MEMOIRS HEALTH SCI. MED. KANAZAWA UNIV. Vol. 24 No. 1
151~153 2000

Fatigue Effect on the Center of Gravity of Whole Body during Dynamic Exercise.

Fujiko Someya Tomomi Hamada * Hitoshi Asai ** Munehiro Ikuta

KEY WORDS

fatigue, center of gravity, dynamic exercise, repetitive movement

INTRODUCTION

The maintenance and control of posture and balance under dynamic conditions are essential requirements for physical and daily activities. However, a reduction in postural stability has been demonstrated in persons after prolonged exercise as evidenced by means an increase in postural sway while standing on a platform[1]. For this reason, there appears to be a need for assessing body sway during exercise to prevent falls especially in aged persons and patients with disuse syndrome.

The study presented here was conducted to evaluate the center of gravity of the whole body in healthy women during dynamic exercise until the point of exhaustion. For the postural task we chose a repetitive standing up and sitting down exercise, because this physical exercise has been used extensively in physiotherapy programs and the movement itself is important in daily life.

SUBJECTS AND METHODS

Subjects

The 15 subjects consisted of healthy women students (aged 21-26years) of our university, who volunteered to participate in this study. Their average body height and body mass were 157.1 ± 5.4 cm and 4 9.6± 5.6 kg (mean ± SD), respectively. The average length of the lower leg (from the knee joint to the sole) was 42.8± 3.1 cm.

Protocol

Procedures involved the use of a platform system (Pedoscope G1820S, and Gravi Analyzer G3850, Anima Co. Ltd., Japan), from which the center of gravity of the whole body was recorded by a data recorder (RPT-50A, Kyowa Co. Ltd., Japan). A seat made of styrofoam (weighing 600 g and measuring 190 (w) ×385 (d) ×400 (h) mm) was placed on the platform and the subject sat on it with her heels 10 cm in front of the seat. The seat was light enough for the effect of its weight on the measurements of body sway to be neglected. The subject was asked to stand up in one second and sit down in one second, and the motion was repeated until the subject felt exhausted or could not maintain the one-second rhythm.

Because the endurance time varied between subjects, at five points, i.e., 0, 25, 50, 75, 100% of the total repetitive motion time, the body sway of 10 consecutive sets were resampled for total, anteroposterior, and lateral body sway. The data for 0% and 100% of motion time were obtained from respectively the first and the last set. For total body sway, the length of the tracing representing the subject's center of gravity on the platform was calculated during 10 consecutive sets. Anteroposterior and lateral body sway were evaluated at three phases : standing up, maintaining the standing position, and sitting down. For each phase, the anteroposterior or lateral sway distance was measured, and the mean value of 10 consecutive sets was used for subsequent analyses.

Department of Occupational Therapy
* Kagayahata-Onsen Hospital
** Department of Physical Therapy

Statistics

All results are given in mean ± SD. The values for total, anteroposterior, and lateral body sway were analyzed in terms of motion time using one-way ANOVA. If there was a difference of variance, the paired t test was used. The level of significance was set at $p < 0.05$.

RESULTS

The subjects' motion time ranged from 130 to 396 seconds with a mean of 276.7 ± 73.4 seconds. Total length of the tracing of the subject's center of gravity increased significantly during the experiment (Figure 1). A similar tendency for the distance to increase was observed for anteroposterior sway (Figure 2). However, statistical significance was only attained for the maintenance of standing position phase, where the distances were longer at 75 and 100% than at 0% of motion time. Finally, lateral sway distance showed no significant differences for any phase (Figure 3).

DISCUSSION

The major finding in this study is that repetitive movement causes the effect of fatigue on body sway to increase during exercise. Postural instability was mainly observed in the anteroposterior sway distance just after standing up, that is, while maintaining the standing position. In addition, lateral body sway was not affected by fatigue in any phase. These findings suggest that anteroposterior sway is more sensitive to fatigue than lateral sway. In fact, the most obvious reason for the subjects to stop the repetitive movement was that they could not stand straight on the platform except with their trunks bent forward. This phenomenon was observed in eight of the 15 subjects.

Lepers et al.[1] also reported that the ability to maintain stability while standing decreased for anteroposterior body sway after physical exercise. They explained the post exercise balance disorders as being the result of adaptation to prolonged stimulation of proprioceptive, vestibular and visual inputs. This explanation seems to apply also to our results for maintaining the standing position phase. Whether these mechanisms would also affect stability in the absence of fatigue, and what their effects on the dynamic phases (standing up and sitting down phases) are remains unclear, however.

On the other hand, muscle fatigue during dynamic and static contractions has been explained in terms of changes in the electromyographic power spectrum[2, 3]. Standing up and sitting down motions are performed by means of dynamic contraction, while to keep standing, static contraction seems to be more important. It is known that the median frequency of the

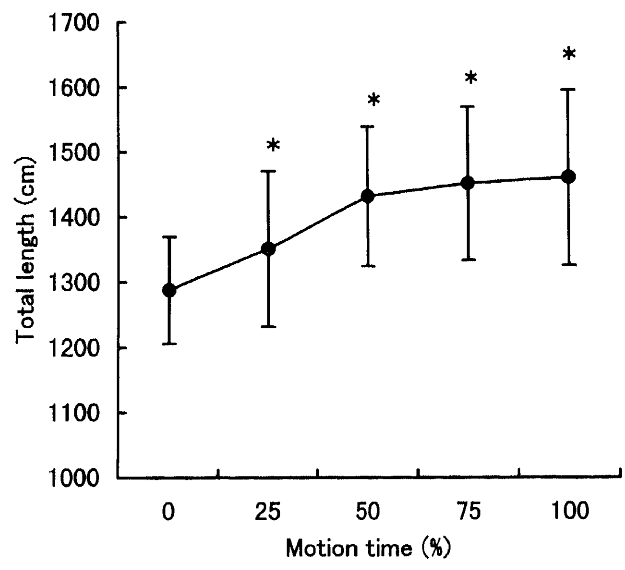

Figure 1. Changes in total body sway during dynamic exercise on a platform. The length of the tracing representing the subject's center of gravity increased significantly during the experiment ($p < 0.05$). Values are mean ± SD for 15 subjects. Asterisks show significant differences from the length at 0% of motion time.

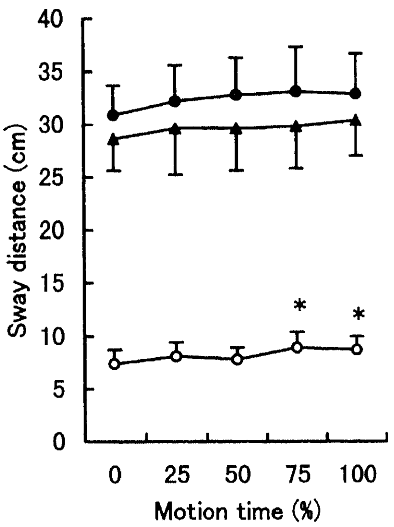

Figure 2. Changes in anteroposterior body sway during dynamic exercise on a platform while standing up (●), maintaining the standing position (○), and sitting down (▲). The sway distance became significantly longer only during the maintaining the standing position phase ($p < 0.05$). Values are mean ± SD for 15 subjects. Asterisks show significant differences from the distance at 0% of motion time.

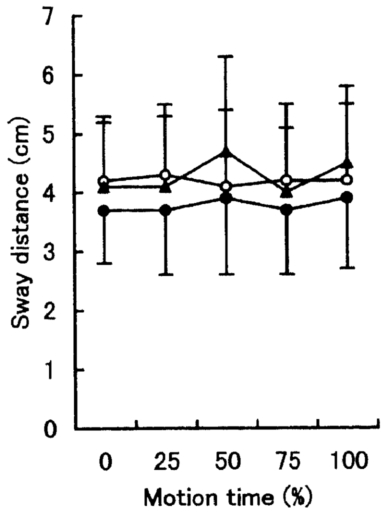

Figure 3. Changes in lateral body sway during dynamic exercise on a platform while standing up (●), maintaining the standing position (○), and sitting down (▲). None of the phases showed any significant difference in distance. Values are mean ± SD for 15 subjects.

power spectrum during the static contraction declines more rapidly than during the dynamic contraction because of fatigue[2]. These results agree with the increased body sway observed during maintenance of the standing position in this study and the reduced effect of fatigue on body stability during dynamic phases.

Postural instability is associated with a high risk of falling[4]. So that, fatigue induced by dynamic repetitive exercises could result in falling. When we assist a person suffering from fatigue during a locomotion activity, the risk of falling forward or backward, especially just after standing up, should be kept in mind.

CONCLUSION

Increased body sway during dynamic exercise observed in this study represents a higher risk of falling in anteroposterior directions because of fatigue. Our study population was of a limited age range, so that it cannot be assumed that our findings apply to other age groups, especially the elderly. This must be established in future studies.

REFERENCES

1. Lepers, R., et al. : Posture control after prolonged exercise. Eur J Appl Physiol 76 : 55-61, 1997.
2. Masuda, K., et al. : Changes in surface EMG parameters during static and dynamic fatiguing contractions. J Electromyogr Kinesiol 9 : 39-46, 1999.
3. Potvin, J.R. : Effects of muscle kinematics on surface EMG amplitude and frequency during fatiguing dynamic contractions. J Appl Physiol 82 : 144-151, 1997.
4. Hurvitz, E.A., et al. : Unipedal stance testing as an indicator of fall risk among older outpatients. Arch Phys Med Rehabil 81 : 587-591, 2000.

動的運動時の疲労が重心動揺に与える影響

染矢富士子，濱田ともみ，浅井　　仁，生田　宗博