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Article

Application of deep learning and biological evolution in personalized physical education teaching plan for student physical fitness generation

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Abstract: In the realm of physical education in higher education institutions, dance courses have emerged as a vital component due to their holistic nature and technical demands. However, traditional teaching methods often face challenges, including limitations in teaching resources, learning interaction, and motion correction. To address these shortcomings and enhance teaching effectiveness, this study introduces a biometric and motion analysis system tailored for sports dance instruction. Grounded in biomechanical principles and leveraging wearable devices alongside intelligent mobile terminal technology, the system collects kinematic and dynamic data from students' dance movements. By employing biomechanical models, it quantitatively evaluates movement standardization and provides real-time feedback to students. The research findings demonstrate that this innovative system significantly improves teaching interactivity and student movement accuracy, achieving a 14% increase in teaching efficiency. Furthermore, 93% of students expressed high satisfaction with the system. This study advocates for the integration of mobile intelligent terminals and biometric technology, the optimization of course design, the development of teaching resources guided by biomechanics, and the strengthening of the synergy between practice and theory. By doing so, it aims to establish a more scientific and effective sports dance teaching model.

Keywords: biomechanics; sports dance; wearable devices; intelligent mobile terminals; motion analysis

1. Introduction

In modern physical education and dance training, biomechanics is gradually becoming a core technology, providing a solid theoretical foundation for the precision, scientificity, and personalization of movements. Biomechanics, as a scientific branch that studies the laws of human motion, reveals the physical and mechanical principles that the human body follows during the process of movement by analyzing the kinematic and dynamic characteristics of movements [1–3]. Research in this field not only helps improve athletic performance, but also reduces the risk of injury caused by incorrect movements, making its application in sports dance teaching of great significance [4].

Sports dance is a sport that combines art and sports, with extremely high requirements for athletes' posture, rhythm, coordination, and strength distribution. Traditional dance teaching mainly relies on teachers' experience and visual observation. Although it can intuitively capture students' movement problems, there are obvious shortcomings in detail analysis and quantitative evaluation [5–7]. In addition, students often find it difficult to fully understand the mechanical principles involved in movements due to a lack of immediate and objective feedback, which in turn affects their learning effectiveness and accuracy of movements [8].

The introduction of biomechanics in sports dance teaching provides a new approach to solving the above-mentioned problems. Through biomechanical analysis, key parameters of dance movements can be measured and evaluated, including joint angles, angular velocities, ground reaction forces, and center of gravity trajectories. These data can not only help students intuitively understand the details of actions, but also provide teachers with more scientific teaching basis [9,10]. For example, in rotational movements, biomechanical analysis can accurately calculate the angular momentum changes of the body, providing reference for optimizing the balance and speed of rotation. In jumping movements, analyzing the mechanical performance of lower limb muscle groups can guide students to allocate force reasonably, thereby increasing jumping height and reducing impact injuries during landing [11].

With the popularity of wearable devices and intelligent mobile terminals, the application of biomechanical technology in sports dance teaching has further expanded. These devices can collect real-time motion data from students and analyze and provide feedback on their movements through algorithms [12]. For example, smart wearable devices can capture the center of gravity changes of students at every step during the dance process, and smart terminals can generate personalized training suggestions and motion correction plans based on this data. Compared to traditional teaching methods, this biomechanical based system not only enhances interaction between teachers and students, but also significantly improves teaching efficiency and students' learning initiative.

Current research has shown that deeply integrating biomechanical principles with dance teaching can achieve multiple improvements [13]. On the one hand, through quantitative analysis and real-time feedback of movements, students can master the technical essentials faster and reduce the time cost of repetitive exercises; On the other hand, teachers can use biomechanical tools to more accurately identify students' movement problems and develop more targeted teaching plans. In addition, the teaching system based on biomechanics can effectively prevent sports injuries and provide students with a safer learning environment [14].

In the future development, the potential application of biomechanics in sports dance teaching still needs to be further explored. For example, artificial intelligence and big data technology can be used to model and analyze a large number of dance movements, providing more comprehensive theoretical support for teaching. Meanwhile, combined with virtual reality technology, biomechanics can also be used to create an immersive dance learning environment, further enhancing the fun and effectiveness of teaching.

2. Methods

Through an investigation and analysis of the teaching processes in certain physical education courses and student classes, it was observed that the predominant approach to physical education dance instruction relies on teacher demonstrations. In this traditional format, students primarily observe the teacher's movements during class and subsequently attempt to imitate them under the teacher's guidance. The incorporation of modern educational technology is limited, typically involving teachers playing instructional videos during class. This method often requires additional teaching support personnel to operate equipment, increasing the complexity of class organization.

Students are generally limited to observing their movements in mirrors during practice. While this approach works for some sports movements, it proves ineffective for others where self-observation is impractical. Furthermore, using mirrors can divert students' attention, hampering their focus during practice. Interviews with instructors revealed additional challenges. Many teachers reported the inability to use blackboards during physical dance instruction and highlighted the difficulties of integrating theoretical teaching conducted in classrooms with the practical nature of dance courses.

The introduction of intelligent mobile terminals has significantly enhanced the compatibility of teaching processes and resources. These tools expand class content and foster improved communication between teachers and students, as well as among students, both before and after class. Such integration demonstrates potential for creating a more interactive and cohesive learning environment for physical education dance courses.

2.1. System structure design

The overall architecture design of the teaching system for the needs of teachers and students in the process of teaching physical dance is shown in **Figure 1**.

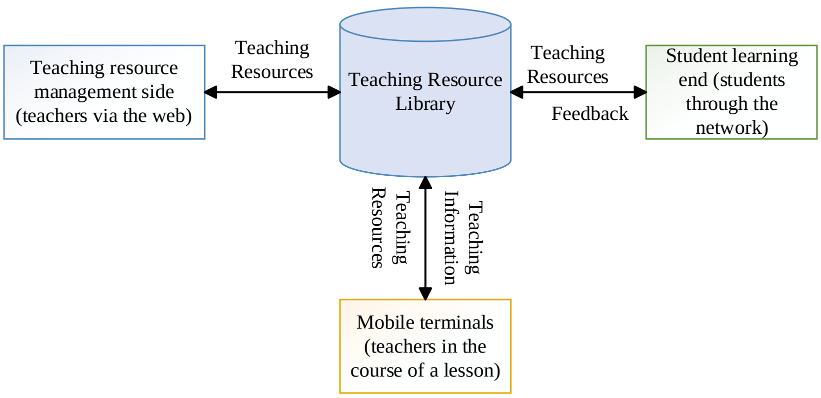

Figure 1. Overall architecture design.

Teaching resource library: It is mainly used to store high-quality teaching resources used by teachers in the course of lesson preparation. Teachers can store their multimedia courseware and videos according to their lesson planning, and also provide help for students to pre-study and review in class. In addition, a discussion forum is deployed in the learning resource server to facilitate student-student and student-teacher communication.

Teaching resource management terminal: It mainly provides teachers to upload and download multimedia information and teaching resources. Teachers can access through web pages without restricting their geographical location, and they can access through computers and wireless mobile terminals, while communicating with students and colleagues, fully reflecting the combination of teaching and learning.

Mobile terminal: mainly used for teachers in the process of class, teachers can access the teaching resources in the server through the mobile terminal in the process of class, if not in the wireless network coverage of the venue, teachers can also download the content of the class to the mobile terminal in advance, convenient for use in class. The teacher can also connect the mobile terminal to the multimedia projector in the course of the lesson to realize the same screen of the mobile terminal and the projection, which can easily combine the course and multimedia technology to realize the writing of the teacher's board in the process of teaching physical dance. Teachers can also take videos and photos of students' movements in the teaching process and play them on the big screen, and make timely corrections to students' technical movements, which can greatly improve the efficiency of the classroom and increase students' motivation in class. The teacher can also upload the files and videos of the class process to the server [15].

Student side: Mainly provides students with pre-study and review before and after class, as well as discussion of learning content in the discussion forum.

2.2. Intelligent mobile terminal application design

According to the analysis, the teaching system for mobile terminals within the need to carry out local area network environment to work, for this part of the structure design as shown in **Figure 2**.

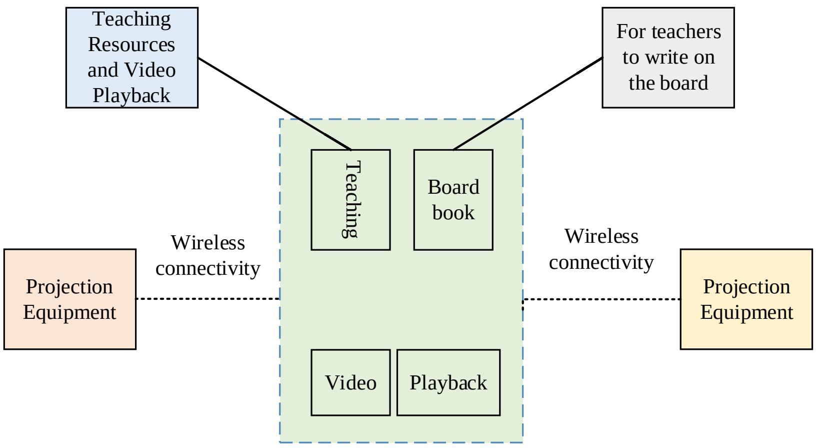

Figure 2. Intelligent mobile terminal application structure design.

In addition to the basic functionality, the mobile terminal and projection system also enable dynamic interaction between the teacher and students. For example, the teacher can pause the video or image displays at key moments to provide real-time corrections or feedback on students' movements. This facilitates a more personalized learning experience and ensures that students receive immediate guidance on improving their posture, form, or technique.

Furthermore, the system supports the integration of motion analysis software, allowing for detailed biomechanical evaluations of students' movements. By analyzing parameters such as joint angles, speed, and alignment, the system can provide quantitative feedback on the quality of students' dance movements. This objective data enhances the teacher's ability to track students' progress over time and offer targeted recommendations for improvement.

The use of this technology also fosters greater student engagement. With the ability to view their own movements from different angles on the projection screens, students are more actively involved in the learning process, increasing their awareness of both strengths and areas for improvement. This approach not only makes learning more interactive but also promotes a deeper understanding of biomechanical principles, encouraging students to make informed adjustments to their movements.

Moreover, the system supports remote learning by allowing students to access recorded lessons and feedback outside of class hours through mobile devices, enhancing learning flexibility and reinforcing concepts taught in class. This combination of real-time feedback, motion analysis, and accessible learning resources helps create a more holistic and effective learning environment for dance students.

2.3. Interactive teaching in physical dance classroom

The interactive teaching mode of students learning physical education based on mobile intelligent terminal devices is shown in **Figure 3**.

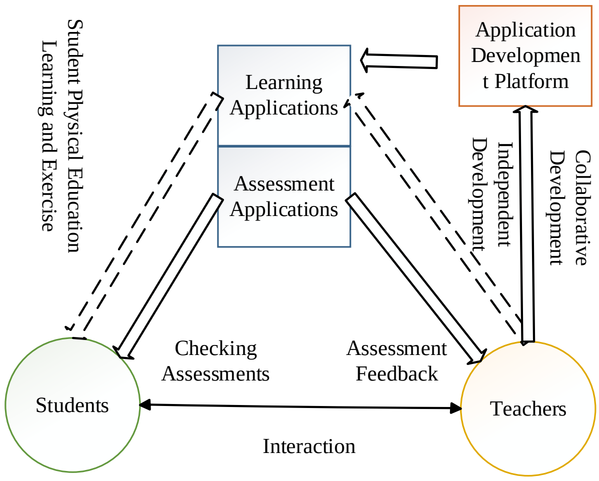

Figure 3. Interactive learning model of physical education based on mobile terminals.

2.4. Construction of physical education dance teaching strategy indicators

After collating the literature and books related to physical education teaching strategies, the structure indexes of physical dance teaching strategies were initially constructed based on the National Curriculum Plan for Physical Education Undergraduate Programs in General Higher Education Schools and the Theory of Physical Education Teaching. After the indicator questionnaires were collected, the mean value of each item was calculated based on the score assigned to each indicator by the experts, and the results are shown in **Table 1** and **Table 2**.

Table 1. Mean values of the first- and second-tier indicators in the first round of expert survey.

Primary Indicators	Average value	Secondary Indicators	Average value
A Instructional preparation strategies	4.50	A1 Analysis of students' learning situation strategy	4.40
		A2 Selecting teaching content strategies	4.30

Table 1. (*Continued*).

Primary Indicators	Average value	Secondary Indicators	Average value
B Instructional implementation strategies	5	B1 Diversified introduction strategies	3.10
		B2 Presentation strategy	4.35
		B3 Explanation strategy	4.90
		B4 Practice strategy	4.50
		B5 Instruction strategy	4.15
		B6 Thinking guidance strategy	3.50
		B7 Cooperation and communication strategy	3.40
C Instructional evaluation strategy	4.40	C1 Differentiation of evaluation criteria strategy	4.20
		C2 Evaluation content comprehensiveness strategy	4.85
		C3 Diversification of evaluation subjects	3.75
		C4 Diversification of evaluation methods	3.85

Table 2. Mean values of indicators at three levels in the first round of expert survey.

Tertiary indicators	Average value
A11 Technical skill level	4.80
A12 Theoretical knowledge base	4.50
A21 Sorting out the structure of physical education materials	4.35
A22Integrate the content of other subjects	4.15
A23 Orchestrating the overall knowledge framework	3.70
B11 Question-based introduction	4.85
B12 Project-based introduction	4.35
B13 Music-based introduction	4.65
B21Visualization with pictures	3.65
B22Processing with video	4.25
B23Detailed teacher demonstration	5
B24 Student presentation competition	4.15
B31 “Story” approach to introduction	3.95
B32Teaching of specialized terms	5
B33 Comprehensive knowledge support	4.45
B34Inspiring questions for guidance	4.55
B35 Motivational language encouragement	3.85
B41 Targeted practice content	4.85
B42 Flexible practice format	4.35
B43 Practice in a gradual manner	3.75
B44 Reasonable control of practice load	4.15
B51One-on-one guidance	4.55
B52 Group-based instruction	4.65
B53 Group instruction for error correction	3.75
B54 Theory prompting instruction	3.85
B61 Guiding students’ thinking on the integration of multidisciplinary knowledge	4.25
B62 Inspiring students to apply theoretical knowledge to solve technical problems	4.45

Table 2. (*Continued*).

Tertiary indicators	Average value
B63 Encourage students to think independently and try to innovate	4.30
B71 Discuss with each other in small groups	4.30
B72 Discuss with each other and the teacher	4.30
C11 Gender differences between men and women	4.30
C12 Differences in learning ability	4.75
C21 Degree of understanding of theoretical knowledge	4.30
C22 Degree of technical skill mastery	4.75
C31 Teacher evaluation	4.65
C32 Self-evaluation	4.35
C33 Intra-group mutual evaluation	4.15
C34 Inter-group evaluation	4.35
C41 Process evaluation	1.25
C42 Summative evaluation	4.25

Based on the results from the table above, the initial physical dance teaching strategy indicators were revised. Indicators with a mean value lower than 3.5 were eliminated. For example, the mean value of the B1 diversified introduction strategy index was 3.15, the B6 cooperative communication strategy index was 3.40, and the B7 thinking guidance strategy index was 3.30, so these three indicators were removed. Following expert recommendations, the secondary index B6 (cooperative communication strategy) was integrated into B4 (practice strategy), with the aim of achieving effective group practice through communication and collaboration. Similarly, the B7 thinking guidance strategy was merged into B3 (explanation strategy), as the objective of providing guidance can be accomplished more effectively through clear explanations[16].

In the second round of expert surveys, the same index screening method was applied as in the first round. Indicators that received objections were revised according to the feedback provided by the experts. After distributing the revised indicators to 20 experts, no significant changes were made, indicating that the experts recognized and approved the revised indicators, meeting the study's criteria. To assess the consistency and objectivity of the experts' ratings, the Kendall's concordance coefficient formula was employed. The formula used for this test is as follows:

$$W = \frac{\sum R\, l^2 - \frac{(\sum R\, t)^2}{N}}{\frac{1}{12}K^2(N^3 - N) - K\sum \frac{3-n}{12}} \tag{1}$$

$$W = \sum_{i}^{n} \frac{(R_i - m(n+1)/2)^2}{(m^2) - n(n^2-1)/12} \tag{2}$$

The results of the indicator consistency test are shown in **Tables 3–5**.

Table 3. Kendall's harmony coefficients of the first-level indicators.

Primary Indicators	Kendall Harmony Coefficient
A-C	0.89

Table 4. Kendall's harmony coefficient for secondary indicators.

Secondary indicators	Kendall Harmony Coefficient
A1-A2	0.78
B1-B4	0.85
C1-C4	0.87

Table 5. Kendall's harmony coefficient for the three levels of indicators.

Tertiary indicators	Kendall Harmony Coefficient
A11-A12	0.78
A21-A23	0.85
B11-B14	0.87
B21-B25	0.85
B31-B34	0.79
B41-B44	0.67
C11-C12	0.88
C21-C22	0.78
C31-C34	0.84
C41-C42	0.75

The results of Kendall's harmony coefficient calculation show that the structure of 3 primary indicators, 10 secondary indicators and 32 tertiary indicators in the established physical dance teaching strategy is consistent.

In order to provide teachers with better teaching strategies for physical dance, the third round of expert survey ranked the indicators at all levels and calculated the weight values of each indicator according to the results of expert ratings, and the results are shown in **Table 6**.

Table 6. Indicator weighting values.

Primary Indicators	Weighting value	Secondary indicators	Weighting value	Tertiary indicators	Weighting value
A		A1	0.502	A11	0.468
				A12	0.532
		A2	0.498	A21	0.368
				A22	0.307
				A23	0.321

Table 6. (*Continued*).

Primary Indicators	Weighting value	Secondary indicators	Weighting value	Tertiary indicators	Weighting value
B		B1	0.245	B11	0.202
				B12	0.252
				B13	0.304
				B14	0.245
		B2	0.278	B21	0.165
				B22	0.235
				B23	0.213
				B24	0.222
				B25	0.165
		B3	0.248	B31	0.312
				B32	0.238
				B33	0.265
				B34	0.187
		B4	0.225	B41	0.253
				B42	0.355
				B43	0.261
				B44	0.133
C		C1	0.262	C11	0.472
				C12	0.523
		C2	0.298	C21	0.412
				C22	0.586
		C3	0.232	C31	0.293
				C32	0.245
				C33	0.235
				C34	0.233
		C4	0.208	C41	0.512
				C42	0.488

3. Case study

In this study, 25 physical dance teachers who taught physical dance special classes in six colleges and universities in a Province were surveyed respectively, and the findings were as follows.

3.1. Results and analysis of teaching preparation strategies of physical dance

Teaching preparation strategy is the premise of teachers' teaching activities, including the strategy of analyzing students' learning situation and the strategy of selecting teaching contents [17].

The results of the statistical data in **Table 7** and **Figure 4** show that 48% of the teachers of physical dance always consider the students' technical level and 36% do not pay attention to the students' knowledge reserve at this stage. This shows that teachers are most concerned about the technical level of students in physical dance before class, and slightly less concerned about the knowledge students have mastered.

Table 7. Statistics of teachers' survey on students' learning analysis strategies (N = 25 unit: People).

Strategies	Always	Often	Sometimes	Rarely	Never
Consider students' knowledge base	3	3	4	6	9
Understand students' technical level	11	9	2	2	1

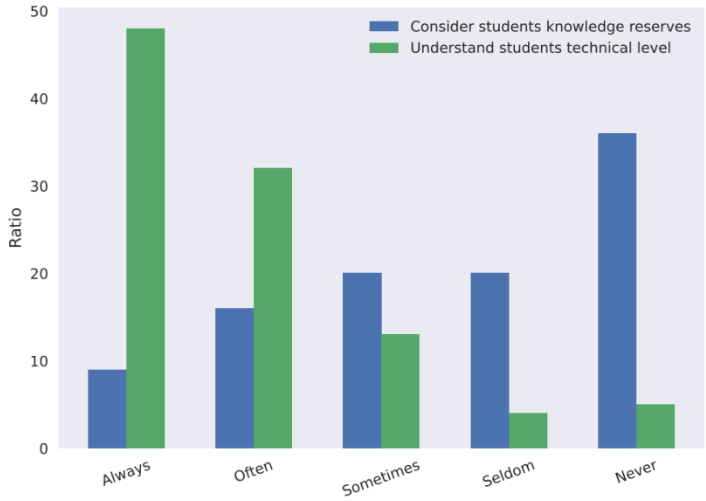

Figure 4. Statistics of the survey on teachers' strategies for analyzing students' learning (N = 25 units: People).

The results presented by the data in **Tables 8** and **Figure 5** show that 76% of the physical education dance teachers' strategies for selecting teaching contents before class sort out the contents of physical education textbooks; 52% of the teachers do not pay attention to the contents integrated with the knowledge of other subjects; and 64% of the teachers do not rearrange the knowledge related to teaching contents. This shows that most physical dance teachers pay too much attention to the teaching content of physical dance itself when they select the teaching content before class, and less to the content of other subjects [18].

Table 8. Statistics of teachers' survey on the strategies of selected teaching contents (N = 25 unit: Person).

Strategies	Always	Often	Sometimes	Rarely	Never
Sorting out the content of physical education materials	18	5	2	0	0
Integrating knowledge from other subjects	1	2	5	6	11
Reorganize the knowledge framework	1	2	1	6	15

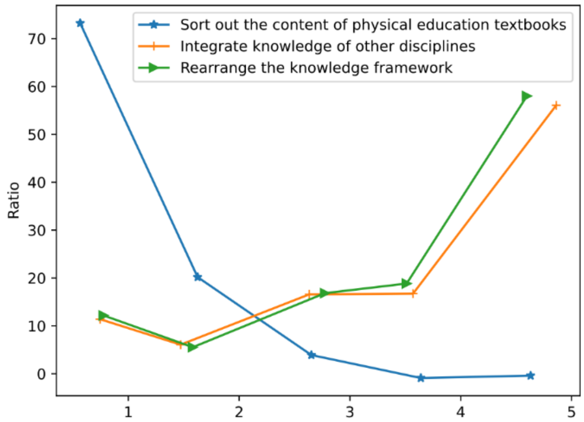

Figure 5. Statistics of teachers' survey on the strategies of selected teaching contents (N = 25 unit: Person).

3.2. Results and analysis of strategies implemented in physical education dance

The strategies implemented in class reflect the teachers' teaching ability and effectiveness, and are the main manifestation of teachers' teaching level and the key link of students' learning. The strategies implemented in class include: Presentation strategies, explanation strategies, practice strategies, and instruction strategies.

According to the results shown in **Table 9** and **Figure 6**, 60% of physical dance teachers frequently use teacher demonstrations to illustrate the details of movements to students, while 40% rarely use visual aids, such as pictures, to present the teaching content. Additionally, 40% of the teachers never have students perform demonstrations themselves, and 11 out of the 25 teachers surveyed (44%) never allow students to view physical dance videos.

From the analysis of these data, it can be concluded that physical dance teachers primarily rely on a single method of instruction, mainly through their own demonstrations. While teacher demonstrations help clarify the flow of technical movements and are essential for students to accurately imitate the movements, relying solely on this method can lead to a decrease in students' long-term interest in learning. To achieve the desired teaching outcomes, it is crucial for teachers to incorporate a variety of presentation strategies and use them in combination, enriching the learning experience and maintaining student engagement.

Table 9. Survey statistics of teachers' use of presentation strategies (N = 25 unit: Person).

Strategies	**Always**	**Often**	**Sometimes**	**Rarely**	**Never**
Using pictures to present	4	6	2	11	2
Use video to show	2	6	5	10	2
Teacher demonstration	14	4	3	4	0
Student competition show	3	2	4	6	10

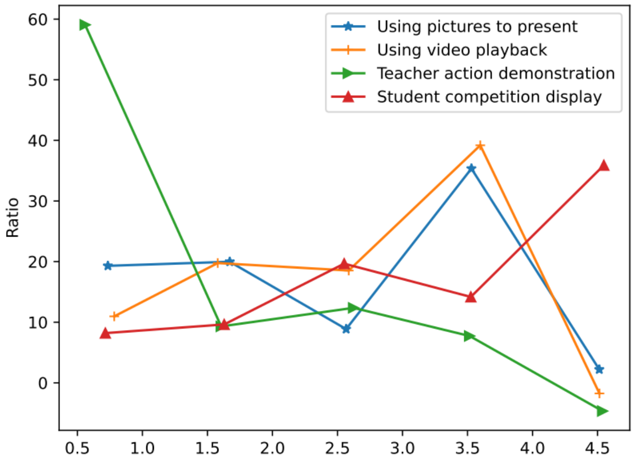

Figure 6. Statistics of the survey on teachers' use of presentation strategies (N = 25 unit: Person).

The results presented in **Table 10** show that 40% of the teachers often use the terminology of physical dance to teach; however, the same percentage of teachers rarely use "stories" to improve students' memory of the teaching content; 60% (15) of the physical education teachers rarely use other subjects to support the teaching of physical education and dance. However, 60% (15) of the physical education and dance teachers seldom used other subjects to support the teaching of physical education and dance and to guide their comprehensive thinking; 60% and more than half of the teachers seldom used motivational language to encourage students in the teaching process.

It can be analyzed that physical dance teachers are teachers of art courses, and they pay too much attention to technical movements in the teaching process, but pay little attention to theoretical knowledge which is beneficial to students' technical learning and development, and even do not pay attention to it, which will cause the phenomenon of "knowing the technique but not knowing the theory" among students of physical dance in colleges and universities.

Table 10. Survey statistics of teachers' use of explanation strategies (N = 25 unit: Person).

Category	Always	Often	Sometimes	Rarely	Never
Introduction by "story" method	2	6	4	11	2
Technical terminology	8	9	4	3	1
Comprehensive knowledge support	1	2	2	4	16
Inspiring questions to guide	4	2	5	14	0
Motivational language encouragement	2	5	8	6	4

From the statistics in **Table 11** and the results in **Figure 7**, it can be concluded that 40% of the physical dance teachers would let students practice step by step until they mastered the exercise content; 32% of the teachers seldom used multiple organizational forms to let students practice the teaching content.

The results of the survey showed that a few teachers would use flexible and varied organizational forms to let students practice, while most teachers still organized students' practice in the traditional single practice way. Because of the rigid organization and weak interest, they cannot reach the understanding of the teaching content in the whole practice, and there is no good practice atmosphere, so they cannot promote the overall practice effect.

Table 11. Survey statistics of teachers' use of practice strategies (*N* = 25 unit: Person).

Strategies	Always	Often	Sometimes	Rarely	Never
Exercise content is targeted	5	8	6	4	2
Exercise form is flexible and diverse	3	8	7	7	0
Exercises in a gradual and progressive manner	9	4	3	6	3
Reasonable control of exercise load	3	2	4	7	9

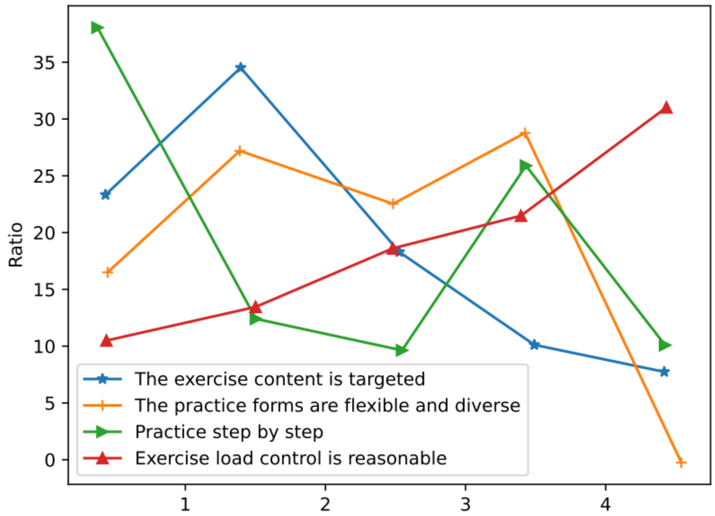

Figure 7. Statistics of the survey on teachers' use of exercise strategies (N = 25 unit: Person).

According to the data presented in **Table 12**, 52% of teachers consistently use group error correction to guide students during practice sessions; 44% frequently employ group instruction during lessons; 36% often provide one-on-one targeted instruction, while 4% of teachers do not offer individual guidance; and 60% of teachers rarely incorporate theoretical knowledge related to technical movements into their instruction. The majority of teachers rely heavily on one-on-one instruction.

An analysis of these findings indicates that most physical dance teachers tend to focus on group-based instruction, with less emphasis placed on individualized attention. The instruction predominantly revolves around technical aspects of the movements, with fewer teachers incorporating theoretical knowledge as a foundation for the learning process. This gap suggests that starting from theoretical concepts could significantly enhance students' understanding of the technical movements. By offering theoretical insights before diving into the practical execution, teachers can provide students with a deeper comprehension of the principles behind the movements. This approach could also aid in correcting errors more effectively by linking the technical corrections with a conceptual understanding, thus helping students improve both technically and cognitively. Integrating theoretical knowledge into the instructional process would create a more holistic teaching method, fostering better long-term retention and mastery of physical dance skills.

Table 12. Survey statistics of teachers' use of instructional strategies (N = 25 unit: Person).

Strategies	Always	Often	Sometimes	Rarely	Never
One-to-One	7	8	5	4	1
Grouped	10	8	3	4	0
Collective error correction	12	9	3	1	0
Theoretical knowledge tips	1	4	4	16	0

4. Conclusion

Biomechanics, as an interdisciplinary science, has demonstrated its enormous potential in multiple fields. From understanding the mechanisms of biological movement to developing innovative medical devices, research in biomechanics has always revolved around the complex relationship between mechanical principles and biological systems. The summary of this study emphasizes the following core aspects:

Firstly, biomechanics provides a powerful tool in revealing the laws of human movement. Through modeling and experimental verification, researchers can accurately describe the dynamic behavior of biological structures such as joints, muscles, and bones. This not only helps diagnose and treat sports injuries, but also provides a scientific basis for optimizing sports performance. For professional athletes, biomechanical analysis can help them improve their training methods; For ordinary patients, accurate assessment of motor mechanics can guide the design of rehabilitation plans.

Secondly, biomechanics plays a crucial driving role in medical technology innovation. For example, in the design of artificial joints, orthopedic implants, and prosthetics, biomechanical principles are used to optimize material selection and structural design to achieve higher biocompatibility and mechanical stability. At the same time, research on soft tissue biomechanics has also promoted the development of biomaterials, providing new solutions for fields such as cardiovascular repair and tissue engineering.

Finally, with the advancement of technology and the deepening of interdisciplinary collaboration, biomechanics will continue to play an important role in emerging fields. The combination of digital simulation technology, artificial intelligence, and high-resolution imaging technology provides unprecedented possibilities for a deeper understanding of the mechanical properties of biological systems. These technological breakthroughs will not only drive the development of basic research, but also accelerate the transition from laboratory to clinical applications.

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

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