Assessment of Postural Regulation during Standing on the Unstable Board

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Abstract. This study examined the anticipated postural control and the dynamic postural control ability through measuring required times with the maze-induction type balance board (MIBB) test. The subjects were eighty-seven healthy persons (20–83 years old), divided into three groups by age. The subject was made to take an upright stance on MIBB, then and carry out a task quickly, guide a ball through the maze after a signal, and the required time was measured. The required times were recorded for latitudinal and longitudinal directions. The results were as follows: 1) The required times of longitudinal and latitudinal directions of the aged group were significantly longer than those of the young and middle-age groups. 2) The aged and middle-aged groups by standing on one foot were divided into two groups of stable (holding of 30 sec. over) and unstable (holding of 30 sec. less). The length of center of gravity (C.G.) of opened eyes of the unstable group was significantly longer than that of the stable group (p<0.01), and the length of C.G. of closed eyes also gave a significant result (p<0.05). 3) The required time of longitudinal direction of the unstable group was significantly longer than that of the stable group (p<0.01), and the required time of latitudinal direction also gave a significant result (p<0.01). These results suggested that the MIBB test could be useful in dynamic balance training for keeping the body segments during movement and to prevent falling.

Key words: Equilibrium response, The maze-induction type balance board (MIBB) test, Physical therapy, Fall.

(INTRODUCTION

Falls are common even among the elderly residing in the community. A number of underlying problems have been directly associated with the cause offall. These include: vertigo and dizziness¹, gait disorders of orthopedic origin², postural hypotension³, cardiac dysrhythmias⁴, anemia, cerebrovascular disease⁵, parkinsonism, vertebrobasilar ischemia⁶, etc. However, once such intrinsically, as well as extrinsically caused falls have been accounted for, the etiology of a major portion of falls still remains unexplained. Therefore, we are much interested to know the dynamic response of lower extremities during standing against a sudden stress. Balance and posture are interrelated and a series of physiological mechanisms exist to inform the body if posture has been compromised and the body is in danger of falling. These include: the vestibular system, the visual system, pressure receptors in the feet and stretch reflexes on the antigravity muscles⁷. These mechanisms form a feedback loop and are constantly informing the body of changes in position and pressure distribution⁸. But, there are many factors that contribute to poor posture and an
increase in falling frequency. These include: pain, decreased range of movement and flexibility, muscle imbalance, altered joint biomechanics, pathological conditions, altered sensation and proprioception in the elderly, adaptations to the environment, and more commonly, persistent adaptation of posture in daily living. For the normal aged, deterioration of lower extremity strength, and gait are seen, particularly, a decline in gait velocity, and step length, etc.

Physical therapists in general should evaluate whether there are any pathological or biochemical abnormalities and whether any anatomical structures are tight or weak. Then, they should initiate a program of stretching for tight structures, strengthening for the muscles that are weak and retraining for the ability to perform functional activities. Physical therapists plays a major role in posture reeducation and the retraining of balance and posture following pathological disorders or injury. Earlier research has developed new examination in this area9–11). But, there are very few equipment which can evaluate dynamic response quantitatively. Therefore, we developed a new machine for training and assessment of dynamic postural control ability, called the maze-induction type balance board (MIBB), and the reliability and validity of its test were reported.

The purpose of this study was to investigate the anticipated postural control and the dynamic postural control ability through measuring the required time of the MIBB test.

METHODS

The subjects were eighty-seven healthy persons, divided into three groups by their ages: 24 young people (13 males and 11 females, mean age 25.9 years old), 30 middle-aged people (17 males and 13 females, mean age 54.6 years old), and 33 aged people (15 males and 18 females, mean age 70.8 years old). All the subjects had no discrepancy in the length of both legs and had no medical history of neurological diseases. All gave their informed consent.

First, the length of the center of gravity (length of the C.G.), for which the subjects maintained a standing posture for 30 seconds with eyes opened or closed respectively, was recorded with a stabilogram (Sanei Sokki SG-06). Next, the subject was made to stand upright on the MIBB with feet 4 cm apart, and, asked to carry out a task quickly, guide a ball through a maze after a signal. The time required for the task was measured. This investigation included two series of examinations: the a maze aligned in a longitudinal direction or latitudinal direction. In previous studies12–14), we reported the maze-induction type balance board (MIBB): a balance board (the circle has a diameter of 30 cm) with a maze (an oblong box 22.5 cm long by 16.5 cm wide by 2cm deep) at a height of 50 cm. Furthermore, we measured how long the aged and middle-aged groups could stand on one foot and divided them into two groups of stable (holding of 30 sec. over) and unstable (holding of 30 sec. less).

Data were analyzed using the Student t-test and correlation relationship, and differences were considered significant at p<0.05.

RESULTS

1. Comparison of the required times among the three age groups

Means and standard deviations for the required times of longitudinal direction and latitudinal direction are shown in Table 1. For the aged group, the required times of longitudinal direction and latitudinal direction were 45.2 ± 4.5 sec, 54.7 ± 7.1 sec, respectively. The required time of the longitudinal direction in the aged group was significantly longer than those of the young group (p<0.01) and middle age group (p<0.01). The required times of the latitudinal direction also gave the same significant result (p<0.01). A positive correlation was found between the required times of the longitudinal direction and latitudinal direction (r=0.82, p<0.01), and the regression equation was found between the required times of the two directions (y=0.74x + 3.14).

<table>
<thead>
<tr>
<th>Groups</th>
<th>Longitudinal</th>
<th>Latitudinal</th>
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<tbody>
<tr>
<td>Young (n=24)</td>
<td>30.6 ± 4.3</td>
<td>39.8 ± 5.1**</td>
</tr>
<tr>
<td>Middle-aged (n=30)</td>
<td>34.6 ± 6.1</td>
<td>43.9 ± 7.1**</td>
</tr>
<tr>
<td>Aged (n=33)</td>
<td>45.2 ± 4.5</td>
<td>54.7 ± 7.1**</td>
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Mean ± SD, **p<0.01.
2. Comparison of the lengths of C.G. between opened eyes and closed eyes

Table 2 shows the lengths of C.G. when subjects had opened and closed eyes for the three age groups. For the aged group, the lengths of C.G. were 430.5 ± 48.7 mm during eyes opened, and 464.6 ± 50.8 mm during eyes closed. For the middle-aged group, the lengths of C.G. were 407.4 ± 65.9 mm during eyes opened, and 441.4 ± 75.9 mm during eyes closed. The lengths of C.G. of opened eye in the aged and the middle-aged groups were significantly longer than that of the young group. The lengths of C.G. of closed eyes also gave the same significant result.

3. Comparison of the required times between the stable and unstable groups in the longitudinal and latitudinal directions

We measured how long the aged and middle-aged groups could stand on one foot and then they were divided into two groups of stable (holding of 30 sec. over) and unstable (holding of 30 sec. less).

Table 3 presents the means and standard deviations of the required times between the stable and unstable groups in the longitudinal and latitudinal directions. For the unstable group, the required time of the longitudinal direction was 44.2 ± 6.9 sec and the required time of the latitudinal direction was 56.9 ± 8.1 sec. For the stable group, the required time of the longitudinal direction was 38.2 ± 6.2 sec, and the required time of the latitudinal direction was 45.9 ± 5.0 sec. The required time of the longitudinal direction of the unstable group was significantly longer than that of the stable group (p<0.01), and the required time of the latitudinal direction also gave the same significant result (p<0.01).

4. Comparison of the lengths of C.G. between stable and unstable groups in opened and closed eyes conditions

Table 4 presents the means and standard deviations of the length of C.G. between the stable and unstable groups during opened eyes and closed eyes, respectively. For the stable group, the length of C.G. was 406.0 ± 37.2 mm with eyes opened, and 445.6 ± 47.2 mm with eyes closed. For the unstable group, the length of C.G. was 440.9 ± 45.0 mm with eyes opened, and 471.7 ± 46.3 mm with eyes closed. The length of C.G. of opened eyes of the unstable group was significantly longer than that of the stable group (p<0.01), and the length of C.G. of closed eyes also returned a significant result (p<0.05).

DISCUSSION

Many investigations of lower extremity strength have been performed on the aged, and it can be concluded that there is a generalized decline in static (isometric) and dynamic (isokinetic) strength of lower extremities in the aged. In particular the four key muscles (quadriceps, hamstrings, triceps surae, gluteus medialis) involved in lower extremity balance function are important in relationship to falling. But, there are many factors that contribute to poor standing posture and unstable gait. The physical therapist should identify whether there are any pathological or biomechanical abnormalities and whether any anatomical structures are tight or weak. They should then initiate a program of stretching for tight structures and strengthening for those muscle groups that are weak. This should be monitored to avoid developing a further muscle imbalance or instability. Pathological or biomechanical abnormalities will require further investigation and may necessitate involvement from orthotists or surgeons.

Many elderly are unaware that their posture is incorrect and may in fact be contributing to their physical symptoms. For the correction of habitual posture it is essential that the elderly are aware of what is correct and what is bad and what has become ‘habit’; it is only then that correction may begin to take place. Education of the elderly is, therefore, essential. This may include advice on the height of furniture and work surfaces, types of mattresses, pillows, etc. and lifting and handling techniques. Long length mirrors, electrical feedback machines, balloons, the unstable board, etc. are frequently used in physical therapy departments to make the elderly more aware of their static posture either in sitting or standing, and dynamic posture during movement. Unstable board and mirrors are also employed in gait retraining, for example, for the provision of patients with cerebrovascular disease or parkinsonism.

Both types of balance may be affected by a person’s ability to move quickly from one position to another. When we change standing posture from the upright, we are controlled by an organization of
reflexes, which try not to be out from the C.G. by having highly toned postural muscles. But we have to keep our balance when we have an unexpected change on the ground or an unexpected motion of the lower extremities.

Static balance refers to a person’s ability to maintain his/her balance when in a specific posture and dynamic balance refers to keeping the body’s segments under control during movement to prevent falling. Obviously, both types of balance are important and may require retraining. Static balance is perhaps the easiest to retrain as it involves maintaining the body’s equilibrium in a particular posture. This may be achieved by starting with a large base of support or by increasing the amount of support above normal levels. As balance improves this additional support may be gradually reduced. For example, in standing extra support may be achieved by holding on to a rigid support, e.g. wall bars, with the arms. A larger base of support is achieved by standing with the legs wide apart, a smaller base of support is obtained by standing with the feet together. Dynamic balance may be facilitated by using moveable supports instead of rigid ones, e.g. gymnastic balls instead of wall bars, or by using more unstable bases of support, e.g. wobble boards. Advanced training may involve a person standing on a wobble board and attempting to maintain their balance while throwing and catching a medicine ball. More functional tasks may include walking over an uneven surface, turning round comers and negotiating obstacles.

Nakayama et al.\(^\text{18}\) introduced a balance board that is based on the idea of DYBOC (dynamic body control training & evaluation machine) to evaluate dynamic response. We examined the usefulness of the MIBB test, which is used for clinical evaluation of the dynamic response of the elderly in the field.

### Table 2. The length of center of gravity during standing in the two eye conditions (mm)

<table>
<thead>
<tr>
<th>Groups</th>
<th>Conditions</th>
<th>Eyes opened</th>
<th>Eyes closed</th>
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<tbody>
<tr>
<td>Young (n=24)</td>
<td></td>
<td>363.4 ± 46.9</td>
<td>388.9 ± 59.2</td>
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<tr>
<td>Middle-aged (n=25)</td>
<td></td>
<td>407.4 ± 65.9</td>
<td>441.4 ± 75.9</td>
</tr>
<tr>
<td>Aged (n=20)</td>
<td></td>
<td>430.5 ± 48.7</td>
<td>464.6 ± 50.8</td>
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</tbody>
</table>

Mean ± SD, **p<0.01, *p<0.05.

### Table 3. The required times of longitudinal direction and latitudinal direction in two groups (sec)

<table>
<thead>
<tr>
<th>Groups</th>
<th>Directions</th>
<th>Longitudinal</th>
<th>Latitudinal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stable (n=24)</td>
<td></td>
<td>38.2 ± 6.2</td>
<td>45.9 ± 5.0**</td>
</tr>
<tr>
<td>Unstable (n=20)</td>
<td></td>
<td>44.2 ± 6.9</td>
<td>56.9 ± 8.1**</td>
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</tbody>
</table>

Mean ± SD, **p<0.01. The middle-aged and aged groups were divided into two groups of stable by standing on one foot (holding of 30 sec over) and unstable (holding of 30 sec less).

### Table 4. The lengths of the center of gravity in two groups (sec)

<table>
<thead>
<tr>
<th>Groups</th>
<th>Conditions</th>
<th>Eyes opened</th>
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<tr>
<td>Stable (n=24)</td>
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<tr>
<td>Unstable (n=20)</td>
<td></td>
<td>440.9 ± 45.0</td>
<td>471.7 ± 46.3</td>
</tr>
</tbody>
</table>

Mean ± SD, **p<0.01. The middle-aged and aged groups were divided into two groups of stable by standing on one foot (holding of 30 sec over) and unstable (holding of 30 sec less).

The required time of the MIBB test of the aged group was significantly longer than those of the young and middle age groups. And the length of the C.G. of the aged group was significantly longer than those of the young and middle-aged groups, too. The aged groups were divided into a stable group and an unstable group by standing on one foot. We compared the groups on the point of the required time of the MIBB test and the length of the C.G. Both in the required times and the lengths of the C.G. in the aged, there were significant differences between the unstable group and the stable group. This sudden onset produces almost instantaneous longitudinal direction and/or latitudinal direction movements of the center of gravity as compared with the delayed trunk movement seen in the MIBB tests. According to controlled the MIBB tests, to be most effective, the muscle synergies must proceed from distal stabilization of foot with dorsiflexion to improve more proximal muscles of the lower extremity, trunk, and finally the upper extremities. Nakayama said that DYBOC training helps people to acquire stabilization of the joints of lower extremities and equilibrium dynamic response in standing. The standing posture is controlled by...
input of the nervous system from standing sensory receptors and output of the effective motor responses to muscle which corresponds to the MIBB test has the same feature of DYBOC.

We think the MIBB test is useful as a screening test to evaluate dynamic responses by the required time, because it produces results similar to other common balance tests show. The MIBB test makes it possible to screen the risk of elderly people from falling down.

REFERENCES