Influence of Muscle Fatigue on Balance Disturbance in a Stable Upright Position

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Abstract. In order to identify the group of muscles related to deterioration of balance function in the elderly, an exploratory experiment was conducted to analyze and study the influence of lower limb muscular fatigue on balance disturbance in the stable upright position. A stabilometer and a multipurpose muscle function testing and training system were used to assess 12 normal healthy subjects. Evaluations were made using the total trajectory length and the trajectory length per unit area with the eyes-open for 30 seconds. All statistical analyses were performed using SPSS Ver. 13.0 with analysis of variance (repeated measures) at a significance level of below 5%. In the gluteus maximus muscles, the total trajectory length showed a significant downward trend while the trajectory length per unit area showed a significant upward trend.

Key words: Balance disturbance in stable upright position, Muscle fatigue, Gluteus maximus muscles

INTRODUCTION

In today’s aging society, study of the motor function in the elderly is becoming increasingly important to ensure their well-being. The increasing number of fall injuries among the elderly is adding to the overall national medical bill, and the ratio of people requiring nursing care is higher among those over 64 years of age. No clear evidence has been established as to specific fall factors or the kinds of exercise programs that would help prevent falls. Furthermore, although a number of studies have been conducted regarding falls in the elderly, no clear evidence has been established concerning muscle training methods that would be effective for preventing deterioration of balance function, one of the fall factors1–3). We have conducted a study on the balance function in the stable upright position in the elderly, and examined the influence of exercises on the joints in the lower limbs. In a report on the research, we suggested that exercises involving the ankle improves the balance function4–9).

The present study focused on identifying the groups of muscles relating to deterioration of the balance function in the elderly. An exploratory
experiment was conducted using normal healthy subjects to analyze and examine the influence of voluntary muscle fatigue in the lower limbs.

SUBJECTS AND METHODS

The subjects (Table 1) were 12 students at Saitama Prefectural University. The devices used were a stabilometer (Gravicorder GS3000, ANIMA Corporation) and a multipurpose muscle function testing and training system (BIODEX SYSTEMS3, SAKAI Meical Co., Ltd.).

The stabilometer was used to monitor the balance disturbance (30 seconds in the eyes-open condition: total trajectory length and trajectory length per unit area). Then, the multipurpose muscle function testing and training system was used to work the target muscles down to 30% of maximum muscle strength, when the balance disturbance was monitored again, and at 5 minutes and 15 minutes later. The maximum muscle strength was measured during isometric contraction.

The target muscles (right and left) consisted of the iliopsoas, gluteus maximus, quadriceps femoris, hamstrings, anterior tibial and triceps surae muscles. The evaluation took into account muscle fatigue. In order to avoid overlapping of successive fatigue, the evaluation was performed once a day, with an interval of at least one day before the next evaluation (the target muscles reduced to 30% of maximum muscle strength were: iliopsoas muscles, supine position; gluteus maximus muscles, supine position; quadriceps femoris muscles, sitting position; hamstrings, sitting position; anterior tibial muscles, long-sitting position; triceps surae muscles, long-sitting position). The statistical analyses were performed using SPSS Ver. 13.0 with analysis of variance (repeated measures) at a significance level of below 5%.

RESULTS

The total trajectory length (cm) exhibited a significant (Table 2) upward trend in the gluteus maximus muscle (right), while a significant downward trend was observed in the right anterior tibial muscle, right gluteus maximus muscle, left triceps surae muscle, left quadriceps femoris muscle, and the iliopsoas muscle.

Trajectory length per unit area (1/cm) exhibited a significant (Table 2) downward trend only in the gluteus maximus muscle.

DISCUSSION

The total trajectory length measurements exhibited a significant upward trend only in the right gluteus maximus muscle, indicating that the muscle fatigue of this muscle significantly impairs the balance function. This result shows that the gluteus maximus muscles serve to maintain the posture in the upright position, suggesting that this muscle is involved in the strategies of the hip joint. Further, the triceps surae muscle, the iliopsoas muscle and the gluteus maximus muscle exhibited an increase in the measurement values post-evaluation for both the right and left sides, indicating the need for continuous study with an increased number of subjects. A significant upward trend was observed only in the right gluteus maximus muscle, indicating the need for further study of the difference in the results between the right and left muscles.

The total trajectory length exhibited a significant downward trend in the right anterior tibial muscle, the right gluteus maximus muscle, the left triceps surae muscle, the left quadriceps femoris muscle and the left iliopsoas muscle, showing an improving trend in the balance function, contrary to the above-mentioned upward trend. A significant downward trend was observed in all the results at 15 minutes post-evaluation, indicating the influence of muscle fatigue on improvement of the balance function. These results show that voluntary fatigue of muscles leads to improvement of the balance function at 15 minutes post-evaluation. These results suggest that a supernormal phase\(^{10}\) appears at the recovery stage of muscle fatigue.

The results for the trajectory length per unit area\(^{11, 12}\) exhibited a significant downward trend only in the right and left gluteus maximus muscles, indicating that muscle fatigue significantly impairs the balance function, and muscle fatigue as load decreases proprioceptive posture control.

The fact that these results were obtained only in
the eyes-open condition suggests the need for further study, including in the eyes-closed condition, of the difference between the right and left muscles with an increased number of subjects.

REFERENCES


