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Article

Application of biomechanics in music education—Analysis of the influence of music education on children's joint flexibility

Xiaolei Xu

School of Educational Science and Music, Luoyang Institute of Science and Technology, Luoyang 471000, China; zgjc2018@163.com

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Abstract: In today's society, as an important part of quality education, music education has been paid more and more attention by people. Music education can not only improve children's music accomplishment and cultivate aesthetic taste, but also play a positive role in promoting children's physical and mental health and all-round development. With the renewal of the concept of music education and the innovation of educational methods, how to use music education more effectively to promote children's physical and mental development has become the focus of educators. Biomechanics is a science that uses physics and mechanics principles to study the movement laws of organisms. In recent years, the application of biomechanics in sports science has achieved remarkable results, while in the field of music education, the study of biomechanics is still in its infancy, and the study of the combination of music education and biomechanics can provide new theoretical support and methodological guidance for music education. It is helpful to improve the quality and efficiency of music education. Children's joint flexibility is the degree of free movement of the knuckles within a certain range. This study aims to explore the application of biomechanics in music education, analyze the influence of music education on children's joint flexibility, and find out effective ways to improve children's joint flexibility, so as to provide theoretical support and guidance for the practice of music education

Keywords: music education; biomechanics; joint flexibility; child development

1. Introduction

Music education, as a key path to cultivate children's comprehensive quality and promote all-round development, has attracted much attention in recent years. Under the background of the continuous renewal of the educational concept, people are increasingly aware of the important function of music education in the process of children's growth. At the same time, biomechanics, which applies the principles of physics and mechanics to the in-depth analysis of the movement of living organisms, has been fruitful in the field of sports science. However, in the field of music education, the study of biomechanics is still in its infancy. The exploration of how to effectively integrate biomechanical theories and methods into music education in order to improve the effectiveness of education and promote the all-round development of children has gradually become one of the hot topics in current music education research [1]. As an important part of children's physical movement ability, joint flexibility plays an important role in music education. Good joint flexibility not only helps children better master musical instrument playing skills, but also significantly enhances their musical expression [2]. Introducing the theory and method of biomechanics into the field of music education is helpful to further analyze the characteristics of children's body movement in musical instrument playing and dance

performance, so as to design more targeted and effective training programs, in order to provide strong support for improving the quality of music education.

1.1. Overview of the relationship between music education and biomechanics

1.1.1. Concept of music education

Music education is a process of aesthetic education for individuals with the help of music activities. It includes not only the learning of music knowledge and the cultivation of music skills, but also comprehensive education covering emotion, cognition, behavior and other aspects. Music education aims to cultivate children's aesthetic concept, music literacy, creativity and expression ability, so as to promote the all-round development of individuals. In China, music education, as an important part of quality education, has been strongly supported by national policies and education departments. School music education has gradually changed from a single skill imparting to paying attention to the all-round development of students, and the music curriculum is more diversified and personalized, emphasizing music practice and creative activities.

1.1.2. Application of biomechanics in music education

Biomechanics is the study of the laws of living organisms, which uses the principles of physics and mechanics to conduct qualitative and quantitative analysis of the movement of living organisms. The analysis finds that biomechanics provides a scientific theoretical basis for music education, and the mechanical analysis of the body movement of musical performers can reveal the movement rules and physiological mechanisms in music performance, and provide a scientific basis for music educators to guide students to perform correctly [3–5]. At the same time, the application of biomechanics in music education is helpful to improve students' playing skills. The biomechanical analysis of musical instrument playing movements can find out the unreasonable points in the movements, and then optimize the playing skills and improve the performance effect. In addition, the application of biomechanics in music education can also help students prevent sports injuries. During music performance, students need to maintain a fixed posture or repeat specific movements for a long time, which leads to muscle fatigue and joint damage. The application of biomechanics principles can help students rationally arrange practice time and intensity. Use appropriate training methods to reduce the risk of sports injuries.

1.1.3. Relationship between music education and joint flexibility

Music education is not only a process of developing musical skills and artistic accomplishment, this educational process is also closely related to the development of physical functions, especially joint flexibility. Joint flexibility is the ability of the knuckles to move freely within the normal range of motion, which is particularly important in music performance and dance performance.

Musical instrument playing in music education requires a high degree of physical coordination and joint flexibility. Taking piano playing as an example, piano players need to frequently perform fine finger movements, such as rapid playing, span and chord, etc., which require good flexibility and coordination of finger joints [6]. Studies

have shown that children who practice piano for a long time have significantly higher flexibility in their finger joints than their peers who do not receive music education [7]. For example, a study of children ages 6–12 found that children who underwent two years of piano training had an average of 15 percent more range of motion in their finger joints than children who did not receive training. Joint flexibility not only affects the playing skills of Musical Instruments, but also directly relates to the performance of music. Students with good joint flexibility can express musical emotions more freely when playing Musical Instruments. For example, piano players can better control timbour and strength through flexible finger joints, thus displaying richer emotional levels. Similarly, string players with flexible wrists and arms can better control the bow and show more delicate musical emotions.

1.2. Biological basis of joint flexibility in children

1.2.1. Joint structure and function

The joints of the human body are formed by the connection of two or more bones, and their main function is to achieve the relative movement between bones. The basic structure of joint includes articular surface, articular capsule and articular cavity. Articular surface is the part where two bones contact each other. It is usually covered with a smooth articular cartilage to reduce friction and impact during movement. The joint capsule is the connective tissue that surrounds the joint and provides it with stability; The joint cavity is an enclosed space inside the joint capsule that is filled with joint fluid, which lubricates the joint and provides nutrients. The function of the joints in your daily activities is mainly reflected in allowing the bones to carry out various movements, such as flexion and extension, rotation, adduction and abduction, so as to achieve various movements of the human body, while the joints can also buffer the impact and pressure in the movement, and protect the bones and surrounding soft tissues from damage. In addition, the joint also has a stabilizing effect, which can maintain the balance of the body in motion through the synergistic effect of the joint capsule and the surrounding muscles and ligaments.

1.2.2. Characteristics of joint development in children

Childhood is a key stage of joint development. Compared with adults, children's joint cartilage is thicker, and the development of bones and joint capsules is not perfect, so children's joints have greater flexibility and plasticity. With the increase of age, the joint structure of children gradually matures, and the stability of the joint is increased but the flexibility is relatively reduced. Because children's physical development is not mature, the muscles and ligaments around the joints are weak, resulting in children more prone to joint injury during exercise, so attention should be paid to the strengthening of muscles and ligaments in children's joint flexibility training. The investigation found that there are great differences in the individual development of children's joints, and the speed and degree of joint development of different children are greatly affected by factors such as genetics, nutrition, exercise habits, etc. Therefore, teachers should formulate personalized training programs according to the characteristics of joint development of each student in music education.

1.2.3. Influence of joint flexibility on music education

Joint flexibility plays a crucial role in the field of music education, as it is the cornerstone of musical performance skills and artistic expression. Musical performance, whether musical instrument playing or dance movements, depends on the flexible movement of joints. Therefore, children with good joint flexibility can master musical instrument playing skills more easily. Thus achieving a higher level of musical performance. In the process of music education, musical instrument playing and dance training often require students to maintain specific postures or repeat specific movements for a long time, which may lead to muscle fatigue and even joint damage. Improving joint flexibility can enhance the adaptability and cushioning of joints, effectively reducing the risk of sports injuries. To provide more secure protection for children's music learning [8–10].

In addition, joint flexibility is also crucial for stimulating children's interest in music learning and building self-confidence. Children with good joint flexibility can express their musical feelings more freely in the process of music learning, and the sense of achievement and satisfaction obtained from practice will further enhance their interest in learning and self-confidence. This positive emotional experience not only helps children to better participate in music learning, but also promotes the improvement of overall artistic literacy.

2. Methods

In order to better explore the application of biomechanics in music education, 40 children from W Primary School were selected as the research objects, the sample objects were between 6 and 9 years old, and these children were randomly divided into experimental group and control group, with 20 people in each group. Children in the experimental group participated in a one-semester biomechanical music education practice program, while children in the control group received regular music education and physical education classes.

The experimental group of children participated in biomechanical music education classes twice a week, each time lasting 45 min, including music theory learning, musical instrument playing, rhythm practice and creative dance. In rhythm exercise, children need to follow the rhythm of music to clap hands and stomp feet and other body movements, so as to exercise children's body coordination and joint flexibility; In the process of musical instrument playing, children should learn to play keyboard, play recorder and other instruments to improve the flexibility of fingers, wrists and other parts; Teachers should design suitable dance movements according to children's adaptability, including rotation, jumping, etc., so as to improve the range of motion and flexibility of joints; In the interactive game section, teachers designed music games such as "musical chair" and "rhythm passing" to continuously enhance children's teamwork and joint flexibility.

3. Results and discussion

3.1. Results

In order to evaluate the influence of music education practice on children's joint

flexibility, joint flexibility of the two groups of children was measured at the beginning and end of the experiment. The shoulder joint motion range was measured with a shoulder joint motion measuring instrument, the waist joint motion range was measured with a seated flexion test, and the knee joint motion range was measured with a knee joint motion measuring instrument, as shown in **Table 1** below.

Table 1. Joint flexibility of the two groups of children.

Measurement item	Experimental group (degree)	Control group (degree)
Range of motion of shoulder joint before experiment	150.2 ± 8.5	151.3 ± 7.9
Range of motion of shoulder joint after experiment	170.5 ± 9.2**	152.8 ± 8.1
Test the range of motion of the anterior lumbar joint	75.6 ± 6.3	76.1 ± 5.7
Test lumbar joint range of motion	82.7 ± 7.5**	76.5 ± 6.2
Range of motion of knee joint before experiment	130.4 ± 10.2	131.0 ± 9.8
Range of motion of knee joint after experiment	140.3 ± 11.6**	132.2 ± 10.1

** indicates that the difference is statistically significant compared with before the experiment ($P < 0.05$).

It can be seen from the data table that the range of motion of shoulder joints, waist joints and knee joints of children in the experimental group were significantly higher after the experiment than before the experiment, and the joint flexibility of children in the experimental group was improved more significantly than that of the control group. The analysis shows that rhythm exercises, musical instrument playing and dance movements in music education practice provide children with abundant opportunities for joint activities, which help to exercise children's muscles and joints and improve joint flexibility and stability. The comparative analysis of biomechanical data shows that music education practice has a significant effect on the improvement of children's joint flexibility. It can be seen that the practice of music education can effectively improve the joint flexibility of children under the background of biomechanics, and systematic music activities can significantly improve the range of motion of children's shoulder joints, waist joints and knee joints. Therefore, music teachers and schools should pay more attention to the role of music education in children's physical and mental development and integrate it into daily teaching as an effective exercise method.

3.2. Discussion

3.2.1. Forms of joint movement in music education

There are various forms of joint activity in music education, specifically involving joints in multiple parts of the body. These activities include not only the joint movements of fingers, wrists, arms and shoulders during musical instrument playing, but also the coordinated movements of legs, waist, neck and other joints during dance [11]. In musical instrument playing, piano playing requires a high degree of flexibility and independence of the fingers, while violin playing requires the flexible movement of the wrist and arm to control the bowstring. These activities put forward different requirements on the flexibility of the joints, so children need to carry out specific joint training in music education. Dance is another important form of joint activity in music education. Dance movements require coordinated movement of the whole body joints,

and good joint flexibility is required from the flexible movement of footsteps to the smooth rotation of the body. Various dance steps and body movements in dance training can effectively improve the flexibility and coordination of children's joints.

3.2.2. The positive effect of music education on joint flexibility

Music education not only cultivates children's artistic accomplishment, but also plays a positive role in promoting their physical functions, especially in terms of joint flexibility. The unique training methods of music education, such as musical instrument playing and dance practice, provide children with comprehensive joint activities, thus helping to expand the range of joint activities. It is found that in the learning of musical instrument playing, teachers will guide children to carry out a series of joint stretching and bending exercises. For example, piano learners can significantly increase the flexibility of fingers and wrists through specific finger stretching and wrist rotation exercises, making the performance smoother and freer [12,13]. Similarly, violin learners can better master bow skills through flexible arm and wrist movements. These exercises not only enhance joint flexibility, but also promote blood circulation and help muscles relax and recover.

In addition, music education can also enhance the stability of joints. In musical instrument playing and dance training, children need to learn and master correct posture and movement skills, and the practice of these skills helps to strengthen the muscles and ligaments around the joints, thereby improving the stability of the joints. For example, proper standing posture and dance step practice can strengthen the muscles of the legs and waist, which not only helps to maintain the body's balance, but also can prevent sports injuries. In dance, such as ballet "five feet" and "Arabesque" and other movements require stable support of leg joints, through these training, children's joint stability will be significantly improved. More importantly, these joint activity exercises in music education not only help to improve children's physical health, but also enhance their self-confidence and self-expression ability. In the process of music education, children enjoy the beauty of music and also harvest the harmonious development of body and mind.

3.2.3. Potential effects of music education on joint flexibility

Although music education has a positive effect on children's joint flexibility, there are also potential negative effects. On the one hand, improper training methods or overtraining may lead to joint injury or excessive fatigue of children; On the other hand, certain Musical Instruments or dance movements may place an excessive burden on certain joints in children, thereby affecting joint health. Therefore, when designing training programs, music educators should take full account of children's individual differences and characteristics of joint development, adopt appropriate training intensity and methods to avoid the risk of over-training and joint injury, and regularly assess children's joint health status to ensure that music education can maximize the positive impact and minimize the potential impact on children's joint flexibility [14].

3.2.4. Joint flexibility training strategies in music education practice

Biomechanics studies the mechanical laws of organisms in motion, specifically involving the structure and function of bones, muscles, joints and other motor organs. In music education, these principles are helpful for teachers to understand the

mechanical mechanism of musical instrument playing and dance movements, so as to design more scientific and reasonable training methods. Music education and training based on biomechanics must follow the principle of individalization, gradualism, comprehensiveness and functionality.

Each child has differences in physical conditions, development level, music literacy and other aspects, so music education and training should fully consider individual differences and develop personalized training programs, which requires teachers to deeply understand the physical and psychological characteristics of each student and develop training plans suitable for their development [15]. In music education, teachers should observe students' physical conditions, such as joint flexibility, muscle strength and endurance, and on this basis develop appropriate training plans for students. At the same time, teachers should pay attention to students' psychological conditions to adjust training intensity and difficulty, such as learning interest and self-confidence, and constantly improve students' enthusiasm. Select appropriate training methods and tools according to the age and developmental stage of students to ensure the safety and effectiveness of training.

Music education and training should follow the principle of gradual progress, starting with simple movements and gradually increasing the difficulty and intensity. This training method helps children gradually adapt to the training, thereby improving the flexibility and stability of joints. Therefore, teachers can choose simple joint activities at the early stage of training, such as finger extension and wrist rotation, so that students can gradually adapt to the training. With the depth of training, gradually increase the amplitude and intensity of joint activity, such as increasing the amplitude of finger extension and increasing the speed of wrist rotation. In the process of training, teachers should pay close attention to students' reactions and adjust the training progress according to students' adaptation. Plus. Music education and training should pay attention to the coordinated development of the whole body joints, rather than just the training of a certain part. The principle of comprehensiveness requires teachers to pay attention to the balanced development of all parts of the body in training and comprehensively improve the overall athletic ability of children. Therefore, teachers should design training programs that include the activities of the whole body joints. For example, the whole body coordination movement in dance, the coordinated movement of fingers, wrists, arms and other joints in Musical Instruments. In training, teachers should guide students to pay attention to the balanced development of all parts of the body, avoid over-training of a certain part, and adopt a variety of training methods to improve students' overall athletic ability, such as dance, yoga, Pilates, etc.

Music education and training should be closely combined with actual performance and dance movements, and pay attention to functional training. The functional principle requires teachers to consider the practicability and effectiveness of movements when designing training movements, so that students can better use joints in actual performance and dance. Such as simulating the hand movements of Musical Instruments, dance steps, etc. In training, teachers should emphasize the practicability and effectiveness of movements, so that students can better use joints in actual performance and dance, and can also combine music rhythm to let students feel the coordination of music and movement in training, so as to improve students' musical expression.

3.2.5. Specific methods of joint flexibility training

In the actual process of music education, if teachers want to carry out musical instrument playing or chorus rehearsal, they need to let students warm up and stretch before the teaching, so as to improve the mobility of joints and lay the foundation for subsequent rehearsal and performance. For example, when the teacher leads the students to carry out the violin ensemble, it is necessary to arrange about 15 min of warm-up and stretching before the formal start of practice, so that the students can do some simple physical exercises, such as jogging, jumping and stepping, thereby awakening the muscles and joints of the body; Then guide the students to carry out targeted stretches, such as shoulder stretches, back stretches and leg stretches, and hold each movement for 15 to 30 s; During the stretching process, the teacher can play soft background music to let the students complete the stretching action in the rhythm of the music. The above warm-up exercises can continuously raise the muscle temperature of the child, thereby reducing the stiffness of the muscles and preparing for the subsequent musical instrument playing. In music education, this warm-up exercise helps students better adapt to the holding and playing posture of the instrument, and the addition of background music makes the warm-up and stretching sessions more interesting and improves the participation of students. Stretching helps to increase the range of motion of the joints and reduces the risk of sports injuries, especially in the case of violin ensemble, shoulder and back stretching is important to maintain proper playing posture.

In addition, dynamic joint movement training is an effective program to improve the flexibility of children's joints, and dynamic joint movement is very important in the learning process of percussion instruments such as tabla and cymbals. In the dynamic joint movement training, teachers can first let children imitate the walking way of animals, such as duck step, crab step, etc., these movements involve the dynamic activities of multiple joints in the whole body; The child can then be guided to swing the arms and legs and rotate and twist the body; Finally, let the children perform the above actions in the rhythm of the music to continuously improve the interest and coordination. The above dynamic joint movement training can not only improve children's joint flexibility, but also enhance children's sense of rhythm and coordination, which is particularly important in the learning of percussion instruments, which can help children better control the instrument and accurately hit in different rhythms. Among them, the gamified training mode that mimics animal walking enables children to learn through play, which is conducive to improving children's participation and interest. At the same time, with music, children can imperceptibly perceive the rhythm of music, and improve their music literacy while exercising their body and improving their flexibility.

4. Conclusions

To sum up, music education, as an important part of quality education, plays an increasingly important role in children's physical and mental development. Studies from the perspective of biomechanics can further understand the influence of music education on children's joint flexibility and optimize teaching strategies accordingly. This paper analyzes and finds that rhythm exercises, musical instrument playing and

dance movements in music education can effectively improve children's joint flexibility, and systematic music activities can improve children's shoulder joints, waist joints and knee joint range of motion, indicating that music education plays an important role in promoting children's physical movement ability. The application of biomechanics in music education provides new theoretical support and methodological guidance for music education. The mechanical analysis of the body movement of music performers can reveal the movement rules and physiological mechanisms, so as to optimize the teaching methods and training intensity. The influence of music education on children's joint flexibility varies from individual to individual, so teachers should fully consider the age, development level and individual characteristics of children in the teaching process to develop personalized training programs to ensure that every child can be improved at their own level. Future studies should further explore the influence of music education on children's other physical abilities and psychological development, and how to apply biomechanical principles to music education practice more widely, so as to better play the important role of music education in children's overall development.

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