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Article

Application of AI technology in muscle injury prevention in public sports basketball tests in colleges and universities

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Abstract: AI public sports teaching technology is applied to daily indoor or outdoor fixed sports tests, ability assessments, and sports classroom teaching scenarios. It provides automated voice broadcast guidance, sports video AI intelligent engine automatic analysis, real-time detection of illegal actions, and intelligent real-time output of sports test results; Through AI intelligent guidance, the whole process of basketball test sports analysis and training suggestions are realized, and students are encouraged to conduct self-evaluation, promote training through testing, and practice more frequently. It also promotes the normalization of sports testing/teaching in public physical education in colleges and universities through teaching demonstration video explanations and a combination of various classroom forms, accumulates campus physical test data, and assists public physical education teaching and testing in colleges and universities. AI technology has intelligent joint detection and marking, multi-subject tracking and recognition. It does not require any markers to be installed on the captured object, and can capture accurate motion through video. During the basketball test, if an abnormal situation occurs, the student needs to stop the test. AI technology uses motion capture and analysis systems to help students and teachers better understand the sports skills and techniques tested in basketball, thereby developing more effective sports teaching and training plans. Motion capture and analysis systems can be used to evaluate athletes' gait and posture to help them improve their techniques and reduce the risk of injury.

Keywords: AI; public sports; muscle injury; biomechanics; sports testing

1. Introduction

The arrangement of public physical education courses in Chinese universities is basically a classroom teaching model centered on teachers, mainly imparting professional sports knowledge and specialized skills. It focuses on technical teaching and skill training. Many teaching contents are single and repetitive, tasks are highly decomposed, and the arrangement lacks integration. The teachers arrange the learning tasks uniformly [1]. The teaching content lacks interest and demand. The teaching organization form of class teaching and step-by-step teaching is difficult to mobilize students' interest in learning, and lacks analysis and calibration of students' interest projects. It fails to pay enough attention to students' sports needs. The setting and content of physical education courses are not well matched with students' inner thoughts and ideas, showing a single pattern, and the teaching materials lack flexibility. It focuses on the completion of in-class teaching tasks, ignores the combination of teaching and extracurricular sports activities, and affects the development of students' own interest projects [2].

2. Public sports basketball training and testing content

In recent years, with the continuous development and application of AI technology, AI sports has become a new trend in basketball sports teaching and training. In this context, more and more colleges and universities have begun to introduce smart sports, using technologies such as IoT cameras, face recognition, and smart query screens to achieve intelligent testing and data analysis of college basketball sports projects [3].

Through the study of basketball theory courses, students have a deeper understanding of basketball knowledge and form a new concept of people-oriented and health first. Students master the methods of scientific physical exercise and correct evaluation of their physical health status [4]. Through the teaching of basketball practice courses, teachers arrange teaching competitions and games in a timely manner to enrich teaching content, improve the fun of the class, and enable students to master the most basic techniques and tactics. Colleges and universities use basketball teaching in public physical education courses with different options to improve students' learning interest and enable students to master 1–2 sports more proficiently, thereby achieving the purpose of physical exercise [5].

2.1. Public physical education course teaching content basketball assessment test

Assessment content and proportion.

Theoretical assessment 20%.

Health standard 30%.

Technical assessment 40%.

Usual performance 10%.

2.2. Basketball assessment content and scoring standards

Method: The student stands at a point on the sideline, starts dribbling quickly after hearing the signal, returns to the opposite sideline, and makes two round trips in a row. The score is calculated based on the time.

Requirements: Test according to basketball rules.

Position shooting.

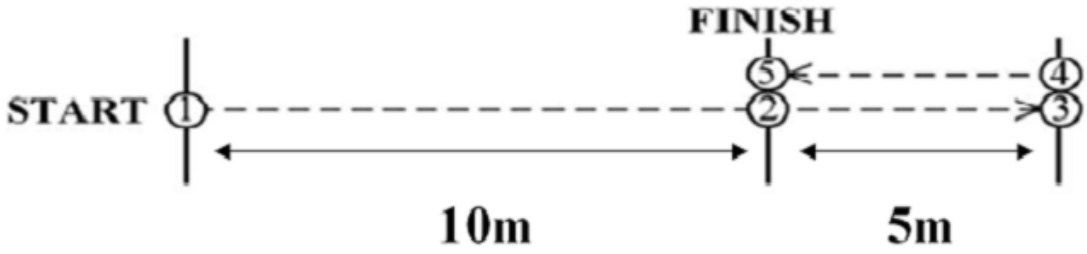

Figure 1. 15 M × 4 dribbling back and forth run.

Method: Run 15 meters back and forth between the two side lines of the basketball court (**Figure 1)**, 17 single times as a group, a total of 2 groups, rest for 2 minutes between each group, and add the two groups of test time to get the total time

for scoring [6].

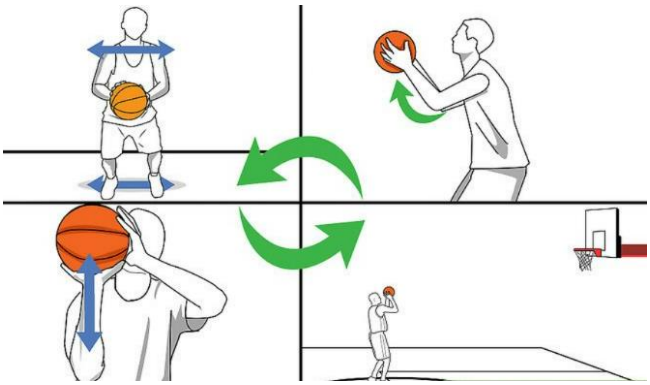

Figure 2. Position shooting.

Method: The subject stands at the free throw line and shoots ten times in a row. The number of shots is scored [6].

Requirement: Test according to basketball rules.

One-minute mid-range shooting (male).

Method: Draw an arc with the projection point at the center of the basket ring as the center and the distance to the free throw line as the radius, and intersect with the end line (**Figure 2**). The subject shoots at any point outside the arc. There is no limit to the shooting posture. The subject can shoot and grab by himself. The number of shots in one minute is scored [7].

Requirements: Test according to basketball rules, otherwise no points will be counted.

One-minute shooting under the basket (female).

Method: The student stands under the basket, starts shooting after hearing the signal, shoots and grabs the ball by himself, and scores according to the number of shots made within one minute.

Requirements: Test according to basketball rules, otherwise no points will be counted.

Half-court dribbling layup.

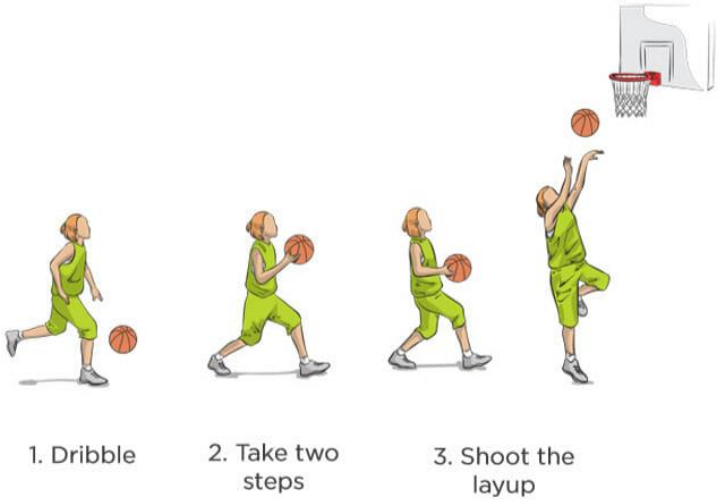

Figure 3. Half-court dribbling layup.

Source: www.online-basketball-drills.com.

Method: The student subject starts dribbling from the intersection of the center line and the sideline. After making a shot, dribble to the other intersection of the center line and the sideline (one foot must be on it) (**Figure 3**). Continue dribbling to the starting point and score by time.

Requirement: Test according to basketball rules, otherwise no score will be given.

Table 1. Scoring criteria for college public sports basketball test.

		40	38	36	34	32	30	28	26	24	22	20	18	16	14	12	10	8	6	4	2
15M×4 dribbling back and forth run	Male	13″5	13″6	13″7	13″8	13″9	14″	14″1	14″2	14″3	14″4	14″5	14″6	14″7	14″8	14″9	15″	15″1	15″2	15″3	15″4
	Female	16″5	16″6	16″7	16″8	16″9	17″	17″1	17″2	17″3	17″4	17″5	17″6	17″7	17″8	17″9	18″	18″1	18″2	18″3	18″4
Position shooting	Male	8	7	6			5			4			3			2			1		
	Female	7		6			5			4			3			2			1		
One-minute mid-range shooting	Male	8	7	6			5			4			3			2			1		
	Female	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Half-court dribbling layup	Male	15″	15″2	15″4	15″6	15″8	16″	16″2	16″4	16″6	16″8	17″	17″2	17″4	17″6	17″8	18″	18″2	18″4	18″6	18″8
	Female	18″	18″2	18″4	18″6	18″8	19″	19″2	19″4	19″6	19″8	20″	20″2	20″4	20″6	20″8	21″	21″2	21″4	21″6	21″8

Source: www.htu.edu.cn/teaching.

During the public sports basketball test in colleges and universities, about 200 students in a grade are tested together (**Table 1**). The basketball test is completed in two days, each time for 2 h. Students do not have enough warm-up time, and it is easy to get injured when making layups and running fast. Preventing students from getting injured has become a key link in the basketball test.

3. Application of AI technology in public sports tests in colleges and universities

The camera of the AI device/IoT camera captures real-time images or videos of students exercising, and computer vision technology is used to pre-process the acquired images and other data, such as denoising and enhancement, to improve image quality. Then, the AI sports vision algorithm is used to identify students' sports postures and human skeleton analysis, and accurate analysis is performed to achieve automatic and accurate recognition of students' scores. Students can query their own sports data overview and other functions [8].

3.1. AI and biomechanics: Scientific basketball training and testing plan

The combination of AI and biomechanics provides a new solution for basketball training and testing plans [9].

Through sensor devices equipped with AI algorithms, such as smart sportswear or wearable devices, we can collect and analyze the movement data of users' bones, joints and muscles during exercise. Based on this data, AI can deeply explore key indicators such as students' movement patterns, force distribution and flexibility, and generate personalized sports correction suggestions and training plans based on their unique needs [10].

AI technology can analyze the user's squat movements, identify problems such

as knee inward and excessive spinal curvature, and then provide targeted corrective guidance to reduce the risk of injury and improve exercise results. Such an intelligent training plan will enable students to make faster progress on the path that suits them best [11].

The AI system wireless sensor and data recorder module combines an orientation sensor, a gyroscope, and an acceleration sensor to collect human movements in real time, and can provide information such as joint angle, speed, position, torque (collected data includes: bending/extension, abduction/adduction, torsion, angular velocity, and angular acceleration, etc.). It can be used for simulation experiments in the laboratory or for field research in the real world without fixed sites [12].

3.2. Biofeedback technology: Real-time monitoring and adjustment of exercise status

Biofeedback refers to the process of enabling individuals to consciously regulate their own psychological and physiological responses by real-time monitoring and displaying changes in physiological parameters. In the field of fitness, biofeedback technology can help teachers better understand and control the movement state of students' bodies, thereby optimizing their sports performance [13].

With the help of AI technology, the equipment is able to collect and analyze various physiological signals in real time, such as heart rate, blood pressure, muscle electrical activity, etc. [14]. For example, in basketball high-intensity interval training (HIIT), AI can provide students with real-time exercise intensity recommendations by monitoring indicators such as heart rate variability and lactate threshold, ensuring that they are always exercising in the best training state [15].

In addition, biofeedback technology also plays an important role in improving specific sports skills in basketball training. For example, during fixed-point shooting exercises, AI can analyze students' muscle electrical signals and body movement trajectories, provide real-time feedback on problems in shooting skills, and help students make timely adjustments, thereby achieving rapid skill improvement [16].

3.3. Dynamic analysis—Comparative rating of live actions

AI capture technology based on deep learning, combined with customized analysis software, can instantly analyze and evaluate sports, dance performances and other scenes through a rich action database, achieve comparative scoring of actions, visualize their detail defects, and enable students to improve their grades [17].

AI technology supports a variety of biomechanical point-attaching methods to meet the needs of motion collection in different parts of the human body, accurately obtain local data, and have a wider application. Using high-resolution AI infrared camera technology, it provides high data rate, low latency and high precision to capture reliable 3D data, and ideally achieves accuracy below 20 μm, providing teachers and students with kinematic data of various needs.

The AI optical motion capture system has a maximum frame rate of 380 frames per second at full resolution, and a latency as low as 2.63 milliseconds. It can easily capture any high-speed sports training of students, help students correct their movements, scientifically improve training efficiency, and capture all the details of the

movement.

The dedicated AI color reference camera can be accurately synchronized with the motion capture system and calibrated synchronously. The motion information calculated by the motion capture system can be accurately back-projected onto the reference camera to simultaneously compare the motion data and the real-shot data to study the students' motion performance. The 89° × 89° field of view can achieve blind coverage of the robot tracking area, increase space utilization from 50% or even 30% to 100%, and capture motion data in all directions [18].

3.4. Markerless motion capture-immediately transported to visions of latex-clad performers tangled

AI markerless motion capture is an emerging motion capture technology that does not require any markers or sensors to be installed on the captured object. The advantage of AI markerless motion capture is that it is more natural and convenient because it does not require complicated preparation and equipment installation, and is suitable for daily teaching and competitive activities. The markerless motion capture system captures the shape and movement of the object and converts it into a three-dimensional model and animation data. The depth camera uses infrared light or laser to measure the distance from the object to the camera and generate a depth image. Computer vision algorithms identify and track the movement of objects by analyzing pixel changes in the video stream. These AI technologies and computers are used in combination to achieve efficient markerless motion capture.

Through AI high-precision sensors and camera systems, modern motion capture technology can record the details of athletes' movements in real time and convert them into digital models. These data are then input into AI algorithms for processing to identify key postures, force distribution and other information for basketball training and testing. For example, in a basketball test, a teacher can optimize the action by analyzing data such as the student's layup route and pitching angle.

The field of sports science uses AI motion capture technology to optimize students' techniques and performance. Teachers can use the motion capture system to analyze students' movements, identify technical defects, and conduct targeted training. In addition, motion capture technology can also analyze movement patterns, prevent sports injuries, and improve the safety of athletes. For example, in half-court dribbling and shooting training, the AI motion capture system can record students' gait, step length, stride frequency and joint angles to help teachers evaluate the effectiveness and stability of running techniques. Through AI motion capture technology, teachers can develop personalized training plans for students to improve training results and sports performance.

4. Muscle injury prediction model in public sports tests based on AI technology

AI technology can be divided into marker-based and non-marker-based motion capture. AI technology based on marker-based motion capture requires attaching reflective points, commonly known as marker points, to key locations on the target object. It uses a high-speed infrared camera to capture the motion trajectory of the

reflective points on the target object, thereby reflecting the movement of the target object in space (**Figure 4**). When capturing human motion, it is often necessary to attach reflective balls to various joints and bony landmarks of the human body, capture the movement trajectory of the reflective points with an infrared high-speed camera, and then analyze and process them to restore the movement of the human body in space.

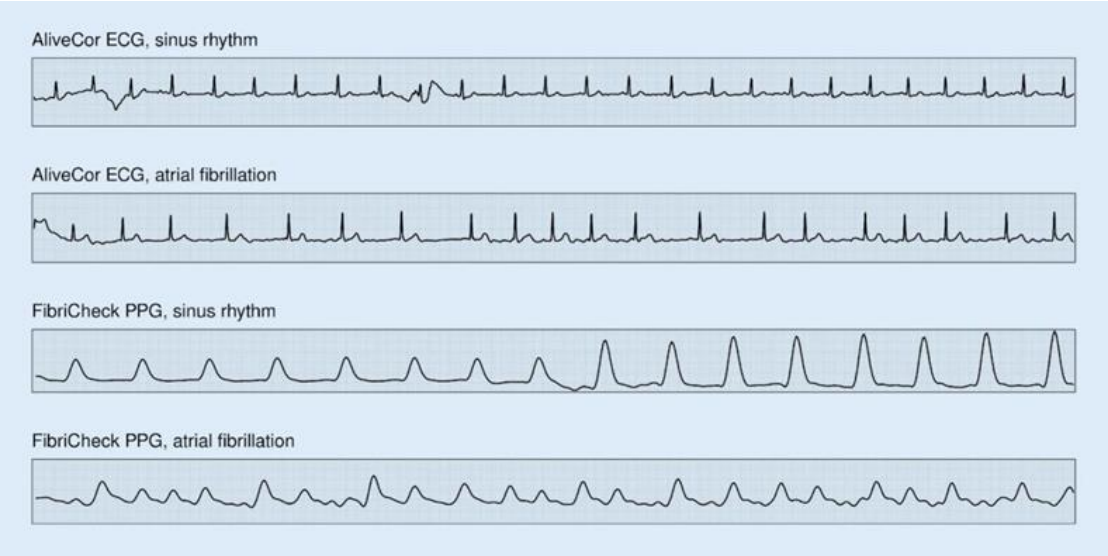

Figure 4. Electrocardiogram analysis.

During the basketball test, AI technology can monitor the students' heart rate, muscle activity, and lung capacity (**Figure 4**). If the students appear pale and dizzy, they can directly test the electrocardiogram to obtain relevant information.

The three-dimensional motion measurement system and gait analysis under AI technology consists of a three-dimensional motion measurement system, a three-dimensional motion force measurement system for gait analysis, a surface electromyography system, and gait/posture analysis software. It can collect and process various parameters in human walking and other movements in real time (such as the interaction force between the foot and the ground, the coordinate position of each joint point in space, etc.). On this basis, it calculates the characteristic parameters that reflect the characteristics of human gait (such as joint angles, center of mass position, internal torque generated by muscles, muscle power, etc.), thereby realizing quantitative analysis and evaluation of human movement function.

In public sports basketball test teaching, body motion capture technology using AI technology can help students improve their sports skills and enhance their competitive level. For example, using the Xsens inertial motion capture system and professional sports training software, students can capture their body movements in real time, analyze the strengths and weaknesses of their sports skills, and improve training results through personalized feedback and guidance.

Through body motion capture technology, AI public physical education can provide a more immersive learning experience, promote learners' all-round development and personalized learning. The application cases of this technology have been verified in many fields, such as medical education, art education and physical

education, further promoting the development and innovation of AI education [19].

The AI markerless 3D motion capture system provides an accurate functional assessment/analysis tool, which is mainly used for performance improvement (such as running gait analysis), injury prevention (such as posture analysis) and assistive device analysis. The results will help sports scientists and coaches design training methods and rehabilitation programs [20].

AI technology anaerobic parameters.

Measurement: Real-time display of SmO2 (muscle oxygen saturation) in muscle capillaries.

Indicators: Total hemoglobin, oxyhemoglobin, reduced hemoglobin, muscle oxygen saturation, etc.

Measurement depth: 0.5″ (12 mm) through skin and fat.

Technical principle: Using continuous near-infrared spectrum, using the modified Lambert-Beer law and the developed ZL mathematical model.

Data recording method: wireless real-time, data line storage.

Wavelength: 380 nm, 630 nm, 750 nm, 850 nm.

Data update: 1 s.

Size: 61 × 44 × 21 mm.

Weight: 48 g.

Before the students took the basketball test, they used a 30-second Wingate test to measure their anaerobic capacity. In practice, the peak power (PP), mean power (MP) and fatigue index (FI) of the first of five repeated 30-second Wingate tests were taken as anaerobic capacity parameters [21].

Different training objectives require different recovery principles.

Anoxic recovery principle (not fully recovered or extended exercise time for each set)

The purpose of anoxic recovery is to prevent SmO2 from recovering significantly. To achieve this goal, each set requires a longer exercise time and a shorter recovery time. This can be achieved in several ways.

First, you can use submaximal loads for multiple, long repetitions until exhaustion.

Second, you can use maximal load exercise followed by low-load training to increase the number of heavy loads (traditionally called drop training).

Third, you can verify the training time by slowing down the movement speed in each movement or performing isometric pauses during exercise.

After completing this extended set, SmO2 should return to baseline. Then start the next set immediately.

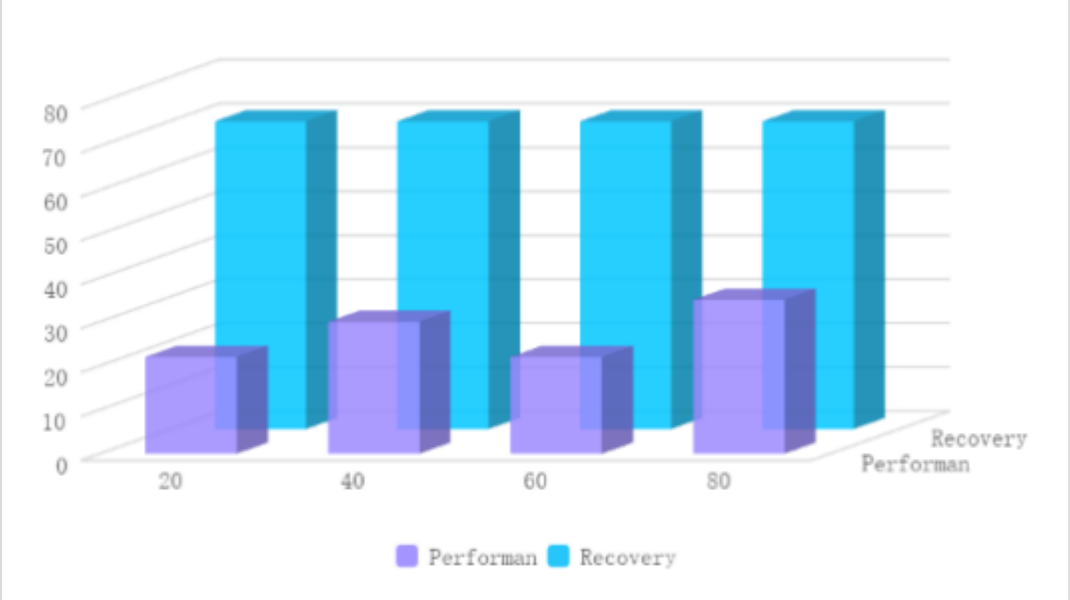

Figure 5. Characteristics of muscle oxygen changes under the principle of hypoxia recovery.

The application of AI digital image capture and analysis system in gait analysis reflects the highest level of technological development (**Figure 5**). When students are taking tests, the system can collect and analyze data in real time and display it in the form of 3D animation [22].

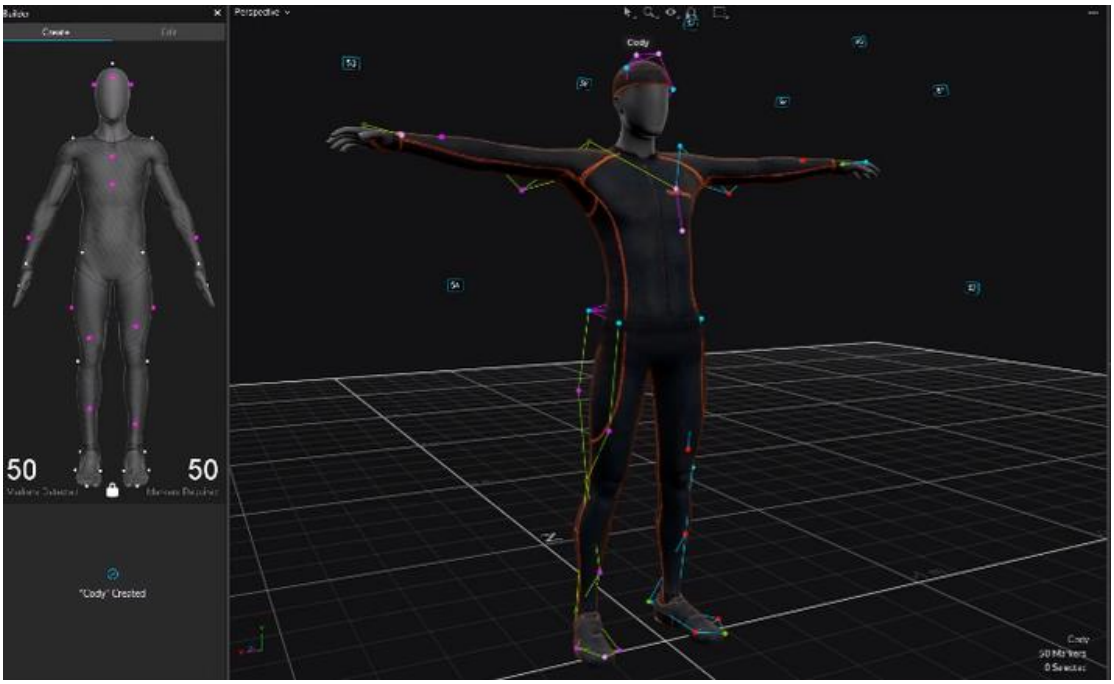

Figure 6. AI motion capture technology.

The motion capture system can track and capture 16 mm reflective markers at a distance of 30 m (passive markers)/45 m (active markers), which can capture a large range and generate accurate and clean motion data (see **Figure 6)**. The system automatically calibrates the data collected during normal use to avoid the degradation of calibration quality due to temperature changes or vibration of the mounting bracket,

and always provides accurate tracking data. The system supports both passive markers and active markers for tracking. Passive markers are lightweight and flexible to use, and active markers are invisible infrared LEDs, which can achieve error-free marker ID, low-latency data and < 0.1 s acquisition time [23].

At the same time, the AI system can also be synchronized with devices that output analog signals such as force plates and surface electromyography. Combined with OrthoTrak, SIMM and other software, the gait, muscle length, surface electromyography (**Figure 7**), force and other data of the subjects can be analyzed at the same time [24].

Figure 7. Finger injury.

Thumb lateral ligament injuries most often occur at the first metacarpophalangeal joint and proximal phalangeal joint, with the first metacarpophalangeal joint ulnar collateral ligament injury being the most common. It refers to the tear of the ulnar collateral ligament with or without avulsion fracture of the corresponding thumb ligament attachment point. Similar injuries, AI devices can instantly detect student finger injuries [25].

AI technology can provide students with accurate analysis and evaluation in many aspects (such as improving sports performance, preventing injuries, recovering from physical condition, sports equipment/rehabilitation equipment, etc.). Based on the accurate data provided by AI technology, coaches, players, team doctors, and rehabilitation therapists can more effectively formulate training plans, treatment methods, and rehabilitation principles [26].

5. Injuries and prevention of students in public sports basketball training tests in colleges and universities

5.1. Abrasions

Abrasions can be said to be very common injuries in playing basketball. It is easy to fall or collide when grabbing the ball or running, which will cause abrasions.

Prevention: The key to preventing foot and ankle injuries is support. Before students are tested, make sure they have the right shoes. Indoor basketball shoes can help prevent slipping on indoor courts, and generally speaking, a good pair of basketball shoes will provide a higher stance and more support around the ankle.

Countermeasures: For mild abrasions, if the wound is clean, it can usually heal itself by applying red or purple medicine. If the abrasion surface is contaminated by foreign matter, it is necessary to wash the wound with saline or hydrogen peroxide.

5.2. Finger joint injury

During the basketball test, fingers are prone to being stabbed, which is manifested by heat in the stabbed part of the finger. There is a burning sensation, obvious redness in the stabbed part, and swelling and pain in the finger joints. Finger joint injuries are mostly caused by the vertical collision between the fingers and the ball when receiving a fast-passed ball, which causes the finger joints to be impacted by external forces.

Countermeasures: When students suffer finger joint injuries, the general emergency treatment is to use local braking, ice compresses, bandages, medical treatment and other measures.

Prevention: Students should do sufficient warm-up exercises before the basketball test, cut their fingernails short, and wear finger sleeves or gloves. They can also wrap the finger joints with sports tape to fix them. They can usually use equipment such as grippers to strengthen their finger strength, which can reduce the chance of finger injuries.

5.3. Knee injury

During basketball test, students need to jump frequently and run rapidly, which puts a lot of loads on knee ligaments and easily causes knee joint strain.

Countermeasures: If students experience knee injury and pain during basketball test, they should stop exercising immediately, apply ice, apply plasters on the painful area, massage, and do half squat exercises to recover. If the condition is serious, they should seek medical treatment.

Preventive measures: Students should warm up before basketball test, wear sports protective gear, such as knee pads to protect the knees, reduce the load on the knees, and pay attention to controlling the amount of exercise.

5.4. Ankle sprain

Ankle sprain is the most common in basketball tests. During the basketball test, the foot lands in the wrong position, steps on air, or steps on other people's shoes, which can easily lead to ankle sprains.

Countermeasures: Students should stop exercising immediately if they have an ankle sprain. When a sprain occurs, do not use pressing, kneading, turning, pulling, etc. to prevent further activities from aggravating the injury. Students can first apply ice after a sprain, and then use an elastic bandage to bandage and fix it. If it is serious, seek medical treatment immediately.

Prevention: Students can improve the flexibility, balance, proprioception and muscle strength of the affected limb through functional exercises to reduce the risk of ankle sprains again. Students wear appropriate protective support gear during the test to reduce the probability of re-injury.

5.5. Hip and thigh injuries

Student rotation, running, jumping, and rebounding all put extra stress on the legs and hips, making players vulnerable to injury. Hip sprains and bruises can be caused by contact on the court or overstretching of muscles and ligaments.

Countermeasures: Students' hamstring injuries usually occur when running fast or changing direction suddenly during sports. You may hear a "snap" or feel redness, swelling, heat, and pain in the back of the thigh. If the muscle is torn and rebounds from the broken end, there may be a local depression. Students need to press the three muscles of the hamstring group, especially the sitting bone and the back of the knee. If there is pain, it may be a hamstring injury.

Prevention: Some contact injuries cannot be prevented, but when students are in doubt, stretching is always a good plan of action. The more flexible the student's muscles and tendons are, the less likely they are to overstretch and hurt themselves in the process. Stretching the hips is key to warming up.

5.6. Hand/wrist injury

This situation is not common during the test. Because basketball tests are mainly conducted with the hands, but according to research, only about 11% of basketball injuries occur in the wrist/hand/forearm.

Countermeasures: After the student is injured here, it may cause wrist pain, soreness, reduced grip strength, pain or sound when twisting the wrist, decreased wrist mobility, and local tenderness on the ulnar side of the wrist. If it is serious, seek medical treatment.

Prevention: Keeping students' hands and wrists healthy is more important than anything else. When the student passes the ball to you, be sure to look at the ball in your hand. Looking away before the student catches the ball is a good way to jam your fingers.

5.7. Head/face injuries

It is never normal to collide with another student's head or accidentally hit the face with an elbow. It may be more normal for a student to be hit in the face by a ball, given the upcoming embarrassment.

Countermeasures: Cold compresses can cause local blood vessels in the face to contract, reduce vascular exudation and bleeding, and effectively relieve swelling and pain. Hot compresses can be applied after 24 h, with hot towels applied to the affected area and gently massage the swollen area, and blood circulation and stasis-removing drugs can also be used.

Prevention: It is important to pay attention to students' concussion symptoms. There are not many ways to avoid contact with the head, but if a student does so, be sure to carefully monitor the student's symptoms and seek medical help immediately

if there are any signs of concussion.

6. Conclusion

AI technology can not only meet students' personalized sports needs through big data analysis, but also monitor students' physical condition in real time. Through the visualization and intelligent display of physical education teaching, colleges and universities enable students to participate in physical education courses more scientifically and reasonably and enjoy the fun of sports. Public physical tests in colleges and universities use AI smart assessments to visually present the exercise data of practitioners through AI visual technology and big data technology, scientifically comment on the weak links of sports and provide targeted guidance and help. If AI technology is used regularly, the excellent rate and pass rate of students' physical tests will increase significantly.

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

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

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