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Study on the Influence of Tai Chi and Latin Dance Exercise on Knee Joint Proprioception Using Common Test Methods

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Abstract

Purpose: To study the influence of two types of motion, dance and Tai Chi, on knee joint proprioception and analyse the different ways in which physical exercise affects body proprioception. Method: All experiments were conducted in Sports Biomechanics Laboratory at College of Physical Education and Sport at Beijing Normal University. The Biodex isokinetic test system (Biodex system 4, BS4) from the United States Biodex medical was used to test passive position sense and force sense of the dominant knee. Results: When the knee joint was at 15, 30 and 45 degree positions, the Tai Chi exercise group was much better than sedentary group ($P<0.05$) and the 45 degree position in the Tai Chi group was much better than that in the Latin dance group ($P<0.01$).When the knee joint was at the 30 and 60 degree positions, the quadriceps force sense was significantly better in the Tai Chi group than in the Latin dance and sedentary groups. In a test of the four angles, the hamstring force sense in the Tai Chi exercise group was obviously better than that in the sedentary group ($P<0.05$); at the 15 degree position, the Tai Chi group was significantly better than the Latin group ($P<0.05$); and at both 30 and 60 degree positions, the hamstring force sense of the Latin group was obviously better than that of the sedentary group ($P<0.05$).

Conclusion: Compared to Latin dance exercise, Tai Chi exercise can improve both position sense and force sense to improve knee joint control ability and increase body balance to prevent injury in athletes and falls in the elderly.

Keywords: Tai Chi; Latin dance; Knee proprioception

Introduction

Latin dance, which originated in Latin America, includes the rumba, samba, Cha Cha Cha, bullfighting dances and cowboy dances [1]. Latin dance steps are flexible and changeable. With the rhythm of music, the body of a dancer amplifies strength, speed and attitude to show the beauty of the human body and perform exercise with a traditional Latin style and delicate technical actions [2]. When performing, the dancers must have good posture control and balance to complete technical actions of different difficulties to obtain a more beautiful posture and performance [3,4]. Tai Chi is an ancient Chinese fitness activity. Since the 1980s, Tai Chi has attracted increasing numbers of students both in China and abroad. Tai Chi culture and function have immense charm and grace [5]. When practicing Tai Chi, practitioners must make repeated body shifts, rotate and alternate single foot support. All of these actions require precise joint control, muscle coordination, and good body balance [6,7]. These two different forms of exercise can improve body balance, and proprioception capability is one of the main factors that affect the balance of the human body [8]. Proprioception in the central nervous system involves mechanical nerve impulses from joints, ligaments, tendons, joint capsules, muscles and skin receptors to eventually lead to corresponding reflex and motion control [9-12]. Corinne et al. [13] used the established endpoint position matching task to measure absolute and directional errors in matching the position of one hand with the other. The matching performance was tested under three different conditions, which involved different information about the target position, including only proprioceptive information from a 'target' hand (either the left or right), only visual information, or both proprioceptive and visual information. Differences in matching errors between these sensory conditions suggest that dancers show a better integration of local proprioceptive signals than do non-dancers, who rely more on proprioception when both proprioceptive and visual information about hand position were present. Anna et al. [8,14,15] demonstrated ballet exercises could improve multi-joint and single joint proprioception. Studies of Tai Chi proprioception have focused mainly on older people and on ankle or knee proprioception. In this paper, the influence of two types of training methods on proprioception was analysed using an American Biodex isokinetic test system (Biodex system 4, BS4) to test the position and strength of the subjects.

Subjects and Methods

Subjects

The subjects were all college students in the General Department of Beijing Normal University. For the Latin dancers, 11 (2 boys+9 girls) were recruited, and they all practiced at least 1 time a week and had an average training period of 5.06+2.35 years. Tai Chi practitioners included 8 girls who had Tai Chi class 2 times a week for 90 min each session and at least 18 weeks of exercise time. A control group of 8 sedentary girls was included. All subjects voluntarily participated in this experiment, were in good health and had no disease or knee injuries. Basic information about the subjects is shown in Table 1.

Methods

All experiments were conducted in Sports Biomechanics Laboratory at College of Physical Education and Sport at Beijing Normal University. The Biodex isokinetic test system (Biodex system

Group	Age (years)	Height (cm)	Weight (Kg)
Latin	22.64 ± 3.56	166.00 ± 5.42	57.55 ± 6.65
Tai Chi	20.50 ± 1.41	160.63 ± 5.63	50.00 ± 5.37
Sedentary	22.33 ± 1.41	162.67 ± 4.62	50.00 ± 6.21

Table 1: Basic information for subjects in the Latin, Tai Chi and control groups.

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4, BS4) from the United States Biodex medical system was used to test the passive position sense (PS) and force sense (FS) of the subject's dominant knee.

Procedure: When subjects were sitting on the seat of the Biodex system, the angle between the back and the seat was 90 degrees. The right leg of a subject was fixed on the power arm and the thigh was fixed to the seat. Before beginning the real test, subjects performed warm-up exercises in passive isokinetic mode at an angular velocity of 60 degree/s. The dynamometer drove the subjects with passive knee warm-ups and exercised the knee 30 times; after 5 min of rest, the normal test began.

Passive position sense test (PS): The knee joint of the subjects was passively randomized to 15, 30, 45 or 60 degrees from 90 degrees (definition: the knee flexion position was 90 degrees, and extension was 0 degrees.). The knee joint was held still for 5 s to allow the participants to feel the position of the knee joint in their relaxed state. When subjects were passive to the 30, 45, 60 and 75 degree positions, the subjects pressed the button, the dynamic head brought the knee of the subjects from flexion to extension. Repeated tests were carried out 3 times at each angle, and the angular velocity of the passive motion was 5 degrees/s. The absolute errors between the target value and the test value were the test values [12].

Force sense (FS): The subject's torso and dominant thigh were fixed to the test chair to remove the compensation from other limbs, and the centre of the knee rotation and dynamometer were placed on a straight line. Test patterns for the isometric strength test and the maximum voluntary isometric contraction (Maximal voluntary isometric contraction, MVIC) were tested at the 15-, 30-, 45- and 60-degrees positions (defined as 0 degrees from the point of view of the extensor). Maximum isometric flexion and extension muscle strength were tested in each knee joint angle with a test time of 5 s and the tests were repeated 3 times, with rest periods of 5 s between each test and with 300 s of rest between test sets. The coefficient of variation (coefficient of variance, CV) required control less than 15%. After 30 min of rest, using 50% MVIC as the target force value, the strength of the knee joint was tested using visual feedback of the target force on the computer screen. Subjects were asked to close their eyes and use the quadriceps/hamstrings of their knee joint to reproduce the target force value and the measured value was recorded. The peak torque (PT) of the quadriceps/hamstrings, the antagonistic ratio (Q/H) and absolute error between the difference force target values and the measured forces were recorded. The test was performed twice [16].

Statistical methods: Using the statistical software SPSS13.0, index statistics analyses of the tests were conducted using the Kolmogorov Smirnov approach to collect data for a normal distribution test to ensure that all test data matched a normal distribution. Paired sample T tests both within a group and between groups using an independent sample T test were conducted. All tests are given as means ± standard deviation and P<0.05 indicated a significant difference.

Results

Analysis of knee position sense

As shown in Table 2, when the knee was located at 45°, the absolute position angle was lower for the Tai Chi group than for the Latin dance group, and at the 15° position, the results for the Tai Chi group were significantly lower than those of the control group (P<0.01). At 30° and 45°, the Tai Chi group results were significantly lower than the control group results (P<0.05). At the 60° angle, the positions of the three groups had no significant difference. Comparing the position of sleep between the Latin group and control group, there was no significant difference.

Quadriceps force sense

As shown in Table 3, when the knee was at the 30 degree position, the value of quadriceps force sense in the Tai Chi Group was significantly lower than that in the Latin dance(P<0.05) and sedentary groups (P<0.01). When the knee joint was at 60 degrees, the value of quadriceps force sense in the Tai Chi Group was significantly lower than in both the Latin (P<0.01) and sedentary groups (P<0.05). There was no significant difference in the force sense of the three groups when the knee joint positions were 15 and 45 degrees.

Hamstrings force sense

As shown in Table 4, there were significant differences between the Tai Chi and sedentary group sat 15, 30, 45 and 60 degrees (P<0.05). There were significant differences between the Tai Chi and Latin groups (P<0.05) at 30 and 60 degrees as well as significant differences between the Latin dance and sedentary groups. When the knee was at the 30 degree flexion position, the extensor strength absolute sense value of the Tai Chi Group was significantly lower than those of the Latin dance(P<0.05) and control groups (P<0.01). The absolute value of the hamstrings force sense of the Tai Chi group was significantly lower than those of the Latin dance(P<0.01) and sedentary groups (P<0.05) at 60 degrees of flexion of the knee joint. There was no significant difference in the absolute value of the three groups at the 15 degree position.

Group	Different joint angles (degree)			
	15°	30°	45°	60°
Latin dance	2.83 ± 1.64	3.18 ± 2.02	4.06 ± 1.64**	2.90 ± 1.93
Tai Chi	1.96 ± 0.74	2.55 ± 1.65	2.06 ± 1.07	1.91 ± 2.14
Sedentary	3.78 ± 1.49**	4.53 ± 1.74*	3.72 ± 1.85*	2.23 ± 1.70

Note: * indicates the Tai Chi group had a significant difference from the Latin group and sedentary control group (P<0.05), * * means that the Tai Chi group had a very significant difference from the Latin group and sedentary control group (P<0.01)

Table 2: Comparative analysis of different joint angles in the Latin, Tai Chi and Sedentary groups.

Group	Different joint angles (degree)			
	15°	30°	45°	60°
Latin dance	2.60 ± 1.77	4.04 ± 1.98*	3.79 ± 2.75	4.50 ± 1.58**
Tai Chi	2.66 ± 1.68	1.75 ± 0.81	2.63 ± 2.71	2.28 ± 0.80
Sedentary	2.65 ± 1.04	4.88 ± 1.57**	4.46 ± 2.56	3.46 ± 0.72*

Note: * indicates the Tai Chi group had a significant difference from the Latin group and sedentary control group (P<0.05), * * means that the Tai Chi group had a very significant difference from the Latin group and sedentary control group (P<0.01)

Table 3: Comparative analysis of different joint angles in the Latin dance group, Tai Chi group and sedentary group.

Group	Different joint angles (degree)			
	15°	30°	45°	60°
Latin dance	2.25 ± 1.35*	2.48 ± 1.77	2.10 ± 1.09	2.00 ± 1.21
Tai Chi	1.14 ± 0.89	2.31 ± 1.71	1.64 ± 0.97	1.64 ± 0.99
Sedentary	2.60 ± 1.14*	5.58 ± 4.08*#	3.00 ± 1.24*	3.39 ± 1.19*#

Note: * indicates the Tai Chi group had a significant difference from the Latin dance group and sedentary control group (P<0.05), * * means that the Tai Chi group had a very significant difference from the Latin dance group and sedentary control group (P<0.01), # indicates a significant difference between the Latin dance and sedentary groups (P<0.05)

Table 4: Comparative analysis of different joint angles in the Latin dance, Tai Chi and sedentary groups.

Discussion

Latin dance, which originated in Latin America, is one type of group dance event that includes the rumba, samba, cha-cha, bullfighting dances and cowboy dances. Previous studies have focused on the major positive impacts of dance on the human body, including its social, physical and psychological impacts [17-20]. Many studies have shown that dance can improve the body's balance, prevent falls in the elderly and increase physical activity levels Dance types that have shown positive benefits include Latin, ballroom dancing, jazz and ballet [18,21,22]. Few studies have demonstrated the influence of Latin dance on the senses of the body and balance. Tai Chi is an ancient Chinese fitness activity. Since the 1980s, Tai Chi has attracted many new students from both China and abroad. Tai Chi culture and power law have showed great charm and grace [5]. Gatts [23] investigated a Tai Chi exercise intervention for the elderly and compared slipping or falling among elderly individuals before and after Tai Chi intervention. They found that Tai Chi training improved lower limb control ability for elderly during a fall, which showed the Tai Chi exercise improved balance in the elderly. Xu et al. [24] compared the movement of tai chi practitioners, a swimming group and sedentary group. They found that the knee joint and ankle joint movement of Tai Chi practitioners were significantly better than subjects in the swimming and sedentary groups. There was no significant difference between the swimming and sedentary groups. After comparing passive position sense and force sense among the Tai Chi, Latin and sedentary groups, we found that there were significant differences in passive position sense between the Tai Chi and sedentary groups when the knee was at 15, 30 and 45 degrees, and the Tai Chi group had significantly better results than did the Latin dance group. For quadriceps force sense, when the knee was at the 30 and 60 degree positions, the Tai Chi group results were significantly better than those of the Latin dance and sedentary groups. In the hamstring force sense test, the Tai Chi group was significantly better at the four angles of the knee joint than the sedentary group was. When the knee was at the 30 and 60 degree positions, the Latin dance group was significantly better than the sedentary group. There were no significant differences in passive position sense and force sense between the Latin group and the sedentary group.

Postural control and balance ability involve the coordination of the central nervous system of the human body with vestibular, visual and body receptors and the control ability of the effector [25]. Physical exercise is the main factor that affects the balance ability of the elderly, and different physical exercises can affect the balance ability from different aspects [26]. Among the receptors that affect the body's balance, the sense of the body plays a major role. Different testing methods for proprioception in the body reflect the ability of the human body [27]. Position sense reflects reaction ability and perception of the muscle spindle receptor. Force sense mainly reflects the ability of the Golgi apparatus and coordination in different muscle lengths [28,29]. In this study, Tai Chi group position sense and force sense were significantly higher in the Tai Chi group than in the Latin dance and sedentary groups, which indicates that Tai Chi exercise can improve human proprioceptive ability from different aspects. Therefore, practicing Tai Chi can better improve the body's ability to balance.

The role of proprioceptors differs at different angles of the knee joints. At the 15 degree position for the edge of the knee extension position, all of the receptors for the knee position sense are acting, and the purpose of that activation is to prevent joint limit movement [30]. In this study, when the knee joint is at 15 degrees, the Tai Chi Group passive position sense and hamstring force sense were significantly better than the sedentary group. At the same time, the Tai Chi group force sense was significantly better compared to the Latin dance group. This outcome shows that the practice of Tai Chi can, to a certain extent, better prevent injury in sports and falls in the elderly. Along with changes in the angle of the joint, the degree of relaxation of the knee joint around the ligament and medial ligament is different. Knee anterior cruciate ligament proprioception between 30 and 40 degree position played a major role. At the 30 degree position, the Tai Chi group passive position sense and force sense were significantly better than those of the sedentary group. At the same time, position sense was significantly better in the Tai Chi group compared to the Latin dance group. Additionally, the Latin flexor was significantly better in the no exercise group. The muscle spindle is located in the muscles, and the elongated, tendon spindle is located between the tendon and muscle tension, which are both in the range of motion in which the subject can feel the movement of the joint.

Muscle spindles play an important role in testing passive movement. In the force sense test, the muscle spindle plays a major role in the regulation of muscle tension and muscle strength [31,32]. In the middle position of the knee joint movement at 45 degrees, the Tai Chi Group passive position sense was significantly better compared to the Latin dance and sedentary groups. The hamstring force sense of the Tai Chi group sense was also significantly better than that of the sedentary group. At the 60 degree position, there was no significant difference in passive position between the three groups, but the quadriceps and hamstring force sense for the Tai Chi group were significantly better than those of the Latin dance and sedentary groups. The hamstring force sense of the Tai Chi group was significantly better than that of the sedentary group, and the Latin dance group was much better than the no exercise group.

From the above analysis, we know that the influence of Tai Chi exercise on position sense is mainly reflected at the 15, 30 and 45 degree positions and that the main role of the muscle spindle angle occurs at 45 degrees. The influence of Tai Chi on the sense of force mainly occurs at the 30 and 60 degree positions, and the main function of the tendon spindle occurs at 60 degrees. Tai Chi exercise improves the proprioception ability of the anterior cruciate ligament in the knee joint. However, Latin dance practice affected only the force sense of the hamstring. Therefore, Tai Chi exercise can improve proprioceptive ability in different aspects, improve the overall control of the knee joint and ultimately improve body balance. Latin dance exercises can improve body balance by improving the proprioception of force sense.

Conclusion

1. When the knee joint was at 15, 30 and 45 degree positions, Tai Chi exercise was much better than the control group ($P<0.05$). At the 45 degree position, the results for the Tai Chi group were much better than those for the Latin dance group ($P<0.01$).
2. When the knee joint was at the 30 and 60 degree positions, the quadriceps force sense was significantly better in the Tai Chi group than in the Latin dance and sedentary control groups.
3. In the test of four angles, the hamstring force sense in the Tai Chi exercise group was obviously better than the control group ($P<0.05$). At the 15 degree position, the results were significantly better compared to the Latin group ($P<0.05$). Finally, at 30 and 60 degree, the hamstring force sense of the Latin dance group was obviously better than that of the control group ($P<0.05$).

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