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Article

# Design of a computer-assisted physical education teaching platform based on the human-ground impact force dynamic model

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**Abstract:** The auxiliary teaching platform of physical education is becoming more and more important in college physical education, and it has become an ideal tool to promote the interaction between teachers and students and improve the teaching effect. Compared with the traditional physical education teaching mode, the platform has stronger interaction, efficient information sharing function and rich and varied multimedia display. However, there are still some shortcomings in the application of biomechanics in the online sports teaching platform. In this study, a computer-aided physical education teaching platform based on the dynamic model of human body-ground impact force is proposed. The study aims at analyzing the mechanical characteristics of human body in contact with the ground during exercise from the perspective of biomechanics, and helping teachers and students to choose sports equipment more accurately according to different course contents and biomechanical needs. By introducing the biomechanical model, the platform can simulate and analyze the key biomechanical data such as impact force, change of center of gravity, joint stress and so on, and provide quantitative feedback for students to optimize the effect of sports training. At the same time, the platform also integrates a variety of functional modules, such as sports resource information module and real-time sports evaluation module. It greatly enriches students' learning resources, prolongs the time and space of self-directed learning, promotes the transformation of learning methods, and improves students' autonomy, learning enthusiasm and sports performance. With the help of this platform, students can access rich learning resources including high-quality biomechanical analysis videos, interactive sports simulation, detailed theoretical explanation and real-time online evaluation system to comprehensively improve their sports literacy and sports performance.

**Keywords:** computer aided; physical model; physical education; teaching platform; biomechanical characteristics

## 1. Introduction

In the pursuit of the simultaneous development of mass sports and competitive sports, the pace of the construction of sports power is accelerating. In order to improve the sports quality of college students, we must face the current challenges [1]. With the rapid expansion of higher education and the surge in the number of students, the per capita distribution of sports resources appears to be inadequate, both in terms of venue and course resources [2]. The traditional model of classroom education has been unable to meet the diverse needs of contemporary students, there is a clear difference between what they desire to acquire and what is actually taught, and it is increasingly difficult to identify true expertise in the extra-curricular environment [3]. In the digital age, teachers and students spend a lot of time in cyberspace, and the electronic products used by individuals gradually evolve from single to diversified [4]. Therefore, the use of modern educational technology to transform multimedia materials into interactive online courses has become the core of multimedia teaching [5]. At the same time, it is an inevitable trend in education development to integrate teaching and management into a new sports network teaching management platform [6]. At present, as the core way of personalized teaching, a computer-assisted teaching system builds a bridge of information exchange and resource sharing between teachers and students with the help of computer and network technology, which greatly promotes the development of student-centred personalized teaching mode [7].

With the rapid development of computer-aided technology, its importance in physical education teaching has become increasingly prominent, providing a new and highly interactive teaching platform for university physical education teaching. Compared to traditional physical education teaching methods, this platform not only greatly enriches the means of physical education teaching, but also significantly enhances communication and interaction between teachers and students. Traditional physical education teaching methods, such as face-to-face guidance, demonstration, and practice, although able to provide students with rich background information and intuitive learning experiences, have certain limitations in resource sharing, personalized teaching, and interactivity. In recent years, computer-aided physical education teaching platforms have made certain progress. These platforms typically integrate features such as video tutorials, online testing, and interactive Q&A, providing students with a more convenient and flexible way of learning. However, although these platforms have improved the efficiency of physical education teaching to some extent, there is still room for improvement in terms of precision, scientificity, and personalized guidance.

The existing platforms usually lack accurate modeling and analysis based on biomechanics, especially the treatment of key biomechanical factors such as impact force, joint stress and center of gravity change when the human body contacts the ground during exercise, which makes the platform insufficient in providing scientific sports guidance. Through biomechanical modeling and dynamic analysis, people can deeply understand the interaction between human body and the ground during sports, accurately measure the ground impact force during sports, and then provide tailor-made sports suggestions and training programs for athletes and students. However, the existing computer-assisted teaching system mostly relies on the form of forums for personalized teaching, which makes it difficult for teachers to effectively supervise the learning progress of students, and students are prone to disorganized learning, thus affecting the effect of personalized teaching [8]. At the same time, strengthening the training of teachers and students and improving their ability to use educational technology are also important measures to improve teaching quality [9].

The purpose of this study is to propose an innovative computer-aided physical education teaching platform design. Based on the dynamic biomechanical model of human body’s ground impact force, the platform accurately models and analyzes the biomechanical characteristics of human body’s contact with the ground, joint stress and center of gravity change during exercise, and provides scientific sports guidance for teachers and students. Specifically, the main goal of this study is to develop a computer-aided physical education teaching platform that can guide teachers and students to choose appropriate sports equipment and training methods according to the needs of different physical education courses and combined with biomechanics principles. In addition, the platform also integrates rich functional modules, such as sports resource information module, aiming at further enriching students' learning resources, broadening the ways of self-directed learning, promoting the change of learning methods, and finally improving students' autonomy, learning motivation and sports performance.

## 2. Research status

There are some challenges in physical education teaching in colleges and universities, especially in the absence of a physical education major, public physical education has become the main form, and the number of physical education teachers is relatively small, resulting in unclear teaching goals [10]. In order to solve this problem, the selection of teaching content should fully consider the needs of students, the situation of teachers and the conditions of site facilities. In addition, it is also necessary to combine the personality characteristics of sports students in the new era to carry out targeted teaching to achieve the goal of national teaching reform [11]. However, due to the late establishment of sports majors in many universities, relatively limited teaching funds, slow introduction of teachers and development of teaching resources, students' enthusiasm and interest in sports learning are reduced, and the utilization rate of some sports resources is also low, which is one of the problems to be solved urgently [12].

As a combination of education and computer technology, a computer-aided instruction system provides a personalized and flexible teaching platform for physical education [13]. Scholars have conducted in-depth discussions in this field from three dimensions theory, technology and application [14]. On a theoretical level, computer-aided instruction systems cover theories of human cognitive development and social dependence, emphasizing the importance of information exchange [15]. Technically, thanks to the development of the computer field, the system provides rich supporting functions, including group technology, collaborative technology and interactive technology, to enhance the communication and interaction between learners [16]. At the application level, many comprehensive application systems have emerged to enrich teaching methods and improve teaching quality and efficiency [17]. Various research organizations have also developed many practical teaching systems, such as the Knowledge Forum System [18] and Blackboard Learning System [19], which provide strong support for personalized teaching. The wide application of these systems has not only enriched the teaching methods but also greatly improved the teaching quality and efficiency [20].

However, although many computer-aided physical education teaching platforms have achieved initial results in practical application, there are still obvious deficiencies in accurate biomechanical analysis and scientific guidance of sports process. Especially in the aspects of impact force generated when the human body contacts the ground, joint stress during movement, change of center of gravity, etc., most of the existing platforms lack accurate biomechanical modeling and analysis [21,22]. These biomechanical factors play an important role in sports performance, sports injury prevention and sports training optimization, so more detailed dynamic modeling and real-time feedback mechanism are needed [23].

In recent years, the research of biomechanics has gradually attracted the attention of scholars. Many researches are devoted to the quantitative analysis of the ground impact force in the process of human movement through biomechanical models help athletes choose appropriate sports equipment and training methods, thus improving the sports effect and reducing sports injuries [24,25]. For example, Aux et al. [26] proposed that by simulating the interaction between human body and the ground in different sports scenes, the ground reaction force could be accurately calculated to help optimize the athletes' movement posture and body strength distribution during training. In this study, a new prediction model of human structure interaction was proposed, which integrated the three-dimensional biomechanical model of human body and the pedestrian bridge expressed as simply supported Euler-Bernoulli beam. Using inverse dynamics, the human model could accurately capture the three-dimensional gait and its interaction with structural vibration. The results showed that this method provided an accurate estimation of human gait kinematics and dynamics, and the response of the bridge under pedestrian load. Wang et al. [27] constructed a biomechanical model of Hydra's hydrostatic skeleton filled with liquid, and showed how the driving of neuron activity activated different modes of muscle activity and biomechanics of body column. By developing a new computational framework based on fluid-structure interaction, Gupta and Chanda [28] tested the design and traction performance of eight kinds of footwear outsoles on the common floor polluted by water. The computer-aided platform based on biomechanics could not only provide customized sports training suggestions, but also realize accurate sports intervention in combination with individual physiological characteristics [29,30]. Therefore, it is not only the key to improve the accuracy and scientificity of teaching, but also the necessary step to promote the development of physical education to a higher level by integrating biomechanical characteristics into the computer-aided physical education platform. Saraiva et al. [31] discussed foot ground contact modeling strategies in human motion analysis. These methods are commonly used to study foot ground interactions in human motion. Daroudi et al. [32] evaluated the ground reaction force and pressure center predicted by the anybody modeling system during load arrival/handling activities, as well as the impact of prediction errors on the model's estimated spinal load. Ripic et al. [33] used an Azure Kinect driven musculoskeletal modeling method to adjust the estimation of ground reaction forces and joint moments during gait. Gao et al. [34] analyzed a new rigid foot ground contact model for predicting ground reaction forces and pressure centers during normal gait. Gonabadi et al. [35] predicted lower body joint torque and electromyographic signals using ground reaction forces during walking and running. It analyzed gait and posture based on an artificial neural network method.

## 3. Physical modeling of computer-aided teaching platform based on biomechanical model

### 3.1. Establishment of a dynamic model of impact force of ground facing the human body

In physical education class, ground impact often leads to foot discomfort and even sports injuries. How to reduce the injury and pain of the foot caused by the ground impact force during exercise has always been the research focus in physical education courses. In order to reduce sports injuries and improve students' sports experience, a dynamic model based on biomechanics principle is constructed to accurately describe the impact of ground impact on various parts of the human body, especially the joints and feet of lower limbs. As shown in **Figure 1**, the physical model of this platform mainly focuses on 4 parts of quality. respectively $m_1$, $m_2$, $m_3$ and $m_4$. Where it represents the mass of the leg near the ground while walking, $m_4$ For the mass of the body itself, between the two is a spring $k_4$, $k_5$ Sum damping $c_4$ Connected. $m_1$ For the rigid body mass of the other leg, $m_2$ For the non-rigid mass of the other leg, $m_2$ and $m_3$ Between to elastic stiffness $k_3$ Connected, $m_2$ and $m_1$ Between is the elastic stiffness $k_2$ Sum damping $c_2$ In connection with, $m_3$ and $m_1$ Between to elastic stiffness $k_1$ Sum damping. $c_2$ Get in touch. $m_5$ Is the quality of the sports shoe, the elastic damping unit parameter of the shoe is $k_6$, $b_6$ and $c_6$. $K$ Represents the stiffness of the ground. $x_1$, $x_2$, $x_3$, $x_4$ and $x_5$ respectively $m_1$, $m_2$, $m_3$, $m_4$ and $m_5$ The displacement, the reaction force from the ground. $F_g$ With the force passing between the legs and the soles $F_s$ Indicates.

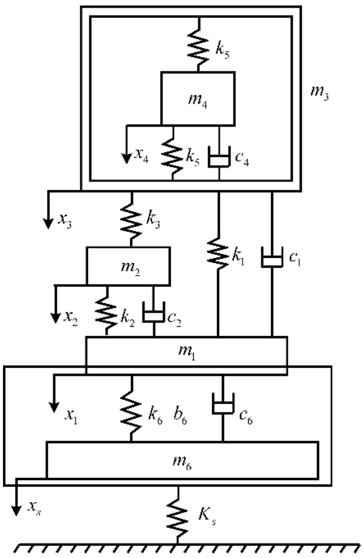

**Figure 1.** Dynamic model of computer-aided physical education platform.

Extending the model to consider the repetitive effects in long-term activities such as running or jumping is an important research direction. This requires the introduction of a fatigue damage model to evaluate the effects of prolonged exercise on shoe soles and body structures. In the modeling process, we considered various motion actions such as running, jumping, and landing, which can cause changes in the impact force of the human body on the ground. Through dynamic models, we can calculate the impact of ground impact on various parts of the human body under different movements, thereby guiding teachers and students to take more scientific and reasonable measures to reduce the damage of impact on the feet when choosing sports equipment and training methods. For example, in running movements, we can use a model to calculate the impact of ground reaction force (Fg) on leg mass (M1) and body mass (M2) under different ground hardness (i.e., Kg value). Based on the calculation results, we can suggest that students choose running shoes with higher cushioning performance (i.e., increasing Ks and Cs values) when running on harder surfaces to reduce the impact on their feet. Similarly, in jumping and landing actions, the model can also be used to calculate the influence of ground reaction force on various parts of human body under different jumping heights and landing postures, and provide corresponding suggestions and guidance according to the results. For example, the research shows that when the jumping height is large, the reaction force of the ground increases the pressure on the knee joint when landing, so it is recommended that students choose sports shoes with more elasticity and damping effect to effectively reduce the impact on the knee joint. Through this dynamic simulation based on biomechanical model, teachers and students can choose appropriate sports equipment more scientifically, and formulate personalized training programs to effectively avoid injuries caused by sports shocks. This model can not only be applied to the field of physical education, but also provide data support for sports shoes design and sports medicine, and promote the continuous optimization of sports equipment and training methods.

### 3.2. Ground stiffness estimation

When the ground stiffness is estimated, the ground can be regarded as an inelastic space. And pass $k_s$ Indicates the stiffness of the ground. A unit load is applied to a circular area with a radius of 100 mm $F$, corresponding to the contact area between the leg and the ground during movement, and assuming that the pressure is uniform, therefore $K_s$ Computationally passes.

$$K_s = \frac{F_{max}}{u_{max}} \tag{1}$$

$$K_s = \frac{1}{u_{max}} \tag{2}$$

Formula, $u_{max}$ On behalf of the maximum displacement of the ground under load, six different sports venues were measured by using the elastic data of the ground. In the final calculation, soft ground S1 and hard ground S2 were used for comparison. The characteristics of the two are listed in **Table 1**.

**Table 1.** Different ground physical characteristics.

| material | Minimum Young's modulus | Maximum Young's modulus | Average Young's modulus | Poisson's ratio | $u_{max}(m)$ | $K_s(kN/m)$ |
|---|---|---|---|---|---|---|
| S1: Soft ground | 3.48 | 6.85 | 5.68 | 0.6 | $6\times 10^{-3}$ | 210 |
| S2: Hard ground | 14.58 | 29.56 | 20.47 | 0.7 | $2\times 10^{-3}$ | 860 |

### 3.3. Kinematic equation modeling

The stiffness of the sole is calculated from the time the heel touches the ground until the knee joint reaches its maximum bending Angle. The weight of the human body is exerted on the ground through the heel of the sole, and the heel of the sole is slightly convex and spherical in contact with the ground. Therefore, the stiffness value of the sole follows the Hertzian contact law. It can be calculated by:

$$F = k_6 u \left(\frac{u}{R_0}\right)^{b_6-1} \tag{3}$$

$R_0$ is the diameter of the indenter of the hardness tester, $b_6$ Is the spring damping unit parameter of the shoe.

The expression of the ground reaction force is as follows: The expression of the surface reaction force is as follows:

$$F_g = -K_s x_5 \tag{4}$$

The cushioning force between the shoe and the ground can be calculated by:

$$F_s = -k_6(x_1 - x_2)\left(\frac{(x_1 - x_2)}{R_0}\right)^{b_6-1} - c_6(\dot{x}_1 - \dot{x}_5) \tag{5}$$

The new model soles and ground are associated with a double-layer mass-spring-damping subsystem ($m_5$, $k_6$, $b_6$ and $c_6$) Ground stiffness $K_s$, And the impact force of the ground, so the dynamic equation of the new model is:

$$\begin{aligned} m_1\ddot{x}_1 = m_1 g - k_1(x_1 - x_3) - k_2(x_1 - x_2) - k_6(x_1 - x_5)\left(\frac{(x_1 - x_5)}{R_0}\right)^{b_6-1} \\ - c_1(\dot{x}_1 - \dot{x}_3) - c_2(\dot{x}_1 - \dot{x}_2) - c_6(\dot{x}_1 - \dot{x}_5) \end{aligned} \tag{6}$$

$$m_2\ddot{x}_2 = m_2 g - k_2(x_1 - x_3) - k_3(x_2 - x_3) + c_1(\dot{x}_1 - \dot{x}_2) \tag{7}$$

$$\begin{aligned} m_2\ddot{x}_3 = m_3 g - k_1(x_1 - x_3) - k_3(x_2 - x_3) - (k_4 + k_5)(x_3 - x_4) + c_1(\dot{x}_1 \\ - \dot{x}_3) - c_1(\dot{x}_1 - \dot{x}_3) - c_4(\dot{x}_3 - \dot{x}_4) \end{aligned} \tag{8}$$

$$m_4\ddot{x}_4 = m_4 g - (k_4 + k_5)(x_3 - x_4) + c_4(\dot{x}_3 - \dot{x}_4) \tag{9}$$

$$m_5\ddot{x}_5 = m_5 g - k_6(x_1 - x_5)\left(\frac{(x_1 - x_5)}{R_0}\right)^{b_6-1} + c_6(\dot{x}_1 - \dot{x}_5) - K_s x_5 \tag{10}$$

The polynomial is calculated by MATLAB. The scope of the study is limited to the vertical displacement of athletes within the first 200 ms after landing, regardless of the time period of athletes in the air. The soles and ground used in the experiment remain the same, respectively soft-soled shoes and hard-soled shoes. The parameter values of these soles were determined by swing and impact tests, the detailed results are shown in **Table 2**.

**Table 2.** Insole parameter values and ground contact speed tested by swing and impact tests.

| **Parameter name** | **a** | **b** | **c** | **d** | **e** |
| --- | --- | --- | --- | --- | --- |
| Soft sole | $1.1 \times 10^5$ | 1.45 | $2.2 \times 10^4$ | 0.72 | 1.1 |
| Hard sole | $1.1 \times 10^5$ | 1.54 | $2.2 \times 10^4$ | 0.74 | 1.1 |
| speed (*m*/*s*) | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |

Some parameters of the improved model insole are basically consistent with the impact test results, and the parameter values are shown in **Table 3**. The experimental design assumes that the foot is fully attached to the shoe within 200 ms, the speed at which the shoe hits the ground is equal to $m_1$.

**Table 3.** Reaction force parameter value and ground touching speed of sole.

| **Parameter name** | **a** | **b** | **c** | **d** | **e** |
| --- | --- | --- | --- | --- | --- |
| Soft sole | $0.5 \times 10^5$ | 1.45 | $2.2 \times 10^4$ | 0.72 | 1.1 |
| Hard sole | $0.5 \times 10^5$ | 1.54 | $2.2 \times 10^4$ | 0.74 | 1.1 |
| speed (*m*/*s*) | 0.85 | 0.85 | 1.5 | 1.5 | 1.5 |

High precision models can provide more accurate and detailed data on student athletic performance, thereby helping teachers develop more personalized teaching plans. However, high-precision models often come with higher computational complexity, which may lead to a decrease in real-time processing speed. Therefore, we need to find a balance point to ensure that the model has sufficient accuracy while meeting the requirements of real-time feedback. This article evaluates the performance of different precision models in providing real-time feedback through comparative experiments. This includes measuring metrics such as model computation time and memory usage to determine which models can meet real-time requirements under given hardware conditions. Explore various optimization methods to improve the real-time processing speed of the model. This includes techniques such as algorithm optimization, hardware acceleration (such as using GPUs for computation), data preprocessing, and simplification.

### 3.4. Performance test of sports equipment required for PE class

This study focuses on the elastic properties of the heel of a sports shoe and uses a special double-layer mass-spring-damping subsystem model to simulate the geometric nonlinear effects between the heel and the ground. We carried out elastic tests on the heel of the sole under a hydraulic press and loaded four pairs of sneakers with the same shape and mass but different sole hardness using cylindrical indenters with spherical tips at a frequency of 1.5 Hz. **Figure 2** shows the cyclic load testing process in detail, visually showing the response of soles with different hardness under the same conditions. Through the in-depth analysis of the experimental data, we determined the elastic coefficient and damping coefficient of the sole and other relevant parameters. In addition, we also compare the experimental data with the calculated results of the improved model and find that the two are basically consistent, which verifies the effectiveness of our model in analyzing the elastic properties of the heel of the sports shoe. The results of this study show that the impact force during exercise is not only affected by the ground stiffness but is also closely related to the performance of sports shoes. Therefore, when choosing sports shoes suitable for different sports courses, these two factors need to be considered comprehensively to ensure that athletes are protected enough in sports while maintaining the best sports performance. This finding has important reference value for athletes, coaches and sporting goods manufacturers. Furthermore, biomechanical analysis shows that the elastic characteristics of the heel of sports shoes directly affect the impact distribution of athletes' feet and knees, and then affect their sports efficiency and safety. By optimizing the elastic structure and damping design of sports shoes, the load on joints during exercise can be reduced, the risk of fatigue and injury can be reduced, and the overall performance of athletes can be improved.

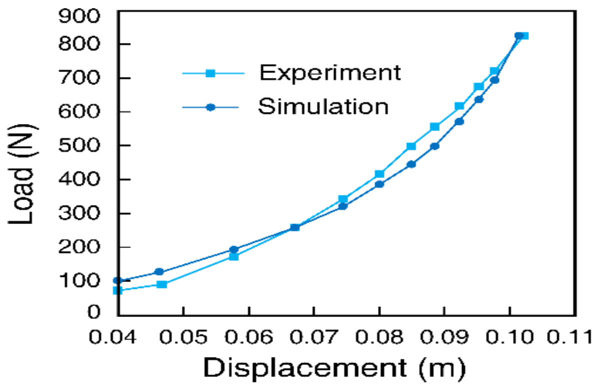


**Figure 2.** Comparison between experimental results and simulation results of mechanical properties of sports equipment required for PE class.

According to the data shown in **Figure 3**, the hardness of the ground has a significant impact on the initial peak force, and a softer ground can reduce the initial peak force of the shoe. This finding is key to choosing the right elasticity for sneakers. Biomechanical analysis shows that when people exercise on the soft ground, the cushioning effect provided by the ground reduces the transmission of impact force, thus reducing the burden on joints and soft tissues, especially in the parts such as feet and knee joints that bear large impact. The figure also shows that hard ground will lead to higher impact peak and higher load rate without fully understanding the ground conditions.

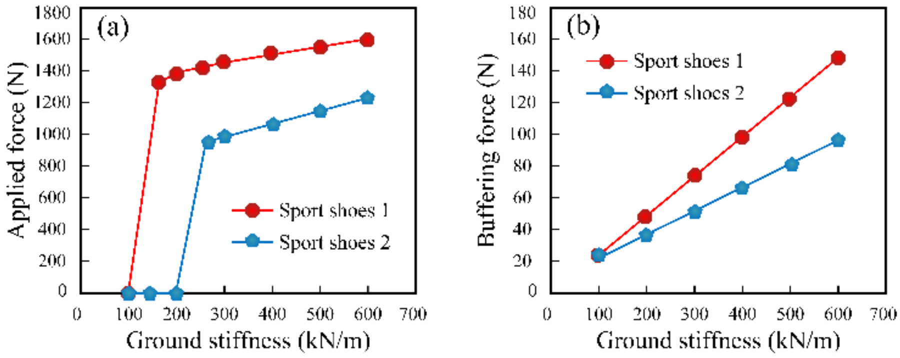


**Figure 3.** Changes of peak force and maximum cushioning force of sports shoes with the ground stiffness of PE class.

Furthermore, from the biomechanical point of view, human neuromuscular system has certain adaptability. Knowing the ground hardness, the nervous system can adjust the motion parameters of lower limb joints through feedback mechanism and actively adapt to the ground hardness. For example, when running or jumping, when the nervous system predicts that the ground is soft, the body can slow down the transmission of impact force by increasing the flexion angle of lower limb joints, thus reducing the burden on lower limb joints. On the contrary, when there is not enough ground information, the adaptability of human body is limited, and the impact force is mainly adjusted by the hardness of the ground. Therefore, understanding and adapting to the change of ground hardness will not only help to reduce sports injuries, but also optimize sports performance. According to the data in **Figure 4**, the cushioning effect of shoes on soft ground is not obvious, while the cushioning effect of shoes on hard ground is more significant. Therefore, when choosing shoes, it is necessary to take into account the hardness of the physical education surface.

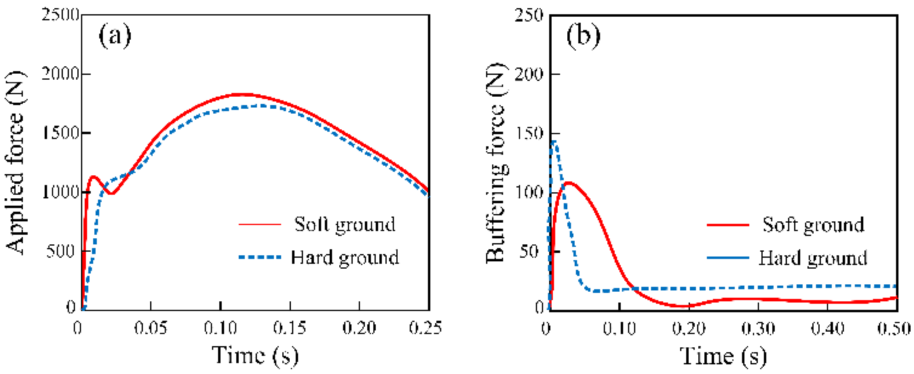


**Figure 4.** The reaction force generated by the ground in different PE classes and the cushioning force of sports shoes.

## 4. Computer-aided physical education platform development

### 4.1. Basic structure and working principle of computer-aided physical education platform

The computer-aided teaching platform developed in this study adopts advanced browser/server architecture. It aims at creating an efficient and user-friendly online physical education environment, and combining with biomechanical characteristics, improving the practicality and scientificity of physical education teaching. In **Figure 5**, the structural diagram of the platform clearly shows its design, which ensures the flexibility and autonomy of learning, and enables students to better understand and apply the mechanical principles in sports activities through the combination of biomechanical data and theory. The platform allows students to access through the browser on personal computing devices, learn the contents of physical education, inquire about sports resource information, interact with teachers and classmates in real time, and upload personal learning data. Different from traditional teaching methods, the platform not only provides theoretical knowledge, but also combines biomechanical analysis, such as the reaction force of joints during exercise and the cushioning effect of sports shoes on impact force, to help students better understand the mechanical mechanism of body movement. For example, in the process of running or jumping, the platform can simulate the ground hardness, the cushioning effect of sports shoes and the influence of different sports modes on the human body through real-time biomechanical data feedback to optimize sports skills and reduce sports injuries.

The platform not only supports students to obtain updated physical education resources, but also provides personalized sports guidance according to biomechanical research results. For example, in the choice of sports shoes, the platform can recommend appropriate insole hardness and cushioning effect according to different ground hardness and students' sports needs, thus reducing the impact force during sports and protecting students' joints and muscles. Through the combination of biomechanical principles and sports education, the platform enables students to combine theoretical knowledge with practical sports and master scientific sports methods. As the core of the system, the Web server of the platform stores various application modules and processes requests from client users. The database server is responsible for storing all the databases needed by the system, and performing data query, update, deletion and other operations according to the requirements of the Web server. Such a clear division of labor not only ensures the efficient operation of the system and the accuracy of the data, but also provides a guarantee for the real-time feedback of biomechanical data. The platform can integrate and update the latest biomechanical research results in time, and turn these results into teaching resources that students can actually apply.

Through this platform, teachers and students can get data support from biomechanical simulation while learning interactively, ensuring that sports teaching is scientific and targeted. The design of the platform not only optimizes the teaching management, but also improves the learning effect of students in physical education courses, and further promotes the application of biomechanical knowledge in physical education.

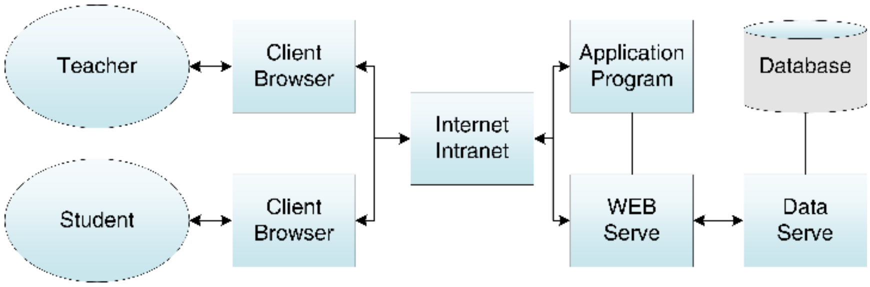


**Figure 5.** Structure diagram of computer-aided instruction platform.

### 4.2. The basic modules and functions of the computer-aided physical education platform

The sensor types are three-dimensional acceleration sensors and force sensors. The accuracy of the acceleration sensor should reach ± 0.01 g (g is the gravitational acceleration), and the accuracy of the force sensor should reach ± 1% F.S. (full range). The sampling rate should be at least 100 Hz to ensure the capture of rapidly changing motion data. Wireless connection supports Bluetooth or Wi Fi wireless transmission, making it convenient to connect with devices and transfer data. Sensors should be compatible with mainstream operating systems such as Windows, macOS, iOS, Android, and can be easily configured and used through platform software. The camera resolution should be at least 1080p high-definition to ensure the clarity of the video image. The frame rate should be at least 30 fps (frames per second) to capture smooth motion movements. The angle of view is a wide-angle lens, with a minimum angle of 120 degrees, to cover a wider range of motion scenes. Built in optical or electronic image stabilization function to reduce blurring and shaking during movement. The promotion of the computer-aided teaching platform in college physical education is inseparable from the construction of the platform environment. The supporting environment structure of college sports computer-aided teaching platform is proposed, as shown in **Figure 6**.

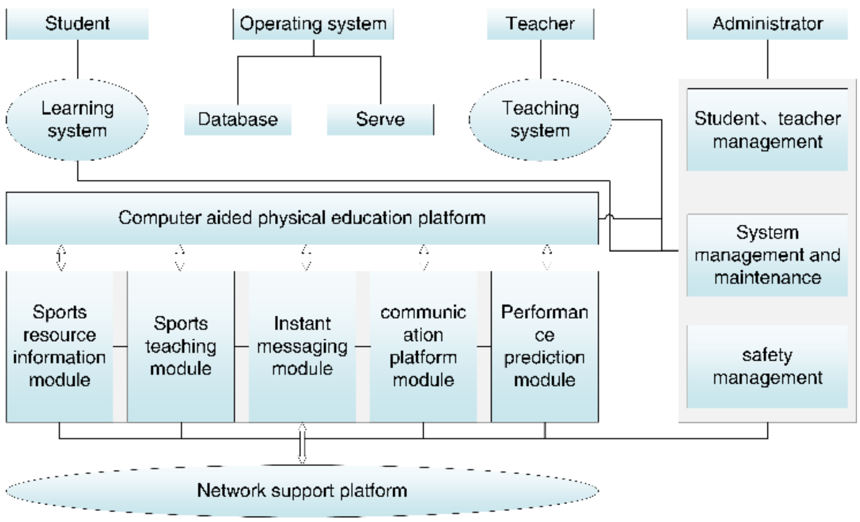


**Figure 6.** Structure of supporting environment of computer-aided teaching platform.

The designed computer-aided instruction platform aims to provide comprehensive and efficient support tools for physical education teaching in colleges and universities. The platform is composed of six core modules, including a sports resource information module, a sports teaching module, an instant communication module, a communication platform module and a function design module.

As the information center of the platform, the sports resource information module focuses on integrating and presenting the latest sports information resources on the Internet. This module uses advanced intelligent retrieval technology to track and capture the latest developments of major sports information websites in real time, including event reports, athlete interviews, sports technology analysis, etc., ensuring that students and teachers can quickly obtain the most cutting-edge sports information. In addition, the module also has powerful video processing capabilities, which can play live broadcasts and videos of major sports events online, bringing users an immersive viewing experience. At the same time, it is also an important channel for schools to release sports news, activity information, and teaching materials, making it convenient for teachers and students to keep up with the latest developments in school sports activities at any time.

In order to facilitate communication and interaction between teachers and students, the platform has designed an instant messaging module. This module supports various forms of instant messaging such as text, voice, and video, allowing teachers and students to stay in touch anytime, anywhere. In addition, it also has group chat function, which facilitates teachers to organize class discussions or students to conduct group learning. In addition to instant messaging, the platform also provides a communication platform module to support functions such as email exchange and file transfer between teachers and students. This helps to strengthen communication and collaboration between teachers and students, and improve teaching efficiency. This module is responsible for the overall functional design and optimization of the platform. It continuously iterates and upgrades the platform based on user needs and feedback, ensuring that the platform remains at the forefront of the industry. At the same time, it also supports user-defined feature settings to meet the personalized needs of different users.

The sports resource information module is an important part of the platform, focusing on integrating the latest sports information resources on the Internet. Through intelligent retrieval technology, the module can capture the latest content of major sports information websites in real-time, and quickly publish it on the platform to ensure that students and teachers can get the most cutting-edge sports information. In addition, the module also provides users with the ability to watch videos of major sports events online, as well as a channel for the school to publish its sports news and activity information.

The physical education teaching module is the core of the platform. As shown in **Figure 7**, teachers can easily edit and upload teaching information through this module, and students can learn course details anytime and anywhere through this module for independent learning. Multimedia network courseware is especially suitable for the demonstration of complex technical movements in physical education. It helps students intuitively understand and master the key points of movement through the form of animation and video. The function of watching the physical education teaching process remotely online can help students get a richer physical education learning experience, especially for colleges and universities with scarce teaching resources. The function of teaching video provide students with a convenient way to review and consolidate knowledge after class.

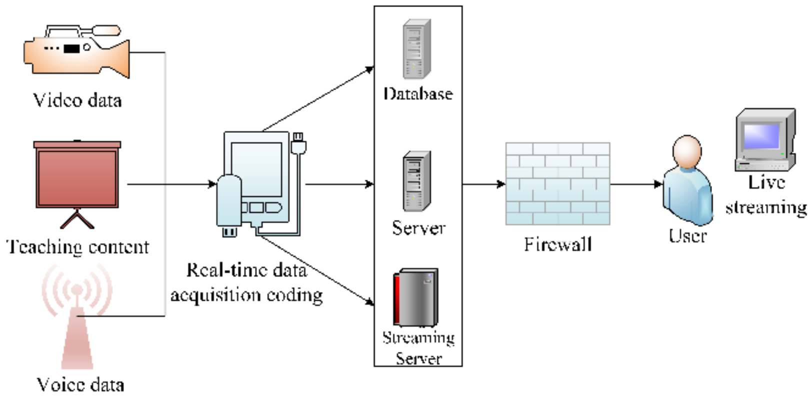


**Figure 7.** Logical structure and implementation of live teaching sub-module of computer-aided teaching platform.

Instant messaging module is the key component of the computer-aided instruction system and plays an important role in real-time communication in the teaching process. It not only supports the instant exchange of information between teachers and students, so that teachers can answer students' questions in time and provide online guidance, but also provides a major platform for interaction and guidance between experts and sports enthusiasts. Through the instant messaging module, users can get timely feedback and guidance no matter where they are, which greatly improves the efficiency and interactivity of physical education. The core function of the communication platform module is to provide a diversified and interactive sports knowledge exchange and discussion platform. The module integrates a variety of functions such as a bulletin board, forum centre, email and online communication software, enabling users to easily post information, share experiences, ask questions and get answers. This module not only promotes the wide dissemination of sports knowledge but also provides an open space for users to exchange ideas and collision views. The functional design module provides a convenient space for college teachers and students to upload and download sports resource information. Users can upload their own sports resources according to their needs, and can also download high-quality resources shared by other users from the platform. These resources include physical education news, all kinds of physical education statistics, physical education research paper library, etc., provide teachers and students with a wealth of learning and research materials, as well as participate in the construction of online physical education environment and online exams, so as to achieve a high degree of resource sharing and personalized learning.

## 5. Comparison of results before and after PE teaching based on computer-aided instruction platform

### 5.1. Analysis of results before physical education

Through one academic year of curriculum learning, we classified and sorted the scores of 40 students in each of the two classes (experimental class and control class) before and after physical education class, and the scores included five grades, namely A (> 90), B (80–89), C (70–79), D (60–69) and E (< 60), as shown in **Figure 8**. The conclusion is as follows: There are 3 students in the experimental class before physical education, and 4 students in the control class. For B-level physical education, there were 14 students in the experimental class and 13 in the control class. For Grade C sports results, 12 people in both the experimental class and the control class chose this option. For the grade D sports results, 10 people in the experimental class chose, while 11 people in the control class chose. It is worth noting that one person in the experimental class scored E in physical education, while no one in the control class. Further analysis showed that we calculated the proportion of students in their respective classes who chose sports as A and B grades. The results show that these two kinds of results account for 42.5% of the total number of students in the experimental class, and the students with grades A and B in the control class also account for 42.5% of the total number of students in the control class. This showed that there was no significant difference in athletic performance between the two classes before the experiment began.

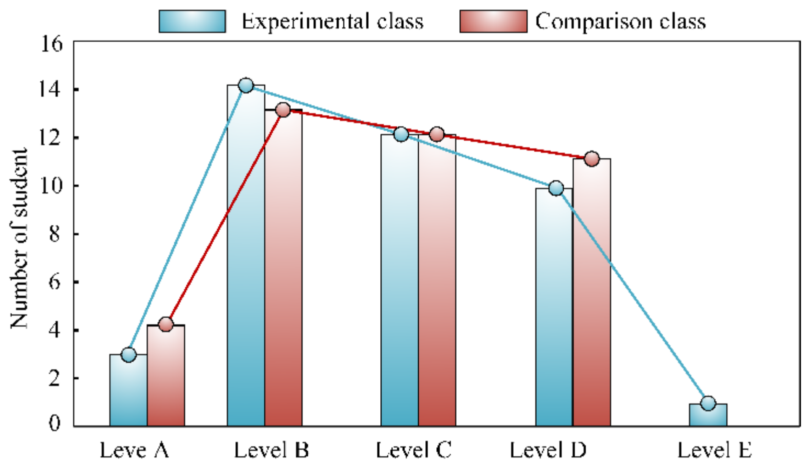


**Figure 8.** Comparison of physical education performance between experimental class and control class before physical education class.

## 5.2. Analysis of results after PE teaching

As shown in **Figure 9**, after one semester of physical education teaching, the physical education results of students in two classes were sorted out and analyzed. The results showed that the number of A's increased significantly to 12 in the experimental class, compared with just four in the control class. At the same time, the number of B students in the experimental class reached 16, compared with 13 in the control class. In the grade C sports, there are 8 students in the experimental class and 15 students in the control class. In the D grade sports results, only 4 people in the experimental class chose, while 8 people in the control class. It is worth noting that none of the students in both classes received an E grade in physical education. Further analysis found that 70% of the students in the experimental class got A and B in physical education, while the proportion was 48.5% in the control class. This data clearly shows that through a semester of physical education experiments, students in the experimental class have significantly improved their physical education scores, while students in the control class have remained relatively stable in their interest level. The above research results show that adopting the proposed computer-aided physical education teaching platform can significantly enhance students' initiative and enthusiasm in physical education, and finally achieve the effect of improving physical education results.

In this process, biomechanical analysis provides a profound understanding of the changes of students' sports performance. For example, in the course, the biomechanical models of joint movement, plantar pressure distribution and ground impact force are combined to analyze the mechanical load of students in different sports. By simulating the influence of different sports modes (such as running, jumping and landing), the platform can provide students with scientific sports data, help them choose suitable sports modes and sports shoes, and reduce sports injuries caused by impact. In addition, the platform also helps students adjust their posture and control their exercise intensity in practice by dynamically simulating the influence of different hardness on joints and muscles, thus improving their sports performance more effectively. Further biomechanical research shows that the improvement of students' sports performance in the experimental class is due to the effectiveness of platform teaching methods. It also closely related to personalized sports data and biomechanical analysis provided by the platform. The feedback obtained by students through the platform enables them to adjust their exercise methods, reduce the adverse impact during exercise and improve their sports skills and physical fitness. Therefore, the biomechanical analysis of this study not only helps to verify the teaching effect of the platform, but also provides scientific sports guidance for students to better achieve the goal of physical education teaching.

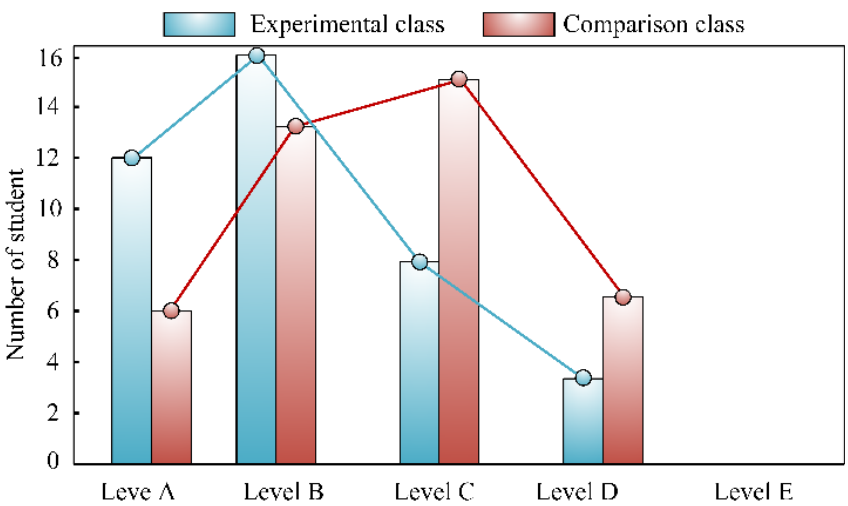


**Figure 9.** Comparison of physical education results between experimental class and control class after physical education.

By using force gauges, we can measure and record the magnitude and time history of ground reaction forces in real-time during student movements such as running, jumping, and landing. These data help us evaluate the impact forces that students experience at different stages of exercise and adjust training plans accordingly to reduce potential risks of sports injuries. Through analysis, it was found that some students experience excessive impact force at the moment of landing, which may be related to their landing style or choice of sports shoes. Therefore, we have provided personalized training recommendations for these students, such as changing the landing angle and increasing the buffering during landing. The distribution of plantar pressure is an important indicator for evaluating students' gait stability and exercise efficiency. By combining a 3D motion capture system with a foot pressure sensor, we can accurately measure the pressure distribution in various areas of the student's foot under different motion states. These data reveal the unevenness of plantar force on students during exercise, as well as possible areas of excessive force. In response to these issues, we provide targeted training guidance for students, such as adjusting gait, enhancing plantar muscle strength, etc., to improve plantar pressure distribution and reduce the risk of sports injuries. In the previous discussion, we mainly focused on the methods of using physical models for motion analysis. However, with the rapid development of artificial intelligence technology, especially in the fields of motion detection, pattern recognition, and personalized training, integrating AI into sports teaching platforms to provide smarter and more adaptive feedback has become a direction worth exploring in depth. This platform can utilize advanced machine learning algorithms to recognize students' motion postures and details in real time through video data captured by cameras. After comparing with the preset standard action model, the platform can quickly identify issues with low exercise efficiency or incorrect posture, and provide immediate corrective suggestions. This real-time feedback mechanism can help students adjust their exercise posture in a timely manner and improve training effectiveness. Combining students' physical fitness data, historical training records, and biomechanical analysis results, the platform can use AI algorithms to generate personalized training plans. These plans not only consider students' current level of physical activity, but also incorporate their personal goals and preferences. By continuously monitoring students' training progress, the platform can automatically adjust the difficulty and content of the training plan to ensure that students gradually improve their athletic abilities in a safe and effective environment.

## 6. Conclusion

Based on the physical model, this study designs and implements a computer-aided physical education platform, and carries out biomechanical research in human movement, especially the parametric analysis of impact force. The study reveals the relationship between ground impact force and joint load, ground stiffness and sole characteristics during human movement, especially in the lower limb joints (such as knee joint and ankle joint) and muscle fatigue. Through in-depth understanding of these biomechanical characteristics, this study can provide accurate guidance for the design of sports shoes, optimize the selection and structure of sole materials, thus reducing the risk of sports injuries and improving sports performance. The design of the platform not only provides a scientific training scheme for athletes, but also provides data support for coaches and sports medical experts to better optimize sports techniques and training strategies, especially in the prevention and rehabilitation of sports injuries.

Through this platform, students can access a variety of sports learning resources based on biomechanical principles, including high-quality teaching videos, sports simulation models, biomechanical analysis and sports injury early warning systems for different sports. The platform uses biomechanical model to recommend personalized exercise scheme, which can effectively guide students to avoid the risk of injury caused by improper exercise posture and improve their sports performance. The platform also introduces real-time impact force and load monitoring, and feeds back the biomechanical data of students in the process of exercise in real time to help them adjust their exercise mode and achieve the optimal exercise effect.

In addition, the platform is limited to the field of physical education, and has a wide application prospect in sports equipment design, sports medical research, sports injury prevention and other fields. The biomechanical model of the platform can provide data analysis on sports impact, joint load and muscle fatigue, help the research and development of sports equipment and sports shoes, provide scientific diagnosis basis for sports medicine, and promote the improvement of sports health and performance.

The future research can be further developed in the following aspects: First, the accuracy of biomechanical model should be further strengthened, especially for the dynamic modeling of ground impact force and human joint load during complex movement. Second, through the introduction of artificial intelligence technology, the intelligent level of the platform is improved, and more personalized and accurate sports guidance is realized, especially the impact optimization and sports injury prevention in different sports scenes. Third, expand the application scope of the platform, especially in sports medicine and sports equipment design, and provide more accurate analysis and suggestions through real-time biomechanical data to optimize the training effect of athletes and reduce sports injuries.

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