

PROPRIOCEPTION OF FOOT AND ANKLE COMPLEX IN YOUNG REGULAR PRACTITIONERS OF WUSHU, TABLE TENNIS AND RUNNING

JING XIAN LI^{1,2}, HONG PO PAN²

¹School of Human Kinetics, University of Ottawa; ²Department of Health and Exercise Science, China Tianjin Sports University

The purpose of the study was to examine the possible effects of long-term wushu, table tennis and running on proprioception of the foot and ankle complex in young people. A total of 50 young male students with different exercise habits formed four groups: wushu, table tennis, running, and sedentary control. Kinesthesia of the foot and ankle complex was measured in plantarflexion, dorsiflexion, inversion and eversion at 0.4°/s passive rotation velocity using a custom-made device. The results showed that wushu group had better proprioception than sedentary and table tennis group in dorsi-plantarflexion and better proprioception than table tennis group in in-eversion. Running did not benefit the proprioception of the foot and ankle complex.

KEYWORDS: ankle, kinesthesia, table tennis, Wushu, running

INTRODUCTION: Proprioception is the sensory feedback that contributes to conscious sensation (muscle sense), total posture (postural equilibrium), and segmental posture (joint stability). Research has shown that postural control stability is significantly affected by proprioception in lower limbs (Lord et al., 1991). Colledge et al.(1994) studied the relative contributions to balance of vision, proprioception, and the vestibular system with age by measuring body sway during standing. In four different age groups through 20 to 70 years old, the relative contribution of each sensory input was the same, with proprioception being predominant throughout each age group. Some published research works have found that proprioception can be improved through exercise, especially proprioceptive exercise that requires three actions: the proprioception of the joints, balance capacity, and neuromuscular control (Irrgang & Neri, 2000; Eils & Rosenbaum, 2001). Studies that prove the effects of specific exercise training on proprioception of lower extremities are limited. Xu et al. (2004) and Li et al. (2008) found beneficial effects of long-term Tai Chi practice on the proprioception of ankle and knee joints. Long-term Ice hockey and ballet participants also showed better ankle joint proprioception than their running and sedentary counterparts (Li et al., 2009). As the table tennis and wushu, or the Chinese “Gongfu” such as Tai Chi, are the most popular sports, exercise and physical activity forms in China, it is of interest to know whether long-term, regular practicing track & field and wushu would have positive effects on ankle joint proprioception.

METHODS: Fifty university students were recruited based on their exercise habits. Ten students who regularly practiced wushu for more than three times each week for more than five years formed the wushu (WU) group. Fourteen students who regularly playing table tennis more than three times each week for more than five years formed the table tennis group (TT). Fourteen students with a regular running habit, running for more than three times each week for more than five years, formed the running (RU) group. And 12 students with no regular exercise habit in the past five years served as the sedentary control group (CT). All students were males. The demographic data of the participants are presented in Table 1. All participants were predominantly healthy and they had no history of metabolic, musculoskeletal, or neurological diseases or injuries. An informed consent form was read and signed by each subject prior to participation. This study was approved by the Human Ethics office, the University where the study was conducted.

Table 1. The demographic data of the subjects in each group (Mean ± SD)

| Group | Age (years) | Body weight (kg) | Body height (cm) | Body mass index (kg/m ²) |
|---------|-------------|------------------|------------------|--------------------------------------|
| WU (10) | 19.93±1.05 | 64.4±4.86 | 168.81±2.32* | 22.60±1.44 |
| TT (14) | 20.06±1.90 | 69.48±10.50 | 173.90±2.53 | 22.93±3.57 |
| RU (14) | 21.41±1.33 | 68.39±1.44 | 176.95±4.57 | 21.86±1.77 |
| CT (12) | 21.78±2.39 | 66.86±10.44 | 173.77±7.54 | 22.04±2.02 |

* P<0.05 vs.all other groups

The testing was performed in a well-lit and well-ventilated room. The room was sound-attenuated and isolated so as to reduce any auditory or visual interference that might distract the participants. After being measured for body weight and height, each subject individually participated in one session of data collection. Data were collected using the instrumentation and procedures described by previous studies (Xu et al., 2004; Li et al., 2008; Li et al., 2009). The custom-made device was a box with a movable platform that was moved by an electric motor to rotate about a single axis in two directions at a rate of 0.4°/sec. For measurement, each subject was seated on an adjustable chair and his dominant foot was placed on the platform so that the axis of the apparatus coincided with the plantar-dorsiflexion axis or inversion-eversion axis of the ankle joint. The hip, knee, and ankle were each positioned at 90°, respectively. Movement could be stopped at any time with the use of a hand-held switch. The device was also equipped with a hanging scale and a fixed pulley system. Using this system, the investigator standardized and controlled that fifty per cent of each subject's lower extremity weight was rested on the platform. During testing, the subjects' eyes were closed to eliminate visual stimuli from the testing procedure and apparatus. Data collected in each test movement began with the foot placed in a starting position of 0°. The subjects were instructed to concentrate on their foot and to press the hand-switch when they could sense motion and identify the direction of the movement. After performing two practice trials, a formal data collection was conducted. The measurement was arranged in two sessions. In the first session, the motor was randomly engaged to rotate the foot along the ankle sagittal plane for dorsiflexion or plantarflexion at a time interval between 2 and 10 seconds after subject instruction. The researcher recorded the rotation angles of the platform and the direction of movements as passive motion sense. At least 3 angles in each direction were recorded. In the second session, the similar approach was adopted to record the rotation angles of inversion and eversion.

All variables were presented as means and standard deviations. Passive motion sense of foot and ankle complex in two directions of each plane were compared using paired t-test in each group. Because there were no significant differences in the data between the two directions of each plane, the data of the two directions were averaged to present the kinesthesia of foot and ankle complex in the sagittal plane for dorsi-plantarflexion (DP) and in the transverse plane for in-eversion (IV). One-way analysis of variance was used to estimate significant differences among groups. The post hoc Scheffe tests were performed when necessary to isolate the differences and $P \leq 0.05$ was considered statistically significant.

RESULTS: The wushu group showed smaller body height than other groups. There was no difference in body mass index among the groups (Table 1).

The D-P and I-E values of each group are presented in Table 2. Foot and ankle complex kinesthesia significantly differed among the four groups in each plane ($P = 0.001$). The post hoc test showed that in sagittal plane, the control group and table tennis group had higher kinesthesia than wushu group. In the transverse plane, the kinesthesia of the table tennis group was higher than that of the wushu group. No significant difference was found in D-P and I-E among the other groups.

Table 2. foot and ankle complex kinesthesia

| Kinesthesia | CT | TT | RU | WU |
|-------------|------------|-------------|-----------|-----------|
| D-P | 0.47±0.11* | 0.47±0.15* | 0.37±0.11 | 0.32±0.08 |
| I-E | 0.65±0.15 | 0.76±0.23** | 0.55±0.27 | 0.51±0.16 |

Data are mean±SD; *P<0.05 vs. WU; **P<0.05 vs. WU

DISCUSSION: The present study provides the evidence that there are significant differences in the perceived passive motion sense between young long-term wushu practitioners, runners, table tennis players and the sedentary people. The long-term wushu practitioners showed significantly better passive motion sense measured in both dorsi-plantarflexion and in-eversion in foot and ankle complex than table tennis players. The long-term wushu practitioners also showed significantly better passive motion sense measured in dorsi-plantarflexion than their sedentary counterparts. On the other hand, the long-term running group did not show significant difference in foot and ankle complex kinesthesia as compared with other three groups.

A few publications examined the impacts of exercise on proprioception function, specifically comparing the effects of different forms of exercise and the findings are inconsistent. This might be related to the exercise mode and measurement method used in the study. According to Irrgang and Neri's description (2000), proprioceptive exercises should be composed of three parts: proprioception of joints, balance capacity, and neuromuscular control. A cross sectional study examining the kinesthesia of the knee and ankle joints among three groups of elderly people showed that long-term Tai Chi exercisers had significantly better kinesthesia of the knee and ankle joint than long-term runners or swimmers. Moreover, long-term runners or swimmers could not perform better in perceiving the passive motion of dorsi-plantar flexion of the ankle joint than did a sedentary group (Xu et al., 2004). The present study on young people supported these results. Tai Chi exercise is a series of individual graceful movements in a slow, continuous, circular pattern. The movements of Tai Chi are fluent and consummately precise because specificity of joint angles and body position is of critical importance in accurately and correctly performing each form (Jacobson et al., 1997). Conscious awareness of body position and movement is demanded by the nature of the activity. Such exercise form contains all components that are needed in training and improving proprioception. Li et al. (2008) examined the kinesthesia among young people with four different exercise habits. The results showed that ice hockey and ballet groups perceived significantly better passive motion sense in each inversion and eversion than running group and the sedentary group. No significant difference in the perceived passive motion sense in dorsiflexion, plantar flexion, inversion and eversion was found between running and sedentary groups. The cyclic movement pattern in running and the quick foot maneuvers pattern in table tennis may not contain training effects on ankle joint proprioception.

Some published work could not support the effect of exercise training on proprioception: Schmitt et al. (2005) studied the effects of 5-month ballet training on ankle position sense. Passive angle-replication tests (joint position sense tests) were conducted during the pre- and post-training program. No significant differences in joint position sense were found either in the pre- or post-test of the training program. It is well known that ballet and other dances have a very high demand to proprioception, balance capacity, and neuromuscular control. Ballet training should be considered as a proprioceptive exercise. The possible cause of the undetectable effect of ballet training on proprioception may be related to the sensitivity and reliability of the testing method. Beynnon et al. (2000) compared the accuracy, repeatability, and precision of seven joint position sense techniques and one joint kinesthesia measurement technique in normal subjects with no history of knee injury. They found that joint kinesthesia was more repeatable and precise than each of the joint position sense techniques. They recommended that studies designed to evaluate proprioception should consider using kinesthesia, which should result in increased power and sensitivity to detect

significant differences, if they truly exist. In Schmitt et al.'s study (2005), proprioception was examined by measuring joint position sense. The testing method may not have been sensitive enough to detect the proprioception function.

Another factor influencing the impact of exercise on proprioception is the duration of training. Li and co-workers (2008) examined the effects of a 16-week Tai Chi exercise program on the proprioception of the knee and foot and ankle complex in elderly people. The results demonstrated that the significant training effect of kinesthesia was found in the knee joint, but not in the foot and ankle complex. The study by Eils and Rosenbaum (2001) showed that 6-week proprioceptive exercise created gains in the joint position sense in young people. In the study, the subjects trained 20 minutes each day, and the intensity of the 6-week training period was increased by small modifications every 2 weeks. These scientific evidences demonstrated that exercise form, training duration, and age of the participants, as well as the evaluation method used, should be considered in the examination and comparison of the effect of exercise on proprioception.

CONCLUSION: Long-term wushu exercise showed training effects on kinesthesia of the foot and ankle complex in young males. Long-term running and table tennis did not yield training effects on kinesthesia of the ankle and foot complex in the young runners. The results suggest that proprioception of the foot and ankle complex could be improved by exercise in young people.

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