

An Empirical Study on Innovative Teaching Strategies for Music Rhythm and Movement Coordination in Sports Dance

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ABSTRACT In sports dance teaching, musical rhythm perception and motor coordination are often treated as independent abilities, although they are intrinsically linked through temporal and spatial organization. To address the separation between rhythm training and movement technique instruction, this study designs and implements a 12-week teaching experiment for music-rhythm and movement coordination in sports dance. Thirty-six university sports dance students were randomly assigned to experimental and control groups. The experimental group received rhythmic auditory feedback and spatial orientation training, while the control group followed conventional instruction. A 3D motion capture system, rhythm perception test, functional movement screening, and expert technical scoring were used before and after the intervention. Results show that the experimental group improved significantly more than the control group in rhythm accuracy, rhythm stability, upper-lower limb coordination, center-of-gravity trajectory smoothness, and overall technical performance. The findings provide empirical support for integrated time-space training. The use of motion capture and auditory feedback also offers reference for wireless sensor networks and electromagnetic-compatible wearable teaching systems.

INDEX TERMS sports dance, musical rhythm, motor coordination, wireless sensing, motion capture

I. INTRODUCTION

AS a skill-based sport which incorporates competition and art, the core of ballroom dancing is the ability of the dancer to properly interpret the inner rhythm of music in dynamic body expression. Musical rhythm, as the basic grounding of the temporal organization of dance, defining the intensity, speed and emotional color of the movement, and coordination, as one of the abilities for the spatial expression, determining the orderly coordination of various parts of the body in the dynamic change. These two are not, however, parallel, independent abilities, but an interdependent and mutually reinforcing organic whole. However, analyzing the present teaching practices for ballroom dance, the rhythm teaching and the movement technique teaching are frequently artificially separated: On one hand, the instruction of rhythm is often limited to the mechanical imitation of external-beats, and on the other hand, movement technique instruction is too often limited to the specification of postural criteria and the presentation of technical movement patterns, without having too deep a knowledge of the natural synergic mechanism of rhythm and movement. This fragmented model of teaching not only restricts students' physical ability to interpret musical content but also fails to achieve comprehensive improvement

in dance expressiveness and artistic appeal.

This study used 36 college students majored in sports dance which were experimental subjects and teaching experiment for 12 weeks. Using multi-dimensional measuring instruments, such as a 3D motion capture system, rhythm perception testing, and technical scoring, it systematically investigated the influence of integrated teaching strategies on rhythm perception ability, motor coordination, and overall technical performance. The main contributions of this paper are threefold: On the one hand, at the theoretical level, it reveals the intrinsic connection mechanism between music rhyme perception and motor coordination, which provides empirical evidence for the necessity of "time-space" coordinated training in sports dance teaching; on the other hand, at the methodological level, it designs and verifies a novel teaching strategy combining auditory feedback and spatial orientation training, which extends the technical pathways of sports dance teaching; on the third hand, at the practical level, through detailed experimental procedures and data analysis, it provides front-line teachers with operable and replicable teaching reform references.

The structure of this paper is as follows: Part II is the systematic review of the relevant research achievements related to the Sports dance teaching and the theoretical

position of this research; Part III is the introduction of the experimental design, measurement tool, and teaching effect implementation process; Part IV is the experimental result and detailed discussion, including the analysis of the difference and cause between two groups of students in the rhythm perception, motor coordination and comprehensive technical performance; Part V is the summary of the research conclusions, the research limitations and the future prospect.

II. RELATED WORK

Research on sports dance teaching presents a multi-dimensional theoretical perspective and technological shift. Engdahl et al. [1] revealed how teachers and educators can create gaps for students to explore and express themselves in structured tasks, thereby cultivating their creative teaching ability as dance teachers in the future. Zhou H [2] showed that image recognition systems based on neural networks can accurately identify and evaluate sports dance movements, providing objective data support for teaching. Zhao et al. [3] explored the actual impact of incorporating traditional dance into the primary school curriculum on the comprehensive performance development of primary school students. Alshemmari et al. [4] pointed out that effective dance teaching leadership lies in whether teachers can successfully shape and internalize a shared group identity. How to use data mining and machine learning techniques to optimize the teaching system and achieve personalized teaching for the massive amount of data generated in the process of dance art teaching has become a research hotspot. Zhang [5] constructed a data-driven intelligent dance teaching system. Lei and Tingting[6] found that the reconstructed teaching content combined with machine learning-based action recognition technology provides new possibilities for sports dance teaching. Li[7] explored the fundamental changes in dance teaching and learning in a virtual environment. Jefferson[8] used stories as a teaching stimulus to explore their application value in the teaching and learning process of primary school dance. Azmi and Ha[9] focused on dance/music rhythm teaching in the preschool stage in Malaysia, and explored gamified learning as a new teaching tool to address the problem that young children have difficulty following traditional teaching content. Yu[10] analyzed the factors that may inhibit or promote students' basic psychological needs in the current college sports dance teaching. Musical rhythm is the basis of time organization in dance, and movement coordination is the key ability of spatial expression. The intrinsic connection and synergistic development mechanism between the two have not been fully revealed. Based on this, this paper explores the effective path of integrating the two in teaching through empirical research, in order to provide more operational theoretical support and strategic reference for sports dance teaching practice.

III. METHODS

A. EXPERIMENTAL SUBJECTS AND GROUPING

This study used 36 university students majoring in ballroom dance as subjects. Inclusion criteria included: at least one year of ballroom dance training experience; ability to perform basic dance steps; no history of serious sports injury; normal hearing; and full attendance during the experiment. The 36 students were randomly divided into an experimental group and a control group, with 18 students in each group, and an equal ratio of males and females. Before the experiment, homogeneity tests were conducted on the two groups based on their age, height, weight, and years of training. The results showed no significant differences between the two groups in any of the indicators, indicating that the grouping was reasonable and the experiments were comparable. This study was approved by the Ethics Committee of Northeast Agricultural University, and was performed in accordance with the principles of the Declaration of Helsinki. All eligible participants signed an informed consent form.

To ensure the integrity and reliability of the experimental data, strict inclusion and exclusion criteria were set. Students who were absent more than three times due to injury, illness, leave, or other reasons were excluded. During the intervention, one female student from the experimental group was excluded due to a lower limb injury sustained outside of the training sessions, which prevented her from completing the post-test. The final effective sample size was 17 in the experimental group and 18 in the control group. There were 8 males and 9 females in the experimental group, with an average age of 20.47 years and an average training period of 1.68 years. There were 9 males and 9 females in the control group, with an average age of 20.61 years and an average training period of 1.72 years. There were no statistically significant differences in basic characteristics between the two groups of students [11-12].

B. EXPERIMENTAL DESIGN

This study employed a pre- and post-test precision experimental design with a 12-week experimental period. Three 90-minute classes were scheduled per week for the experimental and control groups. The total teaching hours were the same for both groups, and the teaching content focused on the basic techniques and combinations of Rumba and Waltz. The difference lay in the differentiated design of the teaching strategies. The experimental group adopted a teaching strategy of auditory feedback of music rhythm and coordinated training of spatial orientation of movement. The theoretical basis of this strategy is that the essence of music rhythm is the orderly organization of time structure, the core of movement coordination is the dynamic coordination of spatial elements, and the integration of the two needs to be achieved through the two-way mapping of "time-space". The specific teaching arrangement includes three stages: the first stage is the rhythm decomposition and auditory feedback stage. Adobe Audition 2024 software was utilized to perform rhythmic decomposition. Specifically, the "Beat Detection" plug-in was used to visualize the waveform and

extract peak beat points, which were then converted into distinctive “woodblock” cue sounds. These sounds were overlaid onto the original music track as real-time rhythm tracking feedback, so that students can obtain auditory feedback on rhythm accuracy in real time during practice; the second stage is the spatial orientation training stage, which marks 8 directional points on the ground, requiring students to perform spatial transformation according to the directional sequence randomly specified by the teacher when completing the movement combination, cultivating the integration ability of movement coordination and spatial perception; the third stage is the integration training stage, which combines auditory feedback of rhythm with spatial orientation tasks, requiring students to complete movement combinations synchronized with the music rhythm at different spatial points, and adjust the movement sequence in real time according to auditory feedback during practice[13-14].

The control group received conventional teaching methods, including rhythm recognition exercises and movement breakdown instruction in a traditional manner. Rhythm training utilized a metronome, requiring students to follow a fixed beat to complete basic steps. Movement instruction employed a demonstration-imitation-correction process, emphasizing standardized movement techniques. The difference between the control and experimental groups was that the control group did not use auditory feedback technology; rhythm training and movement coordination training were implemented as relatively independent teaching units.

C. MEASUREMENT TOOLS AND INDICATORS

This research uses multi-dimensional tool of measurement to fully assess the teaching effectiveness. The construction of the measurement indicator system refers to the principle of objectivity and comprehensiveness, including three aspects: rhythm perception ability, motor coordination level, and technical performance level. Rhythm perception was assessed with the use of a self designed music rhythm test. The test materials were two musical pieces each of 30 seconds from the Rumba and Waltz. Participants were asked to indicate the sounds that were accented beats by pressing buttons while listening to the music. A computer program recorded the time error automatically between the time pointed by the participant and the time of actual accented beats. The test indicators were mean absolute error (MAO) and standard deviation of error; the former is indicative of the accuracy of rhythm perception, and the latter is indicative of the stability of rhythm perception. Two pre-tests had been conducted prior to ensure the participants understood the requirements of the test.

The measurement of the motor coordination has been performed by combination of three-dimensional motion capture system and functional motor screening. The three dimensional motion capture system consisted of eight under infrared cameras with sampling frequency of 100 Hz to collect the kinematics parameters of the subjects when they

did the basic combination of rumba and the right turn step of waltz. The extracted indicators included: the consistency coefficient of the curve of the change of the joint angle of the upper and lower limbs, the smoothness of the moving trajectory of the center of gravity and the coefficient of variation of the speed fluctuation in the moving cycle. The standard procedure of the functional motor screening was implemented (every one consisted of seven items as squat, hurdle step, straight lunge squat, shoulder flexibility, straight leg active lift, trunk stability push up, rotational stability). Each item was scored in the points range of 0-3 with a total of 21 points [15] .

The technical performance overall has been evaluated by a panel of three nationally certified ballroom dance instructors. A double blind technique was applied to scores of the two dances performed by the participants. The scoring criteria were based on the technical level textbook of the China Ballroom Dance Federation, which scored the dance in five aspects, including musical rhythm, standardization of movements, fluency of movements, body posture, and comprehensive artistic expression. Each dimension (including musical rhythm expression, action standardization, motion smoothness, body posture, and artistic expression) was scored out of a maximum of 10 points, that is, 50 points total. The Kendall coefficient of concordance ($W = 0.86$, $p < 0.01$) was calculated across all five dimensions of the technical performance evaluation for both Rumba and Waltz, indicating a good inter-rater reliability.

D. IMPLEMENTATION PROCESS OF TEACHING EXPERIMENTS

The teaching experiment was conducted strictly according to the predetermined plan to ensure the standardization and controllability of the experimental process. One week prior to the experiment, all participants underwent pre-testing, including the collection of basic information, rhythm perception ability testing, functional movement screening, and video recording of dance techniques. The pre-test data was used to verify the comparability of the baseline levels of the two groups.

The experimental teaching officially began in week 1. The experimental group's teaching progressed in three phases: weeks 1-4 were the rhythmic auditory feedback training phase, with 20 minutes of rhythm-specific practice per lesson; weeks 5-8 were the spatial orientation training phase, with 25 minutes of directionchanging practice per lesson; and weeks 9-12 were the integration training phase, with 30 minutes of rhythm and spatial coordination practice per lesson. The control group maintained a conventional teaching schedule, with rhythm training and movement practice alternating according to the traditional method. Strict quality control measures were implemented during the teaching process. Each class was led by the same teacher to ensure consistency in teaching style; the experimental and control groups had staggered class times to avoid mutual influence between the two groups; the auditory feedback

equipment used by the experimental group was only provided during class time and collected afterward to prevent the control group from accessing experimental conditions; the teaching progress and content were checked weekly by the researchers to ensure that all teaching elements, except for the experimental variables, remained consistent between the two groups.

The post-test was completed within one week after the end of week 12 of the course, and the test content and procedure were exactly the same as the pre-test. All test data were collected and processed by research assistants who were unaware of the experimental group assignments to eliminate the influence of subjective factors on the measurement results.

IV. RESULTS AND DISCUSSION

A. COMPARISON OF CHANGES IN RHYTHM PERCEPTION ABILITY BETWEEN THE TWO GROUPS OF STUDENTS

Before and after the teaching experiment, the two groups of students showed different levels of change in their rhythm perception ability test. Pre-test data revealed that both the experimental and control groups were at similar level regarding rhythm perception accuracy and stability and there was no significant difference confirmed by the t-test for independent samples and so the baseline is good to further compare the two groups. After 12 weeks of intervention containing different teaching strategies, differences in the rhythm perception ability of the two groups gradually became apparent.

The results of the accuracy of rhythm perception ability showed a significant improvement in the experimental group compared to the control group. The pre- and post-test results and inter-group comparisons of the rhythm perception ability in two groups are presented in Table 1. As can be seen from Table 1, the average absolute error of the rumba rhythm in the experimental group fell from 187.34 milliseconds before the experimental period to 132.18 milliseconds after the experimental period; the average absolute error of the waltz rhythm fell from 169.28 milliseconds to 121.45 milliseconds. As detailed in Table 1, the experimental group showed a significant reduction in error variance compared to the control group ($F = 8.34$, $p < 0.01$). Analysis of covariance results showed that after statistical analysis of the effect of pre-test scores, the experimental results showed that the experimental group's rhythm perception accuracy in the post-test results was better than the control group, and the difference between the two groups was significant.

TABLE 1. Comparison of rhythm perception ability test results between the two groups of students (unit: milliseconds)

Test metrics	Experimental group (n=17)	Experimental group (n=17)	Control group (n=18)	Control group (n=18)	F value	p-value
	Pre-test	Post-test	Pre-test	Post-test		
Rumba Mean Absolute Error	187.34±28.62	132.18±21.45	184.76±29.13	155.82±24.67	8.34	0.007
Rumba dance error standard deviation	52.46±11.38	38.72±9.64	53.18±12.05	45.93±10.82	4.62	0.039
Waltz Mean Absolute Error	169.28±24.51	121.45±18.73	171.53±25.86	147.39±22.14	9.18	0.004
Waltz dance error standard deviation	47.83±10.26	35.61±8.47	46.97±10.84	41.28±9.56	5.23	0.029

In terms of rhythmic perception stability, the rhythm perception ability of the experimental group also showed significant improvement. The standard deviation of rhythmic error of the experimental group went from 52.46 milliseconds to 38.72 milliseconds for the rumba and for the waltz from 47.83 milliseconds to 35.61 milliseconds, though the decrease was relatively smaller in the control group for both indicators. This result shows that the rhythmic auditory feedback training applied in the experimental group not only improved the accuracy of the rhythmic perception of the students, but also increased the stability of the perception, so that students could achieve accurately rhythmic control throughout continuous musical passages.

From the point of view of gender differences, girls of the experimental group achieved slightly better rhythm perception improvement than boys but this difference was not statistically significant. This may be related to girls innate advantage in music perception or it may be because girls are more sensitive to auditory feedback during the experiment. Regardless of gender, the total improvement of rhythm perception by all students in the experimental group proves the effects of the auditory feedback training.

B. ANALYSIS OF CHANGES IN THE MOTOR COORDINATION INDICATORS OF THE TWO GROUPS OF STUDENTS

Improving motor coordination is one of the core goals of ballroom dance instruction. This study used kinematic parameters obtained through a 3D motion capture system and functional movement screening scores to quantitatively assess changes in motor coordination in two groups of students. Table 2 presents the pre- and post-test results for various motor coordination indicators for the two groups of students. Before analysis, the Shapiro-Wilk test was employed to verify the normality of the data. The FMS total scores were found to follow a normal distribution ($p > 0.05$), justifying the use of Analysis of Covariance (ANCOVA) for parametric testing.

Analysis of the 3D motion capture data showed that the experimental group significantly improved more than the control group in terms of upper and lower limb coordination. The consistency coefficient of upper and lower limb joint angle changes reflects the degree of coordination between the upper and lower limbs in dance movements; the closer the value is to 1, the better the coordination. In the Rumba

basic combination, the upper and lower limb consistency coefficient of the experimental group increased from 0.72 before the experiment to 0.86, while that of the control group increased from 0.73 to 0.79, with a statistically significant difference between the two groups in the post-test. The test results for the right turn step in the Waltz also showed a similar trend, with the consistency coefficient of the experimental group increasing from 0.75 to 0.88, and that of the control group increasing from 0.74 to 0.81.

The smoothness index of the center of gravity movement trajectory measures the fluidity of the body's center of gravity during dance; the smaller the value, the smoother the trajectory and the more natural the transitions between movements. In the experimental group, the smoothness of the center of gravity trajectory decreased from 4.28 cm to 2.93 cm in the Rumba and from 3.76 cm to 2.51 cm in the Waltz; the control group showed relatively smaller decreases in both indicators. This result indicates that the experimental group, through spatial orientation training, improved their balance control during transitions in different directions, resulting in smoother and more fluid weight transfer.

TABLE 2. Comparison of motor coordination indicators between the two groups of students

Test metrics	Experimental group (n=17) Pre-test	Experimental group (n=17) Post-test	Control group (n=18) Pre-test	Control group (n=18) Post-test	F value	p-value
Rumba dance upper and lower limb consistency coefficient	0.72±0.08	0.86±0.06	0.73±0.08	0.79±0.07	8.92	0.005
Waltz Upper and Lower Limb Consistency Coefficient	0.75±0.07	0.88±0.05	0.74±0.08	0.81±0.06	10.23	0.002
Rumba Dance Center of Gravity Smoothness	4.28±0.86	2.93±0.64	4.31±0.91	3.67±0.72	9.47	0.003
Waltz center of gravity trajectory smoothness	3.76±0.79	2.51±0.58	3.82±0.83	3.18±0.67	11.36	0.001
Functional motor screening total score	14.26±2.18	17.53±1.92	14.41±2.24	15.68±2.05	6.84	0.013

The improvement in the total score of the functional movement screening is an indication of the improvement in the basic motor function of the students. The total scores of the experimental group were increased from 14.26 to 17.53, with a rise of 3.27 points; the total scores of the control group were increased from 14.41 to 15.68, with a rise of 1.27 points. Of the seven screening items the experimental group had the most significant improvements in squats, straight lunges, and rotational stability. These are items that are closely related to lower limb support, weight transference and twisting of the body, which is common in dance movements.

This result indicates that integration of musical rhythm and motor coordination training is not only beneficial for improving specific technical skills but also for improving the general development of basic motor abilities. Further analysis is performed on the data and the degree of synchronicity between improvement of motor coordination indicators and rhythm perception ability is observed in the experimental group. Within the experimental group, according to the results of correlation analysis, the students with larger

improvement performance in rhythm perception accuracy also had relatively larger improvement performance on the indicators of upper limb coordination and lower limb coordination. Pearson correlation analysis revealed a significant moderate positive correlation between rhythm accuracy improvement and the coordination consistency coefficient ($r = 0.62$, $p < 0.05$), providing empirical evidence for the theoretical perspective. This finding brings some empirical evidence to the theoretical perspective that musical rhythm and motor coordination influence one another in a reciprocal manner.

C. EVALUATION RESULTS OF THE COMPREHENSIVE TECHNICAL PERFORMANCE OF THE TWO GROUPS OF STUDENTS

Overall technical performance is a key indicator for evaluating the final effectiveness of teaching strategies. Table 3 presents the technical scores given by three judges to the two groups of students in their performances of the Rumba and Waltz. In terms of total scores, the experimental group's Rumba score increased from 34.26 to 42.73, an increase of 8.47 points; the control group's score increased from 34.58 to 38.91, an increase of 4.33 points. The Waltz scores showed a similar trend, with the experimental group improving by 8.91 points and the control group by 4.26 points. Analysis of covariance showed that the difference in total scores between the two groups was highly statistically significant.

TABLE 3. Comparison of overall technical performance scores between the two groups of students (unit: points)

Rating Dimensions	Experimental group (n=17) Pre-test	Experimental group (n=17) Post-test	Control group (n=18) Pre-test	Control group (n=18) Post-test	F value	p-value
Rumba total score	34.26±3.85	42.73±3.12	34.58±4.02	38.91±3.56	12.48	0.001
Musical rhythm expression	6.73±1.12	8.82±0.86	6.81±1.18	7.64±0.94	15.36	0.000
Action standardization	7.12±0.98	8.46±0.79	7.08±1.03	7.95±0.88	5.82	0.021
motion smoothness	6.58±1.21	8.64±0.83	6.63±1.24	7.71±0.96	11.24	0.002
Body posture	7.24±0.92	8.51±0.74	7.31±0.95	7.86±0.81	6.13	0.018
Artistic expression	6.59±1.18	8.30±0.91	6.75±1.21	7.75±0.98	8.47	0.006
Waltz total score	35.18±3.67	44.09±3.04	35.42±3.84	39.68±3.37	14.23	0.000
Musical rhythm expression	7.02±1.08	9.01±0.72	6.98±1.12	7.82±0.85	18.41	0.000
Action standardization	7.31±0.94	8.72±0.68	7.36±0.98	8.06±0.79	6.92	0.012
Smoothness of motion	6.84±1.16	8.93±0.67	6.92±1.19	7.89±0.84	14.78	0.000
Body posture	7.28±0.89	8.67±0.71	7.24±0.93	7.94±0.77	7.35	0.010
Artistic expression	6.73±1.14	8.76±0.78	6.92±1.16	7.97±0.89	9.86	0.003

Looking at changes in the marks obtained in the different dimensions, the experimental group presented the greatest advantages in the performance of musical rhythmic and fluency of movement. In the Rumba musical rhythm performance dimension, the experimental group improved 2.09 points and the control group only improved 0.83 points respectively, in the movement fluency dimension, the experimental group improved 2.06 points and the control group improved 1.08 points. Similar differences were made in the corresponding dimensions of the Waltz. This result is very consistent with the design focus of the experimental group's teaching strategy - the rhythm auditory feedback focuses on the musical rhythm performance ability, while

the spatial orientation training helps to improve the fluency of transitions when moving.

While the experimental group improved more than the control group in terms of both movement accuracy and posture, the difference between the two groups was not very large. This phenomenon could be explained from two viewpoints: first, to improve the movement accuracy and posture takes a longer period of time to achieve the technical accumulation and 12 weeks teaching experiment may not be enough time to make a significant difference between the two groups, second, conventional teaching method used in control group also emphasized the movement accuracy training and did have a certain teaching effect in this dimension to narrow the difference with experimental group. Even so, the superiority of the experimental group in these two dimensions is still statistically significant, which means that the integrated teaching strategy did not come at the expense of accuracy on movement performances in order to enhance rhythm and coordination. The changes in scores in the artistic expression dimension should be paid special attention to. Artistic expression is a high-level ability in the evaluation of ballroom dance. It is forged on a solid foundation of good rhythm perception, standardized movement technique and smooth body coordination, but is more than the summation of those individual parts. The result of the experiment group in artistic expression in Rumba and Waltz was 1.71 points and 2.03 points, which was significantly higher than control group. This result suggests that when the students are able to internalize musical rhythm as an organic part of their physical expression, the artistic appeal of their dance is strengthened. The finding that the group which trained musical representation significantly outperformed the group without musical representation training in improving the smoothness of movement coordination corroborates the findings of this study.

Comparing the changes in scores of students of different genders belonging to the two groups, it was found that girls in the experimental group improved a little more in the dimension of artistic expression than boys and there was no similar difference in terms of school genders in the control group. This may be due to the more acute perception of the emotional contents of music in girls or it may have a teaching strategy, which in the experimental group provided a kind of conditions for leverage this advantage. Regardless of the gender difference, the overall improvement in comprehensive technical performance of all members in the experimental group shows the effectiveness of the teaching strategy which integrates musical rhythm and motor coordination.

Based on the above results and discussion, this study, through the technical form of 12 weeks teaching experiment, verified the promoting effect of auditory feedback on musical rhythm and space orientation training on the teaching effect of ballroom dance. The significant advantages of the experimental group in the core indicators such as rhythm perception, motor coordination, and technical performance

overall are empirical evidence for the theoretical opinion of the synergy development of musical rhythm and motor coordination in ballroom dance teaching. Auditory feedback technology renders abstract rhythmic elements perceptible and controllable, and spatial orientation training enlarges the dimension of motor coordination, and vice versa the organic combination thereof promotes the innovation and development of ballroom dance teaching strategies.

V. CONCLUSION

This study, on the basis of the theoretical analysis of the intrinsic relationship between the rhythmic elements of music and the motor coordination of the human body, designed and implemented a sports dance teaching strategy, which combined the auditory feedback and spatial orientation training. A 12 week teaching experiment gave us the following conclusions: First, the synergy training in auditory feedback of musical rhythm and spatial orientation had significantly improved the rhythm perception ability of sports dance learners. The experimental group demonstrated significantly greater improvement in rhythm accuracy and stability than did the control group, indicating that translation of the elements of rhythm into comparable sounds of realtime feedback is contributing to the acquisition of more accurate internal rhythmic representations for the learner. Second, the effect of the synergistic effect of the integrated teaching strategy on motor coordination was checked on several dimensions. The experimental group was found to have significantly higher improvements than the control in upper and lower limb coordination, smoothness of movement of the center of gravity and total score in functional movement screening, showing that the combination of training in rhythm and spatial orientation were able to promote a general improvement in body control. Third, the synergy of the development of musical rhythm and the development of motor coordination ultimately occurred as the significant improvement of the comprehensive technical performance. The experimental group's scores were significantly higher than the control group's in all aspects of dance technique evaluation, especially in musical rhythm performance, motor fluency and the ability to express the form and art, which verified the efficacy of the integrated teaching strategy in developing comprehensive abilities in sports dance. Fourth of all, there is an innate relationship between better rhythm perception and better motor coordination. Analysis of the data within the experimental group indicated that the improvement of both core abilities was synchronous, allowing empirical evidence for the need for synergistic training of musical rhythm and motor coordination in the instruction of ballroom dance. this study confirms the effectiveness of the integrated teaching strategy, but there are certain limitations in this study: the experimental time period was only 12 weeks, so the long-term retention effect of motor skills could not be traced; the research subjects were only some college students specializing in sports dance, the conclusions should be cautiously extended to other groups of people.

Furthermore, the use of specialized auditory feedback equipment in the experimental group may have introduced a potential Hawthorne effect, where students' performance could be influenced by the awareness of receiving novel technical intervention. Future studies should incorporate placebo conditions to further isolate the pure effect of the teaching strategy. Future research might prolong the time of the experiment, expand the sample size, further investigate technical diversity and different teaching strategies, and encourage the scientific movement of sports dance education.

AUTHOR CONTRIBUTIONS

Huiqiu Guo designed, collected and analyzed the data, and drafted the manuscript. Huiqiu Guo conducted the study, critically revised the manuscript for important intellectual content, and gave final approval of the version to be published. Huiqiu Guo participated fully in the work, take public responsibility for appropriate portions of the content, and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICTS OF INTEREST

The author declares no conflict of interest.

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