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Article

Application of biomechanical analysis based on IoT and deep learning in college basketball education

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Abstract: With the continuous progress of sports science, the application of biomechanics in sports training has become an important tool to enhance sports performance and prevent sports injuries. Basketball, as a collective and confrontational sport, involves a large number of complex technical movements, such as shooting, dribbling, and jumping, which require precise mechanical regulation. The study of biomechanics can provide theoretical support for basketball teaching in colleges and universities, help optimize athletes' technical movements, enhance training effects, and reduce sports injuries. Biomechanics is based on mechanical principles such as Newton's laws of motion, kinematics, and dynamics, which can be effectively applied to basketball technical movements. For instance, in shooting, the motion can be divided into preparation, force application, release, and follow-through phases. Newton's Second Law ($F = ma$) explains how the applied force influences the acceleration of the ball, while projectile motion principles determine the optimal angle and velocity for achieving maximum shooting accuracy. The Magnus effect also plays a role in guiding spin-based shooting techniques, affecting ball trajectory and stability. In dribbling, biomechanical analysis involves understanding how impulse (Impulse = Force × Time) affects ball control. By adjusting wrist force and contact time with the ball, players can improve dribbling efficiency and control under defensive pressure. Additionally, energy transfer and ground reaction forces are critical in jumping mechanics. Using the principles of conservation of momentum and the stretch-shortening cycle, athletes can maximize jump height and power through optimized force application and body positioning. This paper explores the application of biomechanics in college basketball teaching through experimental research. The experimental subjects are college basketball players, and biomechanical analysis of basketball technical movements (shooting, dribbling, jumping, etc.) is conducted using high-precision equipment such as motion capture systems and force platforms. The study collects physical data, mechanical characteristics, and sports performance data of the athletes during the execution of basketball technical movements, analyzing them in combination with biomechanical principles. This approach provides an in-depth understanding of movement efficiency and technique optimization. The results of the study show that training programs optimized through biomechanical analysis can significantly improve athletes' technical performance. In shooting, dribbling speed, and jumping height, the experimental group demonstrated superior results compared to the control group, with statistically significant differences. Specifically, the shooting percentage of athletes in the experimental group increased by 6.3%, the dribbling speed improved by 9.6%, and the jumping height increased by 10.4%. These improvements confirm that the application of biomechanics in basketball teaching not only enhances performance but also reduces the risk of sports injuries by refining movement mechanics and optimizing force distribution. By integrating biomechanics into basketball training, educators and coaches can develop more scientifically grounded training methodologies, improving player efficiency while ensuring long-term physical well-being. This study highlights the necessity of incorporating mechanical principles in skill development, reinforcing the role of biomechanics in advancing sports education and training strategies.

Keywords: biomechanics; basketball performance; IoT; Faster-RCNN; deep learning; psychological resilience; motion analysis

1. Introduction

With the continuous development of science and technology, the application of biomechanics in physical education is becoming more and more extensive, especially in the training of basketball and other collective sports [1]. As a discipline that studies the interaction between human movement and mechanics, biomechanics is able to reveal in depth the coordination and force distribution between various parts of the body of an athlete in the process of movement [2]. Through scientific sports analysis, it can optimize sports skills, improve sports performance, and effectively reduce sports injuries. In college physical education, basketball, as a technical and confrontational sport, has become an important program for students' physical education and athletic ability improvement. How to improve students' basketball skill level and athletic performance through scientific means has become a key issue in physical education research [3,4].

In traditional basketball training, coaches usually rely on experience and intuition to instruct their athletes; however, this approach often fails to fully and accurately reveal the technical details and potential problems of the athletes in the sport [5]. With the advancement of sports science, biomechanics has begun to provide a new perspective and approach to basketball instruction. By accurately analyzing athletes' movements, biomechanics can help coaches identify subtle gaps in athletes' technical movements and provide targeted suggestions for improvement [6]. For example, in basketball shooting, by analyzing the trajectory of the shooter's movements, the body angle and the force exerted, the shooting posture can be optimized, thus improving the accuracy and stability of the shot.

The core value of biomechanics lies in its ability to reveal the movement characteristics and force distribution of athletes when performing technical movements through mechanical modeling and kinematic analysis [7]. This not only helps to optimize motor skills, but also provides precise feedback during the athlete's training process, thus improving his or her technical level. Taking basketball as an example, when athletes perform movements such as jump shot, dribbling and defense, every subtle change of the body will have an important impact on the effect of the movement [8,9]. Through the quantitative analysis of the athlete's movements, biomechanics can help coaches identify the problem areas and develop more personalized and scientific training programs.

In addition, the application of biomechanics in basketball teaching in colleges and universities is not only limited to the optimization of technical movements, but the deeper value lies in its ability to help athletes improve the body's movement efficiency and reduce sports injuries [10]. Basketball as a high-intensity sport, athletes are prone to various sports injuries, such as knee and ankle injuries, during intense confrontation and high-frequency sports. Biomechanics can help students understand their unreasonable postures and movement patterns in sports and correct them in training through accurate analysis of athletes' body mechanical characteristics. By correcting bad sports habits, not only can sports performance be improved, but also the incidence of sports injuries can be effectively reduced [11,12].

The introduction of biomechanics in college basketball education not only improves training methods, but also promotes the overall improvement of students' basketball skills. In particular, biomechanics provides more scientific and precise guidance in the improvement of technical details and athletic performance [13]. For example, using the principle of biomechanics, coaches are able to quantitatively analyze the efficiency of students' movements during dribbling and shooting, so as to prescribe the right medication and formulate a training program that is more in line with the actual situation of students [14]. Biomechanics can also combine psychology and physiology to provide strong support for the improvement of students' comprehensive ability. In competitions with high psychological pressure, athletes' emotions and mentality often affect their technical performance, while biomechanics can help students enhance their self-confidence and psychological adjustment ability by improving the stability and fluency of their movements, so that they can perform better in competitions [15].

At present, with the continuous progress of artificial intelligence, data analysis and sensor technology, the application prospect of biomechanics is getting broader and broader. Through intelligent training tools, coaches can track the athletes' trajectory in real time and obtain data about technical movements and physiological indicators, so as to assess and adjust the training effect of students in a timely manner [16]. In the future, the combination of biomechanics with big data, artificial intelligence and other technologies will bring revolutionary changes to college basketball teaching. Students' athletic ability improvement will no longer rely on pure traditional training, but will be maximized through more personalized and data-driven training programs [17].

In conclusion, the application of biomechanics in college basketball teaching not only provides students with more scientific training methods and technical support, but also provides a new direction for the innovative development of basketball education. Through accurate analysis of athletes' movement patterns, force distribution and physiological feedback, biomechanics can provide students with personalized training programs to effectively improve their athletic ability and competition level, thus contributing to the cultivation of well-rounded sports talents.

2. The application of biomechanics in teaching basketball in college physical education

Due to the extensive use of biomechanics in sports, basketball has emerged as a major component of college and university physical education programs. By using mechanical principles to analyze human movement, biomechanics can help coaches and students better understand how basketball technical movements work, maximize athletic performance, and minimize injuries, all of which can raise competition levels and increase training effectiveness [18]. The accurate examination of technical elements in collegiate basketball instruction can be achieved by integrating the pertinent biomechanics theories and techniques, resulting in more scientific training regimens.

This chapter will focus on the application of biomechanics in basketball teaching in colleges and universities, specifically covering the analysis of technical movements, the construction of mechanical models, the optimization of sports performance, and injury prevention, etc. Through the demonstration of illustrations, formulas, and specific cases, it will analyze in depth the practical value and application effect of biomechanics in basketball teaching.

2.1. Biomechanics in the analysis of basketball technique

Basketball is a sport that contains a variety of complex techniques, in which shooting, dribbling, passing, defense, rebounding and other actions involve the synergistic cooperation of multiple joints and muscle groups [19]. The completion of each technical action is subject to mechanical principles, and biomechanics can reveal the kinematic and kinetic characteristics of these technical actions through quantitative analysis, thus providing athletes with more scientific training guidance.

Biomechanical analysis can accurately measure the mechanical parameters of the athletes in accomplishing different technical movements, such as changes in joint angles, muscle activation patterns, ground reaction forces, trajectories and energy conversion efficiency. For example, in the analysis of shooting technique, biomechanical research can quantify the changes of shooting angle, wrist torque, lower limb force pattern and body center of gravity, so as to optimize the shooting posture and improve the stability and hitting rate of shooting. In dribbling technology, biomechanics can analyze hand control, wrist angle and ball rebound trajectory to optimize dribbling rhythm and stability and improve ball control. In jumping for rebounds and defensive blocking, biomechanics can help study the forces on the knee and ankle joints and optimize the jumping action to increase the height of the bounce and reduce the risk of sports injuries.

In addition, with the development of sports science, the application of high-precision equipment such as motion capture systems, force measurement platforms, electromyography (EMG) and other high-precision equipment has made the role of biomechanics in the technical analysis of basketball more and more significant. Through these advanced analysis tools, coaches and athletes can obtain accurate sports data, develop personalized training programs for individual sports characteristics, and improve the efficiency and stability of technical movements.

In summary, the application of biomechanics in basketball technical analysis can not only help athletes understand the mechanical mechanism of their own movements, but also provide a scientific basis for training and technical optimization, thus improving the overall level of competition. In the future, with the further development of biomechanics technology, its application in basketball teaching and training will be more extensive and in-depth.

2.1.1. Biomechanical analysis of the shooting motion

Shooting is one of the most basic and important techniques in basketball, and optimizing the shooting action can significantly improve the shooting percentage. Shooting movement involves the coordination of upper limbs, trunk and lower limbs, especially the force and trajectory generated by each part of the body have a decisive influence on the shooting effect. Biomechanics, through kinematic and kinetic analysis, can reveal the movement laws and mechanical characteristics of body parts during the shooting process [20].

When shooting, the athlete drives the upper limbs to shoot through the flexion and extension of the knee and hip joints. The action process of shooting can be divided into the following stages, such as **Figure 1**, a schematic diagram of the shooting action, showing the mechanical analysis of various parts of the body when shooting. Squatting preparation stage: the athlete's legs are bent, and the knee and hip joints form an approximate 90° angle. At this point, the muscles generate an elastic force reserve to provide power for the explosive movement that follows. Jump-up phase: the athlete generates an upward force through the explosive force of the leg muscles to propel the body upward in the jump-up phase. During this phase, the flexion and extension of the knee joint is the key to generating vertical upward force. Shooting phase: After the athlete jumps up, the upper body movement starts to shoot the basketball. The shoulder and elbow joints cooperate to produce the rotational force of shooting, while the wrist force determines the rotation and flight trajectory of the basketball.

Figure 1. Schematic of the mechanical analysis of the shooting motion.

In the shooting maneuver, the key factors affecting the hitting rate include the shooting angle, the amount of shooting force, and the wrist force during shooting [21]. Through biomechanical analysis, coaches can derive specific formulas to optimize the mechanical characteristics of the shooting motion. For example, the use of parabolic formulas can help analyze the trajectory of basketball flight:

$$y = x\tan(\theta) - \frac{g}{2v^2\cos^2(\theta)}x^2 \tag{1}$$

where y is the height of the shooting trajectory, x is the horizontal distance, θ is the shooting angle, g is the gravitational acceleration, and v is the initial velocity of the shooting. By adjusting the shooting angle θ and initial velocity v, the shooting percentage can be maximized.

2.1.2. Biomechanical analysis of dribbling movements

Dribbling is a complex dynamic skill in basketball that involves a player's rapid movement and reaction ability. During dribbling, biomechanical analysis mainly focuses on the coordination of the limbs and the fluidity of movements. In particular, the coordination of the upper and lower limbs and the control of the center of gravity of the body have a direct impact on the stability and speed of dribbling [22].

The amplitude and frequency of hand motions, along with the preservation of the body's center of gravity, are crucial aspects of dribbling action in biomechanics. In order to propel the basketball to rebound along the ground, athletes must repeatedly flex their wrists and extend their elbows while dribbling. A schematic diagram of the mechanical analysis of the dribbling motion is presented in **Figure 2**, which illustrates how the hand and lower limb work together to generate force. The athlete must always maintain the body's center of gravity below the ankle to prevent errors brought on by an unstable center of gravity and to guarantee the stability and continuity of dribbling.

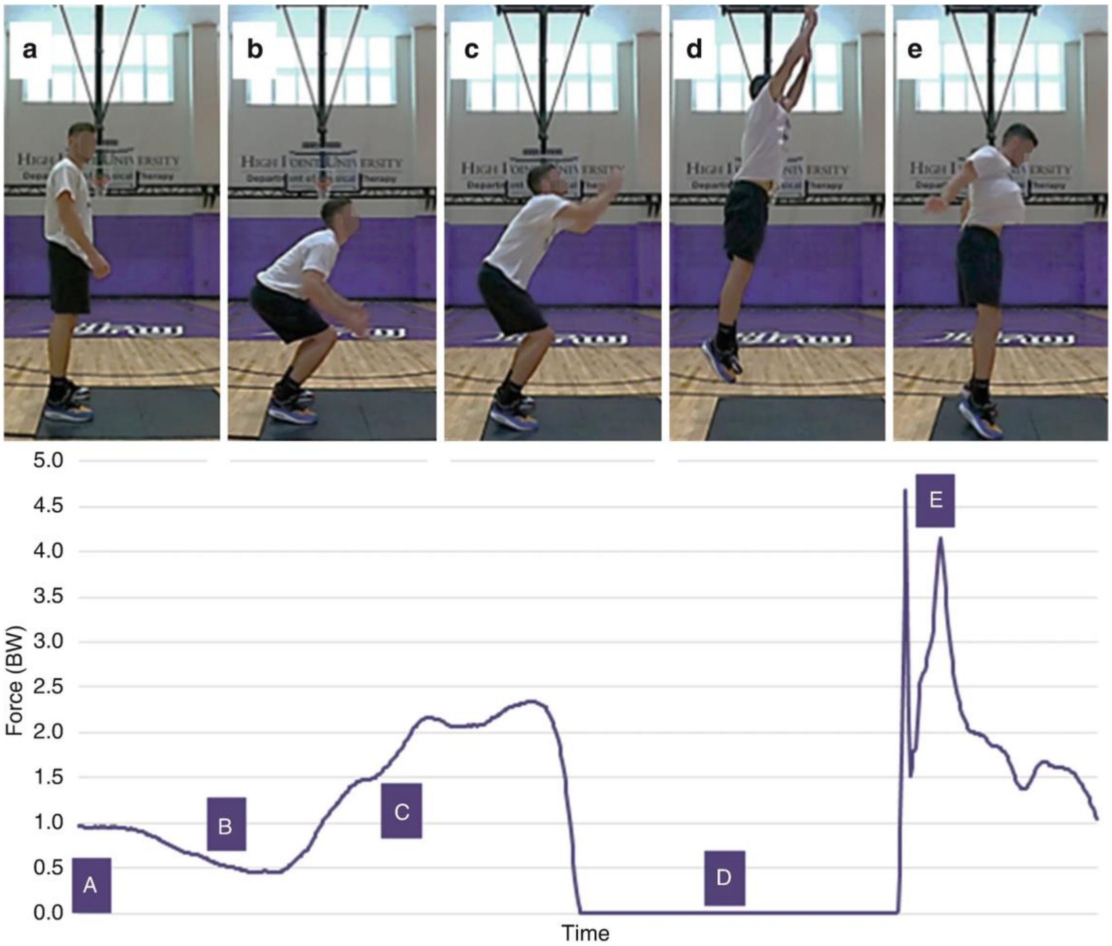


Figure 2. Schematic of force analysis of dribbling action.

2.2. Biomechanics in basketball injury prevention

Basketball being a high-intensity sport, athletes are susceptible to sports injuries when practicing or playing against each other. Common injuries include knee sprains, ankle sprains, and muscle strains. Biomechanics can effectively prevent these injuries by analyzing athletes' movement patterns.

2.2.1. Biomechanical analysis of knee injuries

The knee joint is one of the most injury-prone parts of basketball. Especially in the process of jumping, landing and rapid change of direction, the knee joint endures a large amount of impact force. Biomechanical analysis indicates that knee injuries are often closely related to the athlete's jumping technique and landing position.

During a jump, the flexion and extension motion of the knee generates a large grounding reaction force. When landing, if the athlete's knee joint is in a state of hyperextension, it will easily lead to knee injuries. In order to reduce the risk of injury, athletes should keep the knee joint in proper flexion angle when landing through reasonable force distribution and technical adjustment, so as to minimize the damage to the joint caused by the impact force.

2.2.2. Biomechanical analysis of ankle injuries

The ankle joint is another injury-prone area in basketball. During high-speed running, change of direction and jumping, the ankle joint is often subjected to large external forces, resulting in sprains or strains. Biomechanical research shows that ankle valgus or inversion movements can easily lead to ankle injuries, especially during rapid change of direction, valgus movements are prone to occur.

Figure 3 shows the injury analysis of the knee and ankle joints, showing the force changes in the knee and ankle joints under different movement patterns. By monitoring and analyzing ankle movement patterns, athletes can be helped to identify potential sports risks. For example, using dynamic motion capture technology, an athlete's foot trajectory can be accurately measured to optimize his/her running and jumping movements.

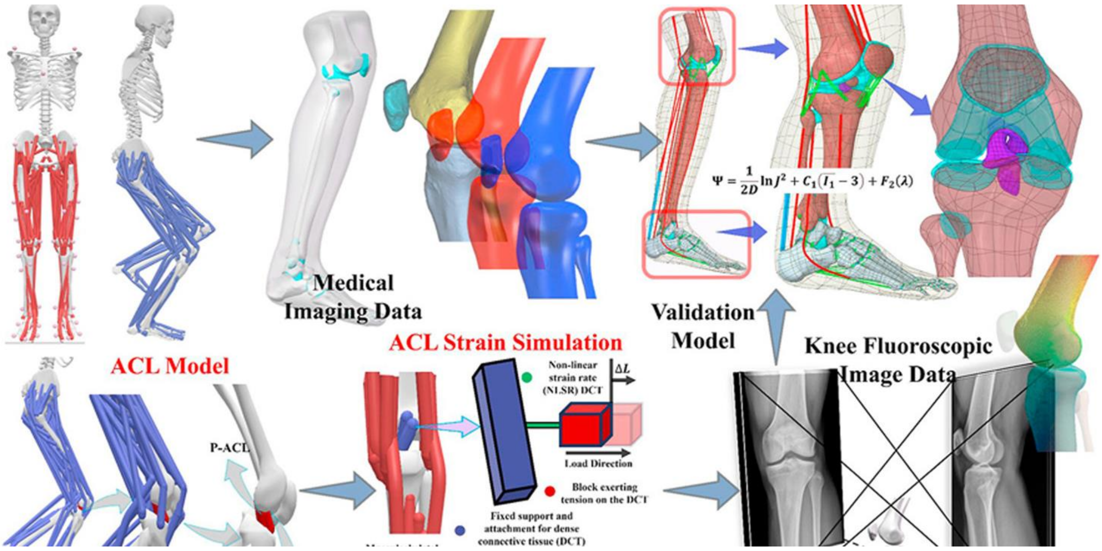


Figure 3. Schematic of biomechanical analysis of knee and ankle injury prevention.

2.3. Personalized application of biomechanics in basketball training

With the continuous progress of data analysis technology and motion sensor technology, the personalized application of biomechanics in basketball training has become possible. By wearing high-precision sensors, athletes can monitor the biomechanical characteristics of their own technical movements in real time, while coaches can precisely adjust the training content and intensity of training according to the data fed back from the sensors, so as to formulate a training program that better meets the needs of individuals.

The core of biomechanical personalized training is to accurately analyze the athlete's movement pattern and physiological load. For example, through inertial sensors, force measurement platforms and electromyography (EMG) equipment, it is possible to measure the mechanical parameters of the athlete's key movements, such as joint angles, ground reaction forces, muscle activation patterns and energy consumption, during shooting, dribbling and jumping. Based on this data, coaches can identify potential deficiencies in an athlete's technical movements and target and optimize training methods. Example:

Shooting optimization: Analyze wrist angle, release point height and shooting trajectory to optimize shooting posture and improve hitting rate.

Jumping training: monitoring the stress on the knee and ankle joints, optimizing the sequence of force generation, enhancing explosive power, and improving the height of the bounce.

Dribbling and pace adjustment: Measuring the athletes' hand control, ball rebound time and body center of gravity change when dribbling, optimizing the dribbling rhythm, enhancing the stability of ball control and breakthrough ability.

In addition, personalized training combines artificial intelligence and deep learning technology, which can analyze the training performance of different athletes through big data and automatically generate personalized improvement suggestions. For example, machine learning algorithms are used to analyze long-term training data to predict athletes' risk of sports injuries and adjust training intensity in advance to reduce the probability of injury. This data-driven training model not only improves the scientific and targeted nature of training, but also significantly improves the athletes' competitive performance.

Overall, the personalized application of biomechanics in basketball training provides athletes with more precise and efficient training tools. In the future, with the further development of wearable devices, smart sensors and artificial intelligence technology, personalized biomechanics training will become an important direction of basketball training, helping athletes make continuous breakthroughs in technology and competitive level.

2.3.1. Motion capture technology and analysis

Motion capture technology can help coaches accurately track athletes' technical movements and provide quantifiable data for training. These data include not only the athlete's speed and acceleration, but also body joint angles, strength distribution and other indicators. Through the analysis of these data, coaches can develop a personalized training plan for each athlete.

For example, through the motion capture system, coaches can accurately analyze the athletes' jumping and shooting movements, dribbling postures, etc., to find the technical defects and correct them. Through long-term data accumulation and analysis, athletes' technical movements will be gradually optimized, thus improving the overall competitive level.

2.3.2. Data-driven assessment and feedback

Data-based evaluation and feedback are becoming more and more crucial in college basketball instruction as kinesiology and biomechanics are combined. To optimize the training effect, instructors can make real-time adjustments to training material by evaluating athletes' movement data. Personalized training regimens can assist athletes of various body types and abilities enhance their basketball skills more effectively.

3. Real scenario program

3.1. Faster-RCNN model

In the middle of teaching (the eighth week) and the later period (the sixteenth week), the two-teaching classes were measured again for the shooting percentage, state anxiety, and athlete level. During the whole experiment, reasonable emotions were required. The therapy experimental group and the control group tried their best not to practice one-handed over-shoulder shooting techniques after class, so as to strive for the reliability of the experimental results. As shown in **Figure 4**:

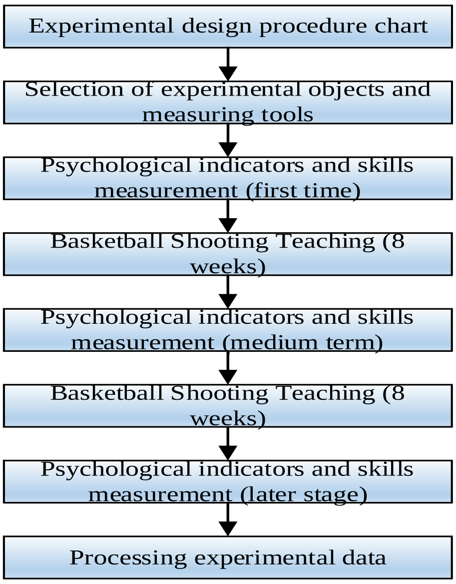


Figure 4. Schematic diagram of psychological indicators.

According to the analysis results in **Table 1**, the experimental group and the control group of rational emotion therapy are basically at the same level in the pre-experiment level homogeneity test, the shooting rate, state anxiety, and stress total scores are basically at the same level, which meet the statistical requirements.

Table 1. Independent sample *T*-test of shooting percentage, state anxiety, and psychological stress between groups in the early stage of the experiment.

	Experience group	**Control group**	***t***	***P***
State anxiety	42.73 ± 6.726	43.86 ± 8.482	−0.606	0.544
Shooting percentage	2.55 ± 1.739	2.46 ± 1.422	0.375	0.705
Total pressure score	51.81 ± 8.141	50.00 ± 5.217	1.117	0.265

In the comparison of various dimensions of the athlete level, it was found that there were significant differences in the two dimensions of life and life events, the differences in social and negative events were close to significant, and the other dimensions of learning, development of family, and positive events and life trivia (no significant differences were shown. The differences in overall athlete level scores between the two groups tended to be marginally significant. As shown in **Tables 2** and **3**:

Table 2. Independent sample *T* test of shooting percentage and state anxiety between groups in the middle of the experiment.

	Experience group	Control group	*t*	*P*
State anxiety	39.44 ± 5.866	45.76 ± 8.766	−3.521	0.001
Shooting percentage	4.53 ± 1.266	3.53 ± 1.962	2.535	0.013

Table 3. *T*-test for independent samples of psychological stress levels between groups in the middle of the experiment.

Dimension	Experience group	Control group	*t*	*P*
Study	53.25 ± 5.323	53.91 ± 3.695	−0.624	0.536
Life	49.88 ± 5.644	52.47 ± 5.115	−2.044	0.043
Development	48.86 ± 4.186	49.75 ± 3.146	−1.003	0.322
Social contact	49.96 ± 7.135	52.82 ± 5.678	−1.856	0.066
Family	43.15 ± 2.547	43.36 ± 2.494	−0.286	0.777
Positive event	44.56 ± 7.582	44.43 ± 5.765	0.055	0.956
Negative events	46.53 ± 4.482	48.15 ± 3.146	−1.792	0.077
Life events	47.53 ± 3.223	49.15 ± 2.547	−2.385	0.020
Trivia of life	51.46 ± 5.236	52.75 ± 3.333	−1.223	0.222
Total pressure score	49.15 ± 3.876	50.62 ± 2.486	−1.875	0.066

3.1.1. Tables 2 and 3 analysis of results

Table 2: Independent samples *T*-test analysis—between groups comparison of shooting percentage and state anxiety.

This table shows the differences in state anxiety and shooting percentage between the experimental group and the control group at mid-experiment.

- State anxiety: the mean score of the experimental group was 39.44 ± 5.866, while the mean score of the control group was 45.76 ± 8.766, with a *t*-value of −3.521 and a *p*-value of 0.001 ($p < 0.05$), indicating that the difference between the two groups was significant. The state anxiety level of the experimental group was significantly lower than that of the control group, indicating that the experimental intervention may have effectively alleviated the players' anxiety.
- Shooting percentage: The average shooting percentage of the experimental group was 4.53 ± 1.266, while that of the control group was 3.53 ± 1.962, with a *t*-value of 2.535 and a *P*-value of 0.013 ($P < 0.05$), indicating that the shooting percentage of the experimental group was significantly higher than that of the control group. This suggests that the experiment may have had a positive impact on the players' shooting performance by increasing the hitting rate.

Taken together, the experimental intervention may have improved the shooting percentage while reducing the anxiety level of the players, further validating the effectiveness of biomechanical training or psychological intervention methods.

Table 3: Independent samples *T*-test analysis—comparison of psychological stress levels between groups.

This table compares the differences in psychological stress levels between the experimental and control groups on different dimensions.

- Academic stress (study): the difference between the experimental group (53.25 ± 5.323) and the control group (53.91 ± 3.695) is not significant (p = 0.536), indicating that the experimental intervention has less impact on academic stress.
- Life stress (life): the mean of the experimental group (49.88 ± 5.644) was significantly lower than that of the control group (52.47 ± 5.115), $t = -2.044$, $P = 0.043$ ($P < 0.05$), indicating that the experimental group's life stress was reduced.
- Developmental stress (development): the difference between the experimental group (48.86 ± 4.186) and the control group (49.75 ± 3.146) was not significant ($P = 0.322$).
- Social contact: slightly lower in the experimental group (49.96 ± 7.135) compared to the control group (52.82 ± 5.678), $t = -1.856$, $P = 0.066$, which is close to the level of significance but not statistically significant difference.
- Family stress (family): no significant difference ($P = 0.777$) between the experimental group (43.15 ± 2.547) and the control group (43.36 ± 2.494).
- Positive event (positive event): the data of the two groups (44.56 ± 7.582 vs. 44.43 ± 5.765) are basically the same, $P = 0.956$, no significant difference.
- Negative event: the experimental group (46.53 ± 4.482) was slightly lower compared to the control group (48.15 ± 3.146), but the difference did not reach the level of significance ($P = 0.077$).
- Life events (life events): the experimental group (47.53 ± 3.223) was significantly lower than the control group (49.15 ± 2.547), $t = -2.385$, $P = 0.020$ ($P < 0.05$), suggesting that the experimental group had lower life event stress.
- The differences between the trivia of life and total pressure score groups did not reach the level of significance ($P > 0.05$).

3.1.2. Integrated analysis

1) Improvement of anxiety and shooting performance: The experimental group was significantly better than the control group in terms of state anxiety and shooting percentage, indicating that the experimental intervention may be effective in relieving anxiety and improving basketball technical performance.

2) Reduction of life stress: the experimental group was significantly lower in the dimensions of life stress and life event stress.

Based on the analysis and comparison of various algorithms for deep learning convolutional neural network target detection. The emergence of YOLO has further improved the processing speed of target detection, but YOLOv1 and YOLOv2 are not rich enough in multi-scale descriptions, resulting in low accuracy; in YOLOv3 in 2018, the problem of insufficient multi-scale was solved. In the end, this paper chooses Faster-RCNN with high robustness and slightly slower speed as the target detection algorithm.

In this paper, a model based on Faster-RCNN is used for player object detection in basketball game videos. The main process of Faster-RCNN model generation is shown in **Figure 5**.

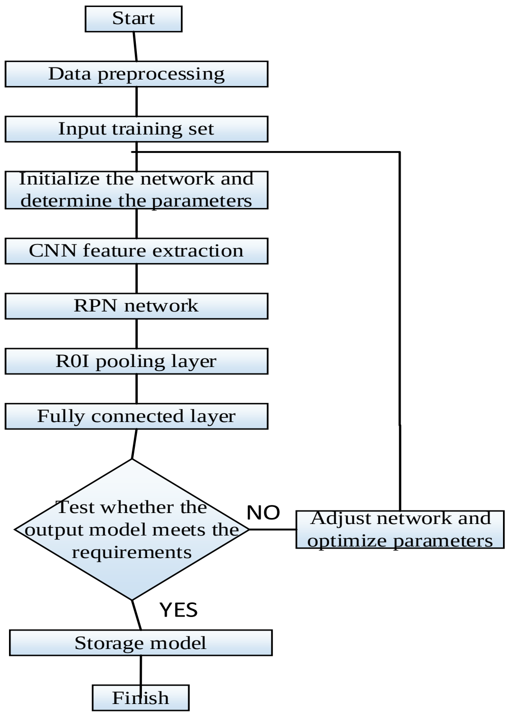


Figure 5. The main process of Faster-RCNN model generation.

To sum up, basketball players maintain a good and stable emotional state during training or competition, which is an important manifestation of their full use of their competitive level and skills and tactics. An athlete's ability to resist pressure in competition or training is one of the important conditions that affects his technical and tactical performance.

3.2. Mathematical analysis

Cognitive decision-making is considered analytical decision-making, emphasizing that decision-making is a high-level cognitive process. It is believed that there is a process of logical thinking in decision making. Intuitive decision-making mainly believes that it is a quick decision made by athletes without a logical thinking process based on their own training and competition experience in complex and changeable sports situations. Researchers generally believe that there will be a certain time difference between the two decisions due to different thinking styles. Therefore, in the previous decision-making research, the presentation of sports scene materials, whether using pictures or videos, is reflected by the length of the presentation time of the materials.

Anchor points are a way to represent candidate regions, an anchor point corresponds to a point in the feature map and has an associated scale and aspect ratio, as shown in **Figure 6**.

Figure 6. Candidate regions corresponding to nine different anchors.

There is no need to adjust the network parameters in the testing phase, and the trained model can be used directly. The specific steps are shown in **Figure 7**.

Finally, the model with 20,000 iterations was selected as the target detection model. The actual detection effect of the basketball game is shown in **Figure 7**. From left to right, the experimental results of the model generated by training with 5000, 20,000, and 30,000 iterations are respectively.

Figure 7. Comparison of the number of iterations in the experiment.

4. Case study

4.1. An experimental study of biomechanics in college basketball instruction

4.1.1. Experimental design

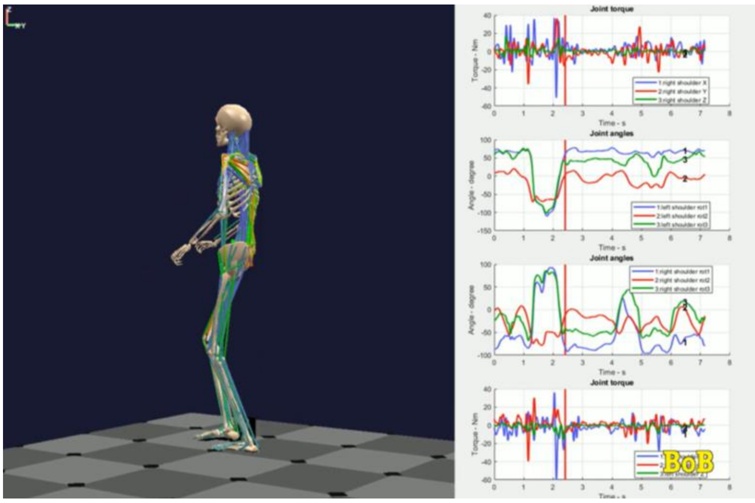
Taking the first-line students in college basketball teaching as the research object, this experiment aims to study the mechanical performance of the athletes when they are performing basic technical actions such as shooting, dribbling, jumping and so on through biomechanical analysis, and to explore how to optimize the teaching program according to the results of the experiment to improve the technical level of the athletes. The experiment mainly contains the following parts:

1) Basic data collection of athletes: basic physical and motor data collection of athletes in the experimental group and control group.
2) Basketball technical movement analysis: analyze the body posture and power distribution of athletes when they perform technical movements such as shooting, dribbling and jumping by means of high speed camera and motion capture system.
3) Athletic performance evaluation: Evaluate the difference in athletes' performance when performing technical movements through multi-dimensional performance tests.
4) Injury prevention analysis: Based on the biomechanical analysis results, assess the potential injury risk of athletes during training and competition.

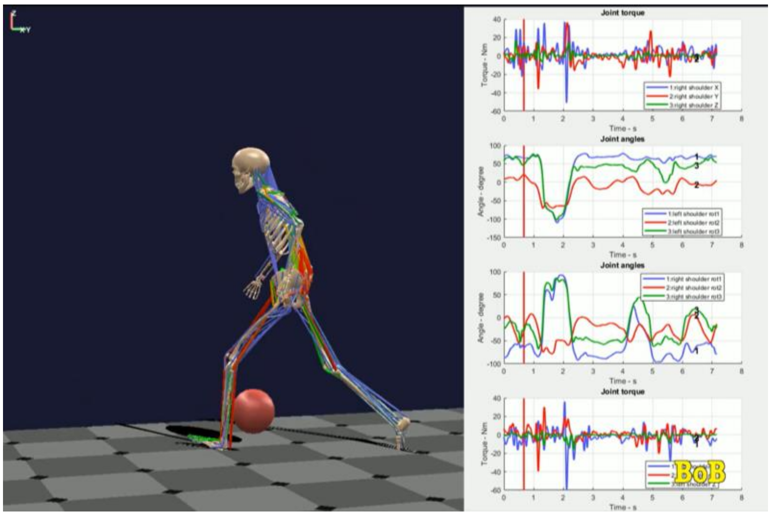
4.1.2. Experimental steps

Prior to the start of the experiment, all participating athletes were first measured for basic physical data, including height, weight, joint angles, muscle mass, and body fat percentage. These data provided basic information for subsequent analysis.

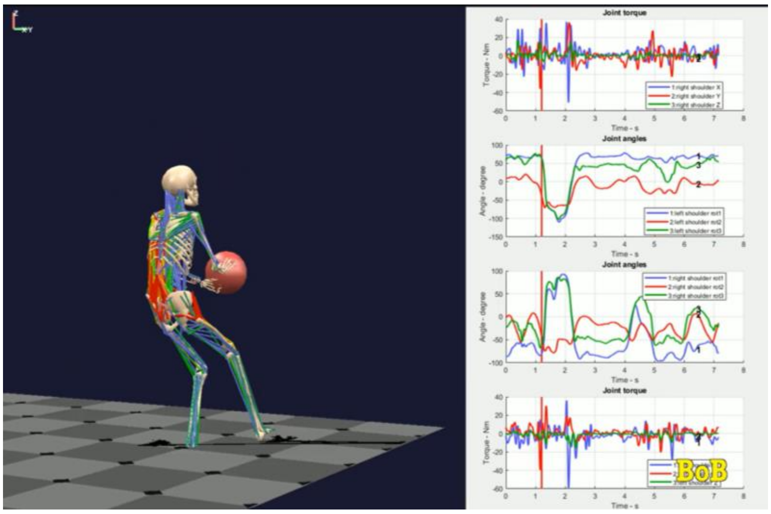
Next, the athletes were dynamically captured using a biomechanical motion analysis system (e.g., Vicon Motion Capture System). By attaching reflective marker points on the athlete's body, the camera can track and record the athlete's movement trajectory, joint angle and limb movement status in real time. **Figure 8** shows the real-time tracking of the movement trajectory of the reflective marker points when the athlete is performing the shooting action.



(a)



(b)



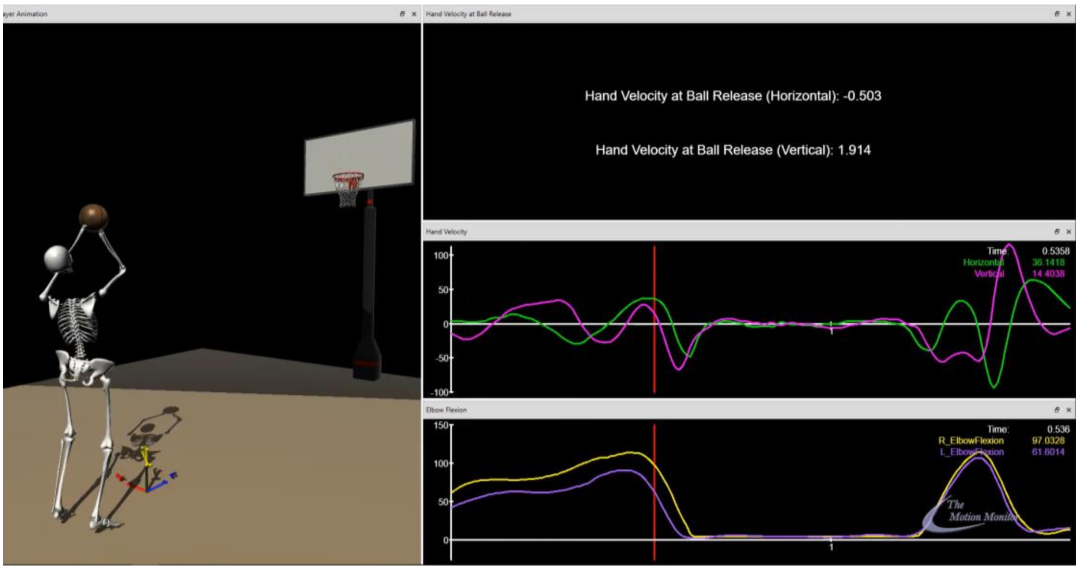
(c)

Figure 8. Schematic of athlete posture capture.

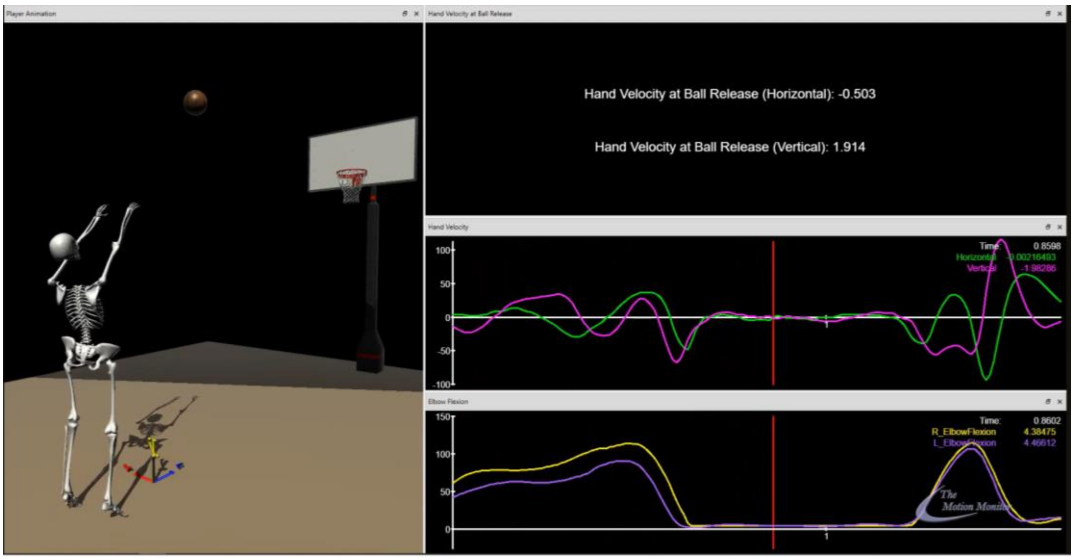
For the experiment, we chose three core technical movements: shooting, dribbling and jumping. **Figure 9** shows the schematic diagrams of the shooting, dribbling and jumping movements, demonstrating the mechanical changes under different movements. Through the combination of motion capture system and force platform, the mechanical characteristics of the athletes when performing these technical movements were recorded.

Note how the athlete distributes power and how well their upper and lower limbs coordinate during the shooting motion. Using a high-speed camera to record the activity, the wrist force and the elbow and shoulder joint trajectory are captured. Note the athlete's starting velocity, shot angle, and other information. While the athlete is dribbling at great speed, note how their body's center of gravity changes and how well their upper and lower limbs coordinate. Use the motion capture equipment to record the athlete's dynamic wrist, elbow, shoulder, and leg movements.

Measure the power changes before and after the athlete's jump, record the joint angle changes during the athlete's squatting, jumping and landing, and analyze the movement patterns of the knee, hip and ankle joints.



(a)



(b)

Figure 9. Schematic diagram of biomechanical analysis of shooting, dribbling and jumping movements.

4.1.3. Experimental results and analysis

As analyzed in detail in **Table 4**, the difference in height between the control group and the experimental group was very small, 169.73 ± 5.02 cm versus 169.54 ± 5.36 cm, and the difference between the two was only 0.19 cm, and the *T*-value was 1.147, with a *P*-value of greater than 0.05, which indicated that there was no significant difference in the data on height. These data indicate that the differences between the experimental and control groups in terms of basic body morphology (height and weight) are small and do not significantly affect the performance of basketball skills. Therefore, it can be assumed that the physical conditions of these two groups have a balanced effect on the experimental results.

The detailed analysis in **Table 5** shows that the dribbling time of the experimental group increased from 67.77 ± 8.66 s before the experiment to 85.73 ± 8.66 s after the experiment, a change of 17.96 s. *t*-value of 3.37 and *p*-value of less than 0.05 indicate that the change in dribbling time is statistically significant. The increase in dribbling time may indicate that the biomechanically optimized training methods were effective in enhancing the athletes' movement efficiency, possibly by improving their pace coordination and increasing their lower limb strength, which resulted in improved dribbling fluency and speed. The number of one-handed over-the-shoulder shots increased from 66.77 ± 7.55 to 84.75 ± 7.43, an increase of 17.98. The *T*-value was 3.43, and the *P*-value was less than 0.05, which indicated that the improvement in the number of shots was significant. The half-court round-trip dribble layup time decreased by 20 s from 63.54 ± 6.56 s before the experiment to 83.44 ± 8.56 s after the experiment. *t*-value was 3.23 and *p*-value was less than 0.05, indicating that the change was significant. The decrease in layup time indicated that the athletes in the experimental group were more efficient in layup movements, which might be closely related to the optimization of movements under the guidance of biomechanics, especially the effective improvement of the mechanical performance in the process of assisted running, jumping and shooting.

The detailed analysis in **Table 6** shows that the change in dribbling time of the control group increased from 67.77 ± 8.66 s to 75.53 ± 7.88 s with a change of 7.76 s and a *T*-value of 3.37 with a *P*-value less than 0.05, indicating an increase in dribbling time, suggesting that the control group may have limited improvement in dribbling skills and did not have a systematic training for biomechanical optimization. The number of shots increased from 66.77 ± 7.55 to 78.47 ± 8.33, an increase of 11.7, with a *T*-value of 3.43 and a *P*-value of less than 0.05, indicating an increase in the number of shots in the control group, but the change was small compared to the experimental group. The half-court round trip dribble lay-up time increased from 63.54 ± 6.56 s to 79.54 ± 9.35 s, an increase of 16 s, a larger change than the experimental group. *t*-value of 3.23 and *p*-value less than 0.05 indicate that the control group athletes showed less improvement in the lay-up time after training.

Table 4. Comparison of body shape test data between experimental and control groups.

Norm	Control subjects	Experimental group	*T*-value	*P*-value
Height (cm)	169.73 ± 5.02	169.54 ± 5.36	1.147	> 0.05
Weight (kg)	65.13 ± 4.84	66.15 ± 5.90	1.268	> 0.05

Table 5. Changes in basketball skill levels of experimental groups.

Technical indicators	Pre-laboratory	Post-experimental	*T*-value	*P*-value
Dribbling time (seconds)	67.77 ± 8.66	85.73 ± 8.66	3.37	< 0.05
Number of one-handed shoulder shots (times)	66.77 ± 7.55	84.75 ± 7.43	3.43	< 0.05
Half-court dribble-to-basket time (seconds)	63.54 ± 6.56	83.44 ± 8.56	3.23	< 0.05

Table 6. Changes in basketball skill levels of control groups.

Technical indicators	Control group before the experiment	Control group after the experiment	*T*-value	*P*-value
Dribbling time (seconds)	67.77 ± 8.66	75.53 ± 7.88	3.37	< 0.05
Number of one-handed over-the-shoulder shots	66.77 ± 7.55	78.47 ± 8.33	3.43	< 0.05
Half-court dribble-to-basket time (seconds)	63.54 ± 6.56	79.54 ± 9.35	3.23	< 0.05

4.2. Program performance

As an improved RCNN algorithm, Faster-RCNN inherits the advantages of the first-generation RCNN and the second-generation Fast-RCNN and improves the shortcomings. The biggest highlight is that based on Faster-RCNN target detection, operations such as feature extraction, candidate region selection, regression classification, etc., which are all integrated into a deep network, and the end-to-end network structure is successfully achieved. The framework of Faster-RCNN is mainly composed of: convolution layer, regional proposal network layer (RPN), feature map candidate region frame adjustment (Roi Pooling) classification and regression. As shown in **Figure 10**.

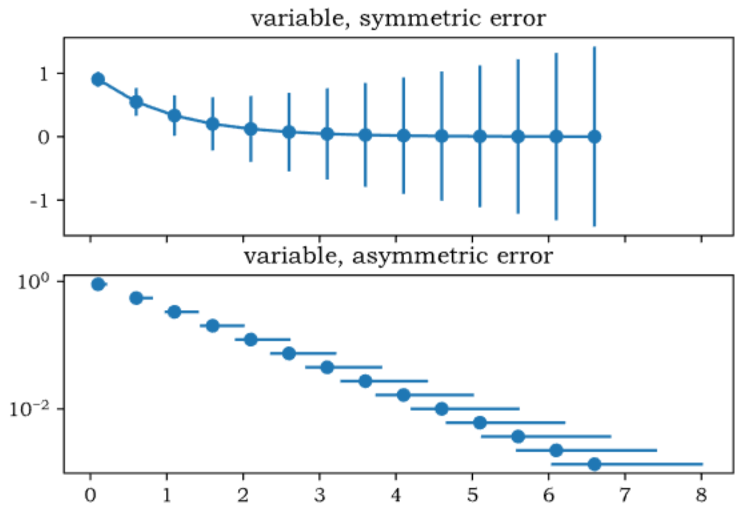


Figure 10. Faster-RCNN network structure diagram.

A schematic diagram of the regional proposal network is shown in **Figure 11**.

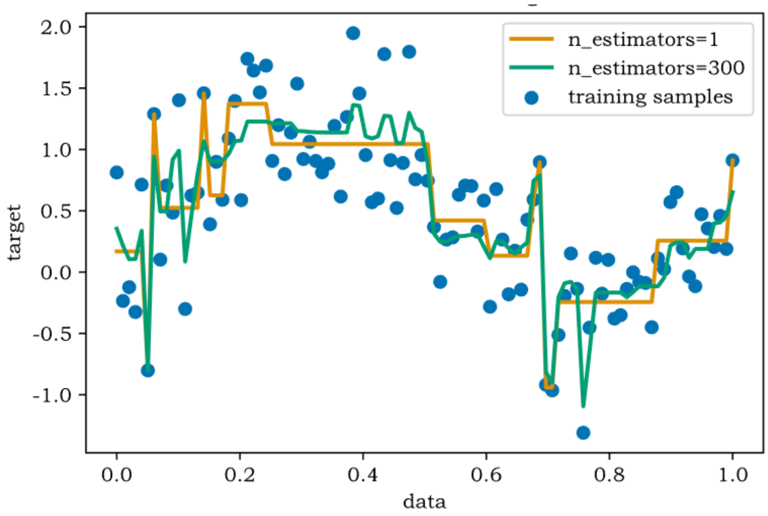


Figure 11. Schematic diagram of regional proposed network.

Feature candidate area frame adjustment, Roi pooling is mainly to solve the problem that the size of the feature map may be different when the feature map output from the previous layer is transferred to the fully connected layer, and a fixed size is obtained by adding the sampling of Roi pooling. The main idea is to solve the problem of different image sizes through the pyramid structure. Roi pooling converts proposals of different sizes into outputs of the same size through down sampling, as shown in **Figure 12**.

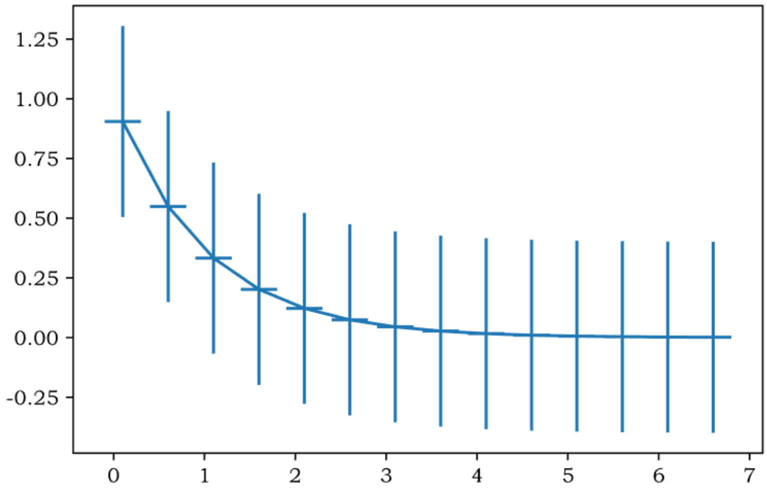


Figure 12. Schematic diagram of Roi pooling.

In this experiment, by analyzing the original signal waveforms of the five basketball footwork, it is found that the peak value and trough value of the five basketball footwork movements are not very different, and the contribution to the recognition of the five basketball footwork may not be large, so this experiment The two features of minimum and maximum are removed, and the two features of mean and standard deviation are retained. Finally, the 12 features obtained after feature selection on the basketball footwork data.

In addition, the selection of different *K* values also affects the accuracy of KNN's recognition of basketball footwork. **Figures 13** and **14** show the accuracy of basketball footwork recognition with different K values. After the above experimental analysis, when the *K* value is 5 and the feature combination is used, the overall accuracy of basketball footwork recognition is the highest, reaching 80.7%.

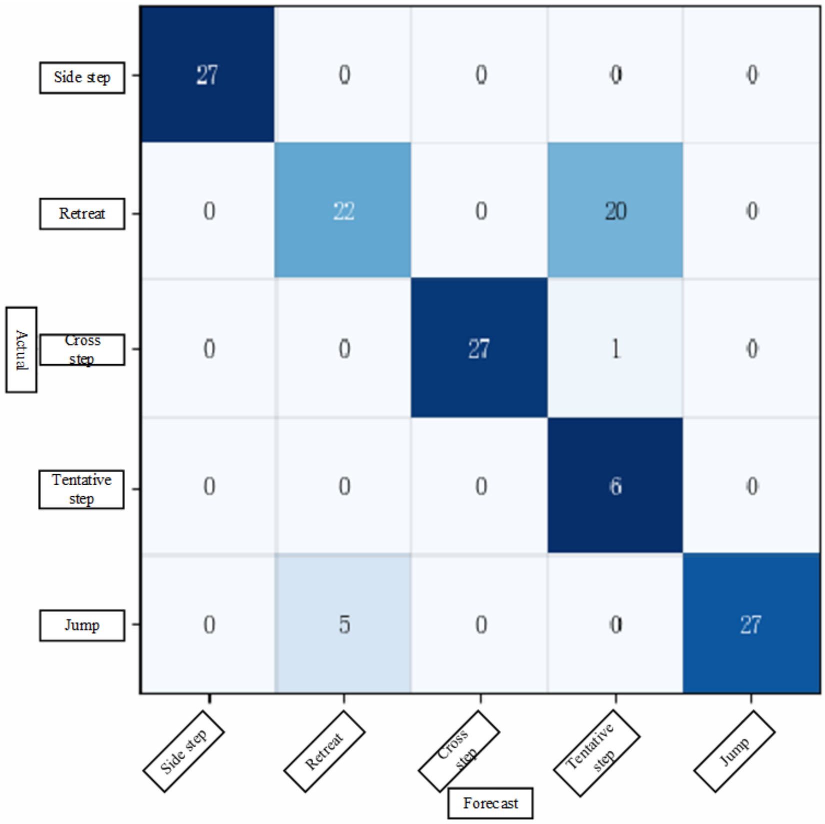


Figure 13. Confusion matrix of KNN.

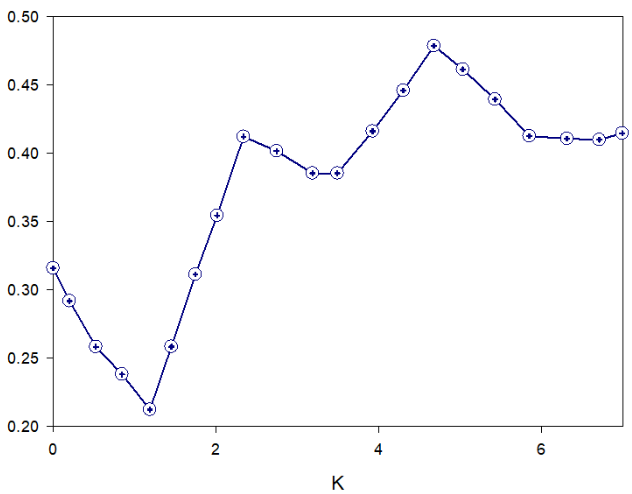


Figure 14. Recognition accuracy of different *K* values.

4.3. Statistics of body shape test

Different sports are appropriate for athletes with varying body types, and each sport has certain requirements for the materials chosen. Basketball is no different. In basketball, physical type and skill level are also strongly correlated. The effects of exercise will vary depending on body shape. Height, sitting height, foot arch height, leg length, arm length, hand length, head length, neck length, foot length, and other length indicators, as well as chest circumference, arm circumference, leg circumference, waist circumference, and hip circumference, are the indicators that show the body shape. Body weight, sebum thickness, and other body fulfillment indicators, as well as isometric indicators, head, shoulder, hip, and other width indicators, etc. Because this experiment is a freshman of the general department, the basketball foundation is relatively poor, and because of the limited equipment for class, only the physical indicators that are easy to measure are selected for measurement. The body shapes of the two groups of athletes are shown in **Table 7**:

Table 7. Statistics of body shape test of experimental group and control group before the experiment.

	Group	***N***	***X* ± *S***	***T***	***P***
Height	Control group	40	169.7335 ± 5.02447	1.147	>0.05
	Experience group	40	169.5433 ± 5.36124		
Weight	Control group	40	65.1335 ± 4.84113	1.268	>0.05
	Experience group	40	66.1525 ± 5.89901		

4.4. Analysis of the basketball technical standards

With a good level of basketball skills, after training, it will achieve twice the result with half the effort, but if you don't have a basketball foundation at the beginning, after the same time, the degree to which the level of basketball has improved is definitely not the same. The specific results are shown in **Table 8**:

Table 8. The statistics of the basketball skill compliance test of the two groups of students before the experiment.

	Group	***N***	***X* ± *S***	***T***	***P***
Dribble (sec)	Control group	40	19.5 ± 0.58	0.37	>0.05
	Experience group	40	19.5 ± 0.75		
One-handed over-the-shoulder shot(s)	Control group	40	2.15788 ± 0.02447	0.434	>0.05
	Experience group	40	1.98646 ± 0.36125		
Half-court round-trip dribble layup (seconds)	Control group	40	37.4345 ± 0.14144	0.237	>0.05
	Experience group	40	38.6575 ± 0.29905		

From the data statistics table in the above table, we can see that the test data of the two groups of athletes' dribbling, one-minute one-handed shoulder shot and half-court round-trip dribbling layup were obtained by *T* test.

4.5. Analysis of the basketball technical evaluation

Correct posture is half the battle. The more stable the technical movements, the greater the chance of success and the greater the impact on future learning. The test of basketball skill level, the test results are shown in **Table 9**:

Table 9. The results of the basketball skill level test of the students in the experimental group and the control group before the experiment.

	Group	***N***	***X* ± *S***	***T***	***P***
Dribble (sec)	Control group	40	67.77 ± 8.66	3.37	>0.05
	Experience group	40	68.54 ± 7.88		
One-handed over-the-shoulder shot (s)	Control group	40	66.76 ± 7.56	3.43	>0.05
	Experience group	40	67.88 ± 8.15		
Half-court round-trip dribble layup (seconds)	Control group	40	63.53 ± 6.56	3.23	>0.05
	Experience group	40	62.85 ± 5.94		

From the data statistics table in the above table, we can see that the test data of the two groups of athletes' dribbling, one-minute one-handed shoulder shot and half-court round-trip dribbling layup were obtained by *T* test.

5. Conclusion

Through in-depth research on biomechanics in college basketball teaching, this study draws the following important conclusions:

Firstly, through the biomechanical analysis of basketball players' technical movements such as shooting, dribbling, jumping, etc., the mechanical characteristics and potential problems presented in the process of their movement can be identified, so as to provide a scientific basis for the optimization of technical movements. The experimental results show that after training under the guidance of biomechanics, the athletes' movement accuracy and overall athletic performance have been significantly improved, especially in the shooting rate, dribbling speed and jumping height and other aspects of the performance is particularly outstanding.

Secondly, biomechanical analysis provides a possibility for the development of personalized training programs. Based on the athlete's physical data and athletic performance, training methods can be adjusted to maximize athletic ability. For example, by analyzing athletes' lower limb trajectories and mechanical data, coaches can optimize their jumping movements, reduce energy loss, and increase explosive power, thus effectively improving jump height and shooting percentage.

In addition, this study shows that biomechanics not only helps to improve the athletes' competitive level and technical ability, but also provides a more scientific and systematic training method for college basketball teaching. With the continuous development of biomechanics technology, future college basketball teaching will rely more on equipment such as motion capture and force measurement platform to optimize the teaching method and improve the training effect through data analysis and real-time feedback.

Overall, biomechanics provides strong support for college basketball teaching, making training and teaching more scientific and refined. Driven by the further development of biomechanics theory and technology, future basketball teaching and training will be more personalized and precise, and the overall level and competitive performance of athletes are expected to be further improved.

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

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