect sports performance prediction model.

For coaching practice, the innovation of this study has high application value. According to the results of this study, coaches can use a variety of testing methods to comprehensively evaluate athletes, formulate personalized training plans, and monitor the training effect and progress of athletes through data analysis. This will help to improve the scientificity and efficiency of training and improve the athletes' performance and competitive level. Therefore, the innovation of this study not only promotes the development of biomechanics research of long jump, but also provides new guidance and support for coach practice, which has far-reaching academic value and practical significance.

Although some achievements have been made in this study, there are still some limitations. For example, the small sample size may limit the universal applicability of the results. Future research can further expand the sample size and verify the stability and reliability of the results of this study. In addition, we can explore the relationship between more biomechanical parameters and long jump performance, and the influence of different training methods on athletes' technical movements and biomechanical characteristics, so as to provide more comprehensive theoretical support and practical guidance for scientific training of long jump.

6. Conclusions and suggestions

Through the experimental analysis of 12 professional long jumpers, this paper reveals the remarkable role of sports biomechanics in optimizing the effect of physical training. It is found that through the analysis of sports biomechanics, athletes' sports skills can be quantitatively evaluated, existing problems and deficiencies can be found out, and targeted improvement suggestions can be put forward. Specifically, after four weeks of training, the average long jump performance of athletes has been significantly improved, and the parameters such as take-off strength, flying time and landing angle have been significantly improved. This shows that personalized training plan can effectively improve athletes' sports performance.

The research suggestions include: firstly, advanced equipment such as high-speed camera and dynamometer should be further popularized and applied to improve the accuracy and reliability of data capture and analysis. Secondly, expand the sample size and diversify the research objects, explore the relationship between more biomechanical parameters and long jump performance, and verify the stability and universality of the results. Furthermore, according to the biomechanical characteristics of individual athletes, a personalized training plan is formulated to optimize technical movements and improve sports performance. In addition, the relationship between biomechanical parameters and sports performance is deeply discussed by principal component analysis and hierarchical clustering, so as to better understand the technical advantages and disadvantages and improve the space. Finally, combining modern science and technology, such as three-dimensional tracking camera, three-dimensional plantar pressure distribution test and human motion simulation technology, we will deepen the application of research methods and technologies and promote new breakthroughs in the field of sports biomechanics.

Applying the theory and method of sports biomechanics to sports training practice can not only improve athletes' performance, but also reduce the occurrence of sports injuries and prolong their sports life. At the same time, this study can also provide scientific training guidance for coaches and improve their training level and efficiency. Therefore, this study has important theoretical and practical value, and has positive significance for promoting the development of sports science and improving the level of competitive sports.

Author contributions: Conceptualization, XG and WX; methodology, XG; software, XG; validation, XG and WX; formal analysis, XG; investigation, XG; resources, XG; data curation, XG; writing—original draft preparation, XG; writing—review and editing, XG and WX; visualization, XG; supervision, XG; project administration, XG; funding acquisition, XG and WX. All authors have read and agreed to the published version of the manuscript.

Ethical approval: Not applicable.

Conflict of interest: The authors declare no conflict of interest.

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