고령자 자세균형 훈련효과 평가
Analysis on Training Effects of Postural Control for Elderly Adults

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Key words : Postural control, Training, Elderly adults

1. Introduction

Posture control was a continuous process and was constantly controlled or adjusted such that the center of gravity of the body can be stably maintained. Adequate postural control depends on the spatial and temporal integration of vestibular, visual, and somato-sensory information about the motion of the head and body, and the generation of appropriate responses to that motion.[1] Diminished balance ability has been identified as a multifactor construct. The results of several studies have shown that lower extremity muscular strength is a common factor associated with balance impairment in elderly fallers.[2] Lord previously determined that ankle dorsiflexion strength was one of the three variables that discriminated significantly between older adults who had not fallen or had fallen only once, and those with a history of multiple falls.[3] The results of these studies revealed a strong relationship between lower extremity strength and posture control ability. The association between weak leg muscles and falling has compelled researchers to conduct studies of strength training for the improvement of balance in balance-impaired older adults. The principal objective of this study was to assess the effects of 8 weeks of postural control training using a postural control training system designed for elderly adults. We hypothesized that the participants would evidence better balance control, i.e. smaller postural sway, larger concentric isokinetic strength of ankle and knee joints, than those who did not participate in the training program..

2. Materials and Methods

2.1 Subjects

30 healthy persons were enrolled in this study, on a volunteer basis. The 15 volunteers were randomized into the training group (TG) (7 males and 8 females; age 68.43±2.44years; weight 64.64 ±9.3kg; height 164.36±8.97cm) and the remaining 15 were allocated into the control group (CG) (9 males and 6 females; age 69.93±3.71years; weight 59.43±8.86kg; height 163.07±6.03cm).

2.2 Experimental procedure

After the first evaluation, the training group took part in an 8-week course of training, whereas the control group received no intervention, although the social contact was maintained. The training group participated in training 3 times a week for 8 weeks, in 1 hour sessions. After the 8-week training session, the second evaluation was repeated for both groups.

2.3 Training

The training was conducted on a training system that we developed.[4] The training sessions included a COP maintenance training session and a trace training session. The COP maintenance training was conducted in eight directions. The subject was instructed to move the COP in the appointed direction and to maintain movement in the appointed target circle for 30 sec, then repeat this protocol twice. The distance of the target circle from the center was 6cm. The directions were anterior, posterior, left, right, anterior-left, anterior-right, posterior-left, and posterior-right. The direction was selected in random order. The trace training was then conducted. The trace training required the subject to perform COP movements following the target circle, which was traced in the appointed trace pattern. The trace patterns were the circle trace, the quadrangle trace, the triangle trace, and the sine curve trace. In this study, the moving speed of the target circle was 0.6cm/s; the selected levels were 5cm and 7cm. All of the trace patterns were selected in random order and repeated twice..

2.4 Evaluation

Static postural stability was assessed while the subject stood on a force plate (Model: 4060-08, Bertec Co.) for 30-second periods. The platform allowed for the measurement of the displacement of the COP (center of pressure). The signals were amplified. The sampling rate was 100. The subjects were asked to stand in three different positions with their eyes open (EO) and then with their eyes closed (EC). The subject stood barefoot with the feet positioned side by side with 200 mm distance between them, with the arms hanging freely at either side. Posturography was performed first with the EO, then with the EC. During the EO test, the subject gazed at a monitor fixed at eye-level at a distance of approximately 80cm. The monitor displayed the COP of the subject. The subject was instructed to minimize postural sway. All sessions were repeated 3 times. The Biodex system 3 (Biodex medical system Inc., Shirley, NY, USA) was used to determine the concentric isokinetic strength of ankle and knee joints. Plantar flexion and dorsiflexion isokinetic concentric strength were measured in both ankles at speeds of 30°/s and 60°/s. Extension and flexion isokinetic concentric strength were measured in both knees at speeds of 60°/s and 120°/s. The average peak torque/body weight (PTBW) was used to evaluate the training effects.

3. Results

3.1 Static postural stability

Figure 1 showed the sway path of COP in the different visual conditions before and after training. The sway path in both EO and EC conditions were reduced significantly after training in the training groups, but not in the control group. Compared to the first evaluation, the sway path was reduced 4% in the EO condition, 4.8% in the EC condition after training. Figure 2 showed the sway area of COP in the different visual conditions before and after training. After training, sway area of the different visual conditions were reduced significantly in the training group, but not in the control group. Compared to the first evaluation, the sway area was reduced 21.5% in the EO condition, 29% in the EC condition after training.

3.2 Average peak torque of ankle and knee joints

Figures 3 (a) showed the PTBW at different speeds of ankle joints in both right and left legs before and after training. The PTBW of the ankle joints in two legs both 30° /s and 60° /s speeds were significantly increased after training in the training group, not in the control group. As concerns the plantar flexion motion, the PTBW of right ankle joint was increased 27% in the 30° /s speed, 12.4% in the 60° /s speed. The PTBW of the left ankle joint was increased 25.4% in the 30° /s speeds, 11.6% in the 60° /s. As concerns the dorsiflexion motion, the PTBW of right ankle joint was increased 21% in the 30° /s speed, 17.2% in the 60° /s speed. The PTBW of the left ankle joint was increased 20.4% in the 30° /s speed, 11.2% in the 60° /s speed.

Figures 3 (b) showed the PTBW at different speeds of knee joints in both right and left legs before and after training. The PTBW of the knee joints in two legs both 60° /s and 120° /s speeds were significantly increased after training in the training group, not in the control group. As concerns the extension motion, the PTBW of right knee joint was increased 17% in the 60° /s speed, 8.6% in the 120° /s speed. The PTBW of the left knee joint was increased 43.2% in the 60° /s speed, 20% in the 120° /s speed. As concerns the flexion motion, the PTBW of right knee joint was increased 23.6% in the 60° /s speed, 20% in the 120° /s speed. The PTBW of the left knee joint was increased 29.7% in the 60° /s speed, 11.7s in the 120° /s speed.

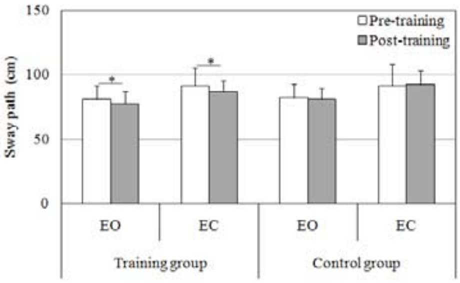


Fig. 1 Sway path of COP in the different visual conditions

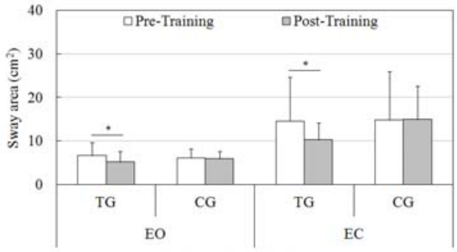
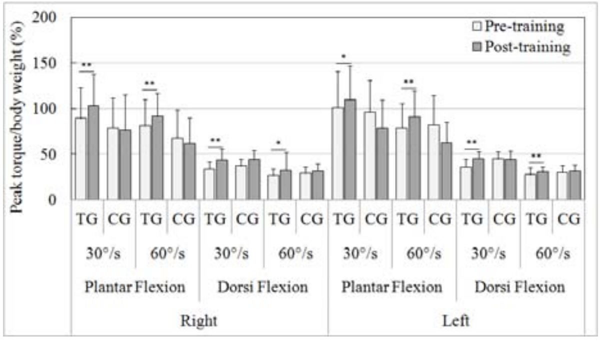


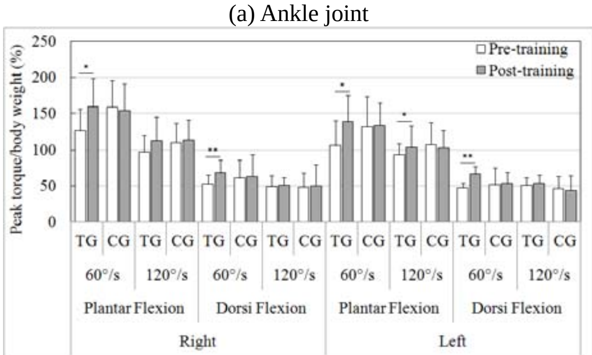
Fig. 2 Sway area of COP in the different visual conditions

4. Discussions

The static postural stability of the training group was significantly improved after the training. It was consistent with the hypothesis. The training significantly reduced the sway path and sway area in both visual conditions. As concerns the control group, it was no significant differences before training compared with after training. The training caused a significant improvement in the postural control ability. The data from our experiments showed that postural sway decreased as somatosensory input increased from the sole and the ankle joint. These effects of tactile sensation are comparatively large with regard to the control of posture by somatic sensation, such as when the subject's eyes are closed. Moreover, it has been proposed that an increase in somatosensory input is also effective for patients with peripheral nerve lesions.[4] These findings suggest that foot pressure receptor input plays a role in the control of standing posture during somatosensory input from the foot sole directory. From these previous studies, it was concluded that the tactile and pressure sensation of the sole of the foot performs an important function in standing balance. Our experimental results indicated that the training system for postural control we developed could effectively improve postural control capabilities. In particular, the somatosensory input from the foot sole and the ankle joint was substantially improved. The unstable platform provides 360 degrees of movement, allowing for posture training in a variety of directions. Using these training programs, trainees could train in COP movement at different directions, angles, and speeds. In order to maintain balance on the unstable platform, more information from the visual, vestibular organ, and somatosensory systems was required. In particular, the foot position, the tilt angles of the unstable platform, the angles of the ankle joint, and the visual information were crucial to the maintenance of balance on the unstable platform. In order to move the COP on the unstable platform, one side, the moving direction, the moving speed, and the control of the body's COG were extremely important to the subjects. On the other hand, the maintenance of body balance on the unstable platform was also very important to the subjects. This process requires a greater amount of informational cooperation from the visual, vestibular, and somatosensory systems, and also requires careful selection of motor responses. The training programs provided a variety of movement patterns. Each pattern provided different movement directions, movement speeds, and movement levels. Thus, elderly subjects may benefit more from training with this system, in terms of improving postural control ability. Our findings in the functional performance test and the significant changes observed in the posturographic parameters were consistent with this notion.



(a) Ankle joint



(b) Knee joint

Fig. 3 PTBW in both legs before and after training

5. Conclusions

In this study, we evaluated the effects of postural control training, using a training system designed to enhance postural control in elderly subjects. The experimental results indicated that the training system could successfully evaluate the gradual improvement of the postural control capability and the concentric isokinetic strength of ankle and knee joints of the trainees in the system. Moreover, the observed significant improvements in the postural capability of the elderly subjects indicated that the elderly subjects could benefit more from training with a system designed to improve their postural control ability.

ACKNOWLEDGEMENT

This work was supported by the Korea Research Foundation Grant funded by the Korean Government (MOEHRD), (The Regional Research Universities Program/Center for Healthcare Technology Development)

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