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Article

Application of artificial intelligence dance art based on biomechanics innovation practice

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Abstract: Research purpose: To explore the influence of dance training and creation methods based on the combination of biomechanics and artificial intelligence (AI) technology on dance expression, biomechanics indicators and subjective satisfaction of dancers, to promote the modern development of dance art, and to optimize the dance education and training methods. **Study method:** A control experiment was designed, and then the subjects were divided into experimental group and control group. The experimental group adopted the dance training and creation method based on the combination of biomechanics and AI technology, while the control group adopted the traditional dance training and creation method. During the experiment, the biomechanical data of the dancers were collected using the 3D motion capture system and EMG measurement equipment, and the AI model was developed for data analysis and training guidance. **Study content:** The experiment involved the assessment of dance performance, the comparison of biomechanical indicators, and the subjective satisfaction survey of dancers. Rate the dance works, evaluate the innovation of dance movements, the depth of emotional expression, etc., use advanced equipment to measure the biomechanical indicators of peak joint strength and muscle fatigue, and understand the feelings and opinions of dancers on the experiment through questionnaire and interview. **Results:** The experimental group showed obvious advantages in dance performance, biomechanics, and subjective satisfaction of dancers. Dance works are equally expressive. All scores were significantly higher than the control group, peak joint stress was relatively low, muscle fatigue increased slowly, and dancer satisfaction scores also were significantly higher.

Keywords: biomechanics; artificial intelligence; art of dance; dance expression; risk of physical injury

1. Foreword

In the rapid development of science and technology, artificial intelligence (AI) is like a surging wave, sweeping and reshaping all fields, and the art of dance is also deeply touched by it. The intervention of AI technology has opened a door to a new dimension for the dance art that has been inherited for thousands of years, bringing unprecedented opportunities for development [1]. Biomechanics, as a subject focusing on exploring the mechanical characteristics of living organisms, is just like an accurate ruler, which provides a solid scientific foundation for analyzing the rationality and efficiency of dance movements, as well as protecting the physical health of dancers [2]. The innovative practice of biomechanics and artificial intelligence are deeply integrated into the dance art, which aims to combine the strengths of both and carefully carve out dance works and performance forms that are full of innovative vitality and strong expression, but also take more care of the dancer bodies [3]. The fusion is not simple superposition, it is like a wonderful chemical reaction, not only can vigorously promote dance art stride toward the direction of modernization, can also for the

innovation of dance education, training methods, provide unique ideas and methods, for the future development of the art of dance draw the outline of a blueprint full of infinite possibilities.

2. Literature review

Looking back over the past few decades, AIs exploration of the arts field has been fruitful. Focusing on the category of dance, the early research mainly focused on using AI algorithm to build the generation system of dance movements [4]. With the help of cutting-edge technologies such as deep learning, researchers conduct in-depth analysis of massive dance samples, enabling the computer to act like a creative choreographer. Zhang [5] There is an error between the movement Angle generated by the traditional dance movement automatic generation method and the initial setting Angle. Therefore, the research based on artificial intelligence is proposed. Collect music audio signal, extract pitch, strength, melody characteristics such as parameters, simplify the robot for seven connecting rod structure, control different connecting rod joint Angle, determine the trajectory and posture, using artificial intelligence technology set robot basic movements, arrangement and combination music characteristic parameters identify music emotion, placed different emotional characteristics of body movements, form the data file optimization master chip, complete the robot automatically generate dance movements. The design comparison experiment measures the overhead Angle of different joints of the robot. The results show that the generation Angle of this method is closer to the initial Angle, which makes the robot dance movement more stable and smooth. Li et al. [6] applied the motion recognition theory of artificial intelligence to dance teaching, the scoring system of human-computer interaction has been developed to realize the real-time query of mobile terminal. During teaching, wearable sensor inertial measurement unit (inertial measurement unit, IMU) was used to collect the data information of dance movements, and then standardized data processing and data segmentation in the sliding window were used to establish a deep learning model of long and short-term memory (long short-term memory, LSTM). By studying the test results of the model action recognition, it is found that the model accuracy can reach 94.28%. At the same time, the LSTM deep learning model, HTML 5, CSS 3 and other technologies are used to realize the visual real-time performance query function in the form of human-computer interaction. The intelligent scoring system proposed in this paper promotes the dynamic combination of the integration of inside and outside the course, and realizes the intelligent teaching of university physical education courses. However, one obvious weakness in these early studies is the lack of consideration of human biomechanical factors. The resulting dance movements are seemingly exquisite, but in fact, in the actual interpretation process, they may bring heavy burden to the dancers body, and even bury the hidden danger of injury. After all, there are many limitations to the bodys physiological structure and motor function, and if the dance movement violates these natural laws, it will inevitably damage the health of the dancers.

In the field of the intersection of biomechanics and dance, many scholars focus on the mechanical principles of dance movements. Chen and Li [7] Sports biomechanics is a science to study the law of human motion mechanics. As an

important branch of biomechanics, it is in an important position in the modern sports science system. Especially driven by computer calculus technology, sensing technology, artificial intelligence and other related technologies, the application scenarios of sports biomechanics in sports are more extensive, and its application value is increasingly prominent. This paper discusses the application of sports biomechanics in dance training. Kang and Du [8] Sports dance has a basic correlation with sports biomechanics, playing a positive role in improving the level of sports, promoting movement innovation, and preventing sports injuries. From the perspective of movement biomechanics, using the literature method and logical analysis of the sports dance content formation literature review, can help coaches and athletes to effectively understand the human mechanical knowledge and movement of sports dance, thus better guidance for sports dance sports training, improve the quality of training. These research results provide a practical scientific basis for the optimization of dance training methods and contribute to the dance teacher system. A more reasonable and efficient training programs to reduce the risk of injury to dancers. Unfortunately, such research has failed to integrate with the booming AI technology for a long time. It was not until recently that some pioneer researchers were keenly aware of the great potential of combining the two and began to try to introduce AI and biomechanics into the field of dance art [9]. However, in general, the research field is still at the beginning of the initial stage, just like a seedling ground, in the improvement of theoretical systems, the development of technical applications and the accumulation of practical experience.

3. Research technique

3.1. Study design

This study aims to explore the impact of dance training and creation methods based on the combination of biomechanics and artificial intelligence technology on dance performance, biomechanical indicators, and subjective satisfaction of dancers. 100 students majoring in dance at a certain university were selected as experimental subjects. These students have a solid foundation in dance and a deep understanding and recognition of the experimental content. In order to ensure the fairness and effectiveness of the experiment, we adopted a random grouping method, dividing 100 students into an experimental group and a control group, with 50 students in each group, as shown in **Table 1**. According to **Tables 2** and **3**, it can be seen that among the 50 participants in the experimental group, 15 are skilled in classical dance. These dancers have received strict and standardized training for a long time, following specific aesthetic principles in body posture and movement rhythm; 18 people focus on modern dance, emphasizing dancers' personal expression and exploration of physical limits. They are very bold in dance concepts and innovative movements; There are also 17 people who are proficient in ethnic dance, combining the unique culture, customs, and living elements of each ethnic group to showcase different ethnic customs. There are still 50 people in the control group, including 14 who specialize in classical dance, 17 who engage in modern dance, and 19 who study ethnic dance.

Table 1. Sample basic information statistics table.

group	sex	number of people	Age (year)	Number of dance years (years)
experimental group	man	25	20.5 ± 1.5	6.0 ± 2.0
	woman	25	19.8 ± 1.2	5.8 ± 1.8
control group	man	25	20.3 ± 1.3	5.9 ± 1.9
	woman	25	20.0 ± 1.4	6.1 ± 2.1

Table 2. Statistical table of dance participation in training.

group	Training attendance rate of (%)	Training time duration (hours/week)	Number of creative practices
experimental group	98	10 ± 2	4 ± 1
control group	95	8 ± 1	3 ± 1

Table 3. Summary table of the interview results.

theme	Main points of the experimental group	Main views of the control group
training effect	"The training program provided by the AI model is very personalized and very helpful."	"Traditional training methods are more systematic, but not more targeted."
production process	"The AI model provides a very creative combination of actions that inspired me."	"Traditional way of creation is free, but sometimes it lacks novelty."
Work effect	"The overall performance of the work has improved, and the audience feedback is very good."	"The performance is ok, but it feels like some highlights."
recommendations for improvement	"I hope the AI model will provide more personalized feedback and advice."	"I hope the teachers can provide more creative guidance and support."

3.2. Experimental methods

1) Preparation before the experiment:

(1) Preparation of data collection equipment

Carefully prepare for data collection before the experiment, equipped with advanced 3D motion capture systems and electromyographic signal measurement equipment. These devices can accurately capture the spatial motion trajectory and muscle activity of dancers during the dance process, obtaining key biomechanical indicators such as joint angle, velocity, acceleration, and muscle activation status. Strictly calibrate the equipment, establish standardized operating procedures, and optimize the experimental environment to ensure the accuracy and consistency of data.

(2) AI model construction

Based on the biomechanical data collected in the early stage, an AI model is constructed using deep learning techniques. This model adopts a combined architecture of Convolutional Neural Network (CNN) and Long Short Term Memory Network (LSTM). CNN excels at extracting spatial features from images and can accurately capture the morphological information of dance movements; LSTM has powerful processing capabilities for time series data and can effectively analyze the temporal variation patterns of dance movements. By combining the two, AI models can comprehensively understand dancers' movement habits and characteristics. The data input features include the dancer's biomechanical data, dance style information, and personal basic information. During the model training process, the data is divided into training set, validation set, and test set. Random gradient descent algorithm is used

for training, and the model parameters are continuously adjusted to minimize the loss function value on the validation set, thereby improving the model's generalization ability and accurately analyzing the relationship between the biomechanical characteristics of dancers and dance movements. This provides personalized training suggestions for dancers and assists in dance creation.

2) Experimental process

(1) Experimental group training plan and creation process: The training lasts for 12 weeks and is divided into three stages. One is the basic training stage (weeks 1–4): Monday to Friday, 9:00–10:30, biomechanical warm-up training is conducted, and AI provides personalized stretching plans based on students' flexibility; from 10:30–12:00, conduct AI based dance movement standardization training, where AI analyzes movement deviations in real-time and corrects them; 14:00–15:30 study the principles of biomechanics; from 15:30–17:00 perform AI assisted dance performance training. On Saturday, we will summarize this week's training and generate an AI training report. The second stage is the improvement training phase (weeks 5–8): From Monday to Friday, 9:00–11:00, a combination of biomechanics and AI exercises will be conducted, with AI generating and adjusting action combinations based on students' situations; From 11:00–12:30, AI intelligent feedback training will be conducted, and students will strengthen their training based on the feedback; From 14:00–16:00, basic dance creation training will be conducted, with AI providing creative inspiration; From 16:00–17:30, group collaboration training will be conducted with AI guidance for group collaboration. On Saturday, there will be a dance demonstration within the group. The third stage is the comprehensive creation stage (weeks 9–12): Monday to Friday, 9:00–12:00, students independently create dance, with AI providing creative and technical support; Rehearsing and optimizing the work from 14:00–17:00, AI evaluation and proposing modification suggestions. Exhibition and evaluation of works will be conducted on Saturday. A team composed of dance experts, biomechanics experts, and AI technology experts. Dance experts determine the basic training content and objectives, biomechanical experts integrate biomechanical principles, and AI technology experts develop AI training systems. Collect dance works and dancer movement data to establish a database, design training content and methods based on training objectives, optimize AI systems through pre implementation testing, and train students.

(2) Control group training plan and creation process: The training also lasts for 12 weeks and is divided into three stages. One is the foundation consolidation stage (weeks 1–4): traditional warm-up training is conducted from 9:00–10:30 from Monday to Friday; Basic skills training will be conducted from 10:30–12:00, with on-site guidance from teachers; Study dance theory from 14:00–15:30; Practice simple dance combinations from 15:30–17:00. The basic skills assessment for this week will be conducted on Saturday. The second stage is the skill improvement stage (weeks 5–8): From Monday to Friday, 9:00–11:00, dance skill training will be conducted, with targeted guidance from teachers; Perform dance performance training from 11:00–12:30; Rehearsing dance performances from 14:00–16:00; Group discussions and exchanges will take place from 16:00–17:30. A group dance demonstration will be held on Saturday. The third stage is the creative practice stage (weeks 9–12): From Monday to Friday, from 9:00–12:00, dance creation learning will be conducted, and

teachers will explain the creative methods; Rehearsing and refining of the work from 14:00–17:00, with guidance from the teacher. Exhibition and evaluation of works will be conducted on Saturday. A training plan is designed by an experienced team of dance teachers, referencing classic textbooks and outlines to ensure that the content covers all aspects of traditional dance training. Considering students' foundation and abilities, arrange training intensity and difficulty, organize teacher training seminars before implementation, and unify teaching standards.

(3) Data collection and analysis: Firstly, evaluation of dance performance: 10 senior dance experts, critics, and excellent dance directors were invited to form a judging panel. The two groups of dance works were rated based on dimensions such as innovative dance movements (30%), deep emotional expression (25%), stage appeal (25%), and compatibility with music (20%). The average score was taken as the final score. The second is the comparison of biomechanical indicators: using a 3D motion capture system and electromyographic signal measurement equipment, the peak joint force (Newton) and muscle fatigue level (percentage decrease in electromyographic signal amplitude) of dancers performing specific dance movements (such as jumping, rotation, squatting) are measured, and the average value is taken three times for each indicator. The third is the subjective satisfaction survey of dancers: design questionnaires and interviews to investigate from the aspects of training methods (30%), creative process (30%), work effect (25%), overall satisfaction (15%), etc. The questionnaire adopts a five levels rating system (1–5 points). The experimental results showed that the experimental group performed better in dance performance, biomechanical indicators, and subjective satisfaction of dancers [10].

4. Finding

(1) Assessment of dance performance ability

In order to objectively and fairly evaluate the expression of the dance works of the experimental group and the control group, we invited a professional dance jury composed of senior dance experts, critics and excellent choreographer. According to a set of strict scoring standards, the jury members scored the dance works of the two groups from multiple dimensions, such as innovation, depth of emotional expression, stage appeal and fit with the music, with a full score of 100 points. The final scoring results are shown in **Table 4** below:

Table 4. Assessment of dance performance.

group	average	high run	discard highest and lowest scores
experimental group	85	92	78
control group	72	80	65

It is clear from the data in **Table 4** that the mean score in performance ability of the dance works in the experimental group was significantly higher than that in the control group. This result strongly shows that the creation method based on the combination of biomechanics and AI technology can inject more innovative elements and emotional tension into the dance works, thus greatly enhancing the artistic appeal and appreciation of the dance works. For example, in the works of the experimental

group, with the assistance of AI model, the dancers can explore some unique action combinations and forms of expression. These novel elements not only attract the audiences attention, but also give a deeper artistic connotation to the works. At the same time, the application of biomechanical principles makes the dancers more confident and smooth in the performance process, and can better integrate their emotions into the dance movements, so as to have a strong emotional resonance with the audience.

(2) Comparison of biomechanical indicators

The peak stress of the knee during a series of specific dance movements. These specific dance movements cover common jumps, rotations, squats and other representative movements. The measurement results are shown as follows:

From the comparison of the data in **Table 5**, the experimental group of dancers had a relatively low peak force in the knees during the same dance movements. This data intuitively shows that AI guidance based on biomechanical principles plays an important role in the dance training and creation process. Through the optimization and adjustment of the dance movements by the AI model, the force of the joints of the body is more uniform and reasonable when completing the movements, which effectively reduces the unnecessary pressure borne by the joints, thus significantly reducing the risk of joint injury. Taking the jumping movement as an example, the AI model may adjust the height and Angle of the jumping and the buffer mode of the landing according to the dancers body conditions and biomechanical data, so that the force of the knee joint during the whole process is within a relatively safe range.

Table 5. Joint forces.

group	Average force peak (*N*)	Maximum force peak (*N*)	Minimum force peak (*N*)
experimental group	350	420	280
control group	480	550	380

(2) Muscle fatigue level

To accurately assess muscle fatigue in dancers before and after training, we employed advanced EMG measurement techniques. The changes of muscle electrical signals before and after training were monitored by attaching electrodes on the main muscles such as the front thighs of the dancers. Take the anterior thigh muscle group as an example, the specific data are as follows:

The data in **Table 6** showed that the rate of EMG signal change in the experimental group was significantly lower than that in the control group. This means that the rate of muscle fatigue in dancers increases relatively slowly under a training mode based on biomechanics and AI technology. This is mainly due to the synergy between AI technology and biomechanics principles in the training process. On the one hand, the AI model can intelligently adjust the training intensity and rhythm according to the real-time muscle state and biomechanical data of the dancers, so as to avoid muscle fatigue caused by overtraining; on the other hand, the application of biomechanical principle makes the dancers more scientific and efficient, reducing unnecessary energy consumption and accumulation of muscle fatigue. For example, during strength training, the AI model can adjust the training weight and repetition

times according to the dancers muscle fatigue, so as to ensure the training effect and protect the muscle health of the dancer to the greatest extent.

Table 6. Analysis of muscle fatigue degree.

group	Mean EMG (μ V)	Mean EMG mean (μ V)	Rate of change of the EMG signal, (%)
experimental group	50	60	20
control group	48	70	46

(3) The subjective satisfaction survey of the dancers

To gain insight into the dancers' subjective feelings about the two different training and creative methods, we conducted a comprehensive subjective satisfaction survey of the dancers in the experimental and control groups. The content of the survey covers the satisfaction evaluation of training methods, creation process, work effects and other aspects, using the 5-level scoring system (1 is very dissatisfied, 5 is very satisfied). The final survey results are shown in **Table 7** below:

Table 7. The subjective satisfaction survey of the dancers.

group	Satisfaction mean score of the training method	Average score of creation process satisfaction	The use of the work effect is satisfactory
experimental group	4.2	4.3	4.4
control group	3.0	3.2	3.1

It can be clearly seen from the results of the survey data that the satisfaction scores of the experimental group were significantly higher than the control group in all aspects. This result fully reflects the dancers high recognition of the dance training and creation methods based on the combination of biomechanics and AI technology. In the feedback of the experimental group, the dancers generally said that this innovative training method and creative mode not only made them feel the convenience and efficiency brought by science and technology, but also provided them with more creative inspiration and personalized development space. For example, through the guidance of AI models, they can have a deeper understanding of their physical condition and potential, so as to be more targeted in the training process and improve the training effect. At the same time, in the process of creation, the combination of AI technology and biomechanics has brought them new creative ideas and methods, so that them to create dance works with more personality and artistic value.

5. Discussion

(1) Reasons for the improvement of the performance force

The application of artificial intelligence dance art based on biomechanics innovation practice has significant advantages in improving the performance of dance. With its powerful data processing and deep learning ability, the AI model excavates massive dance and biomechanical data, finds out the hidden combinations of creative movements, provides inspiration for dance creation, and helps the choreography dancers to break through the traditional thinking and create novel works [11].

Meanwhile, biomechanics indicators are crucial in dance movement optimization. Through analyzing and adjusting the joint force, muscle force and other factors, the dancers complete the movements more easily and smoothly, and the movement quality and beauty are improved. For example, when designing difficult skills and movements, optimize the body posture and force mode are order to make the movements more relaxed and powerful and reduce the risk of physical injury. When the dancers have more relaxed bodies and smoother movements, they can invest more energy and emotions to vividly express the emotion and theme of the dance and enhance the artistic appeal of the works [12].

(2) Reduced risk of physical injury

According to the comparative results of biomechanical indicators, this innovative application is very effective in reducing the risk of physical injury in dancers. In dance training and performance, unreasonable movements will cause excessive joints, muscle fatigue, and increase the risk of injury. Based on the application mode of biomechanics and AI technology, we provide personalized training plans and movement adjustment suggestions for dancers through real-time monitoring and analysis of biomechanical data [13]. Taking joint stress as an example, after the optimization of AI model, the joint stress distribution of dancers' joints is more uniform, so as to avoid excessive pressure on local joints, which is of great significance to the prevention of joint injuries such as knee meniscus injury and hip synovitis. In terms of muscle fatigue management, AI technology adjusts the intensity and content of training according to real-time EMG data to prevent excessive muscle fatigue. This not only protects the health of dancers, reduces the risk of training interruption and career shortening caused by injury, but also creates a safe and healthy training and performance environment for dancers to exert their full artistic potential [14].

(3) Feedback influence of dancers satisfaction

The results of dancers' subjective satisfaction survey show that dance training and creation methods based on the combination of biomechanics and AI technology are very popular among dancers. This innovative model brings a new experience to the dancers and meets various needs. In terms of training methods, the combination of AI technology and biomechanics provides scientific and accurate training guidance. Dancers no longer rely on traditional experience teaching, with the help of data analysis and intelligent models, they understand their own physical conditions and training effects, and develop personalized and efficient training plans to improve training efficiency and reduce training loss. In the creative process, this mode provides rich creativity for the dancers. According to the creative needs and biomechanics, the AI model provides movement advice and creative inspiration to help dancers break through the constraints of traditional creation [15].

6. Conclusion

By combining biomechanics and artificial intelligence technology, this study provides a new idea and method for dance training and creation. The experimental results show that this innovative application method can not only significantly improve the dance performance, but also effectively reduce the risk of physical injury of dancers and improve the subjective satisfaction of dancers. This research result

provides strong support for the modern development of dance art, and also provides unique ideas and methods for the innovation of dance education and the optimization of training methods.

(1) Evaluation of dance performance: A professional dance jury composed of 10 senior dance experts, critics and excellent choreographers was invited to score and evaluate the dance works of the experimental group and the control group. The assessment criteria included innovation in dance movements (30% of the total score), depth of emotional expression (25% of the total score), stage appeal (25% of the total score), and fit to music (20% of the total score). The average performance score of the dance works in the experimental group (85 points) was significantly higher than that in the control group (72 points).

(2) Comparison of biomechanical indicators: The advanced three-dimensional motion capture system and EMG signal measurement equipment are used to measure the biomechanical indicators of the dancers when completing a series of specific dance movements. The results showed that when completing the same dance movements, the peak force of dancers in the experimental group was relatively low, and the change rate of EMG signal was significantly lower than that of the control group, indicating that AI technology played an important role in optimizing dance movements, reducing joint stress and reducing muscle fatigue.

(3) Subjective satisfaction survey of the dancers: Through the survey tools such as questionnaire and interview, a comprehensive subjective satisfaction survey was conducted on the dancers in the experimental group and the control group. The survey content covers training methods, creation process, work effect and overall satisfaction. The results showed that the satisfaction score of the experimental group was significantly higher than that of the control group in all aspects, and the dancers generally highly recognized this innovative training method and creation mode.

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

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