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Effects of wobble board training on weight distribution on the lower extremities of sedentary subjects

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Abstract. Inequality of weight distribution on the lower extremities affects the posture and gait performance of an individual. The effect of wobble board training on weight distribution on the lower extremities is presently unknown. The purpose of this study was to investigate the effects of a six week wobble board exercise training program on the weight distribution in the lower extremities. Subjects (\(n = 16\)) in the wobble board group were trained three times a week for the period of six weeks. The subjects in the control group (\(n = 13\)) did not receive any training. Weight distribution symmetry scores improved by 9\% and 2\% in the wobble board and control groups, respectively, no significant difference was found between the two groups’ pre-training weight distribution on the lower extremities. The two-ways repeated analysis of variance revealed a significant F ratio between the two groups (\(P < 0.001\)). LSD post hoc analysis showed significant improvements in the symmetry of the weight distribution at the 4\textsuperscript{th} and 6\textsuperscript{th} week of training compared to pre-training value within the wobble board group, while no significant improvement was recorded within the control group. Our findings implied that the wobble board exercise program could be used to improve the symmetry of weight distribution on the lower extremities in sedentary subjects.

Keywords: Wobble board, weight distribution, lower extremities, physical therapy

1. Introduction

The standing position of a man is characterized by states of unstable' equilibrium, the maintenance of which requires a constant regulation by contraction of the muscles of the lower extremities and trunk [10]. Vandervoort et al. [17] and Okada et al. [12] state that the control of upright human posture is dependent on the maintenance of the body's center of gravity within relatively small bases. During a normal standing, the center of gravity constantly moves within these bases causing a continuous postural sway require to coordinate control system. The presence of postural sway in an individual when feet are together and eyes are closed is a sign of neurological disorder affecting both cerebella and vestibular structures of the brain. To reverse this defect, patient must be able to distribute his weight almost equally

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or symmetrically. Gait performance therefore depends on the balance performance, strength of muscles of the limbs and weight distribution on the extremities on the lower limbs [2].

According to Byl [5] human locomotion is a dynamic integration of musculoskeletal structure and neurophysiologic function. Sensory information from vestibular and somatosensory receptors (including proprioception of the lower limbs and other body parts) is used to select the appropriate motor responses to achieve a smooth, efficient gait. In case of a patient having undergone amputation, the loss of motor capability and sensory feedback from the lower limb affects the amputee's ability to establish and maintain his or her center of gravity. This deficit is demonstrated in characteristic gait deviations [13]. The deviations in gait pattern include asymmetric gait and weight-shifting difficulties that result in a halting gait pattern [3,11]. In terms of function, the deviations according to Skinner and Efféney [15] increase the energy expenditure during ambulation. Decreased walking velocity and slow cadence may also occur. Gruendel [9] stated that increased symmetrical weight bearing in hemiplegics results in greater ambulatory independence and that most hemiplegics in standing tend to load less weight on the affected limb.

Balance and coordination are usually impaired neurological conditions because of deviation in the gait characteristics. This is usually due to factors such as slow walk speed, short stance phase and loading of less weight on the affected limb [6].

The board is a popular modality used to mobilize the ankle joint, improve static balance and strength of the lower extremity. Balogun and associates [1] found that wobble board exercise over the period of six weeks did not only increase the strength of lower extremities muscles, but also improve the static balance of sedentary subjects. Studies have shown that under a systematic wobble board exercise program the range of motion of the ankle joint complex can be increased, chronic and recurrent ankle joint injuries are reduced, and the strength of the lower extremities muscles increases [8,18].

Different types of wobble boards have been identified in the literature. Burton et al. [4] reported that a wobble board can only be effective, if its angle of tilt is sufficient to destabilize the body but not high enough to injure the ankle joints. Soderberg et al. [16] furthermore concluded from their study that large sized hemispherical wobble boards produced significantly greater EMG activity than the medium sized wobble board; whereby the effect was more pronounced on the tibialis anterior muscle. Recently, Fitzgerald et al. [7] recommended the application of a Balance Master Motorized force platform as perturbation training technique or as part of a rehabilitation programs for non-operative anterior cruciate ligament management. The platform is reported to displace 6.35 cm translationally in approximately 0.5 second.

Despite the reported usefulness of the wobble board in clinical settings, the modality may have additional functions, which so far have been overlooked by researchers. Whether wobble board training can improve the symmetry of the weight distribution on the lower extremities is yet to be investigated. Furthermore, asymmetrical weight distribution on the lower extremities observed in hemiplegics is yet to be investigated in normal subjects.

The purposes of this study were to investigate the weight distribution pattern among healthy subjects and to evaluate the effect of six weeks wobble board training on the weight distribution on the lower extremities of sedentary subjects. We hypothesized that the asymmetry of the weight distribution associated with the lower extremities will improve significantly over the period of six weeks following wobble board training.
2. Materials and methods

2.1. Subjects

Twenty-nine subjects that participated in this study were undergraduate students at Obafemi Awolowo University, Ile-Ife, Nigeria. Sample of convenience (participants who are readily available to and volunteered to participate in the study) was employed in the course of recruitment of the subjects. All subjects voluntarily participated in the study and all signed informed consent forms. Thirty-two subjects started the training sessions, but three of them opted out at the mid course of the training due to academic workload. Their data were therefore not included in the analysis.

2.2. Experimental design

A two (groups) by four (instants of time) design was utilized in this study. The subjects were randomly assigned into the two groups; the experimental group consisted of sixteen subjects and the control group of thirteen subjects. The subjects in the experimental group were trained on the wobble board device recommended by Balogun et al. [1] for 6 weeks. The device measured 24 x 25 cm in diameter with rocker base radius of 11 cm and 14 cm high, respectively. (Fig. 1). The subjects in the control group did not receive any training during the six-week period.

Prior to the training regimen, the weight bearing through the individual lower extremities was measured with the subject standing on two juxtaposed bathroom scales. Thereby, the subjects stood with comfortable rotation of the hip joints and lateral border of the feet at the width of the pelvis. The subjects were instructed to stand fully erect with the eyes focusing on an object at the level of the eyes. For both groups, the weight distribution on the two lower limbs was monitored at different instants of time (pre-training, second, fourth and sixth week of wobble board training). Two persons who were not informed about the experimental protocol took the measurements.

2.3. Procedure

The subjects were fully informed about the experimental procedure, prior to data collection. Their ages were recorded and subsequently, the subjects' weights and heights were measured. During the wobble board training, subjects were instructed to rock back and forth on the device at self-selected
velocity. The movements were performed inside a parallel bar installation to produce a safe support for the subjects. Also a mirror was put in place, directly in front of the subject to minimize the necessity for them to observe the location of the board during the exercise [16].

Each subject in the experimental group trained three times a week for the period of six weeks. The training sessions lasted ten minutes for the first two-week. This duration was increased to twenty minutes in the third and fourth weeks and later increased to twenty-five minutes in the last two weeks.

2.4. Scoring

The weight distribution score (WDS) was used to determine the symmetry of the weight carried in each limb. The side bearing lesser weight (%BW d is thereby divided by the side bearing the majority of the weight (%BW2) and expressed as a ratio between 0 and 100%. The value was converted to the nearest whole number. A score of (WDS 100%) would indicate perfect symmetry of weight distribution [13].

2.5. Data analysis

The initial weight distribution on the lower limbs was analyzed using a one-way analysis of variance. In turn, a two way ANOVA was applied in order to compare the improvement in symmetry of the weight distribution of the subjects in the experimental and control group, respectively, at the different instants of time. A Least Significant Difference (LSD) multiple comparison post hoc test to determine the significance between the means was performed in case of a significant F-ratio value. All tests were conducted at the 0.05 alpha levels. The calculations were done with the use of the SPSS (version 10.0) software on a personal computer.

3. Results

The physical characteristics of the subjects are presented in (Table I). The results of the student t-test showed that there was no significant difference ($p > 0.05$) between the subjects in the two groups in terms of age, height, and body mass index (weight/height$^2$). However, significant differences existed in their weight ($P < 0.05$).

Initial weight scores were found to be asymmetrically distributed in the lower extremities in both wobble board and control groups. Subjects in the wobble board group had an average of 54.4 percent body weight distributed to the left lower limb, while the subjects in the control group had an average of 55.5 percent body weight distributed to the right lower limb. Accordingly, results of two-way analysis of variance revealed a significant F-ratio between experimental and control group before 6 weeks of training.

<table>
<thead>
<tr>
<th>Table 1</th>
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<tbody>
<tr>
<td>Physical characteristics of the subjects</td>
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<tr>
<td>Variables</td>
</tr>
<tr>
<td>Age 9yrs)</td>
</tr>
<tr>
<td>Height (m)</td>
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<tr>
<td>Weight (kg)</td>
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<tr>
<td>BMI (kg/m$^2$)</td>
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*Significant difference at 0.05 alpha levels
The results of LSD post hoc analysis revealed a significant improvement of the weight distribution within the experimental group. Thereby, significant differences existed between the pre-training weight measurements and at the end of the 4th week; and also at the end of the 6th week of the training. In contrast, no significant difference existed within the control group. The symmetry weight distribution of weight was significantly improved after the 6th week of the training in the experimental group compared to the control group ($P < 0.05$) (Table 2). Weight distribution symmetry scores improved by 9 percent and 2 percent in the wobble board and control groups, respectively.

**4. Discussion**

The results of this study revealed an improvement in the symmetry of weight bearing in the lower limbs of the apparently normal subjects in the last two-week period of wobble board training.

Seliktar et al. [14] concluded from their study that the inequality of weight bearing in hemiplegics was not the only indicator of severity; sways, ataxias and tremor also provide information on the pathology. Yet, in their work asymmetry and gait performance was not quantified. In the work of Gruendel [9], in turn, where the relationship between weight bearing characteristics in standing and ambulatory independence was investigated, it was found that weight bearing percentages on the affected sides in standing were significantly related to gait independence. This researcher suggested that weight-bearing characteristics in standing might be useful as a predictor of gait performance in hemiplegic patients.

To the best of our knowledge, no studies have so far investigated the effect of wobble board training in improving the symmetry of the weight distribution in the lower limbs. Nevertheless, other researches have demonstrated that wobble board exercise training can improve the balance performance of sedentary young men [1]. Wobble board was also found to be relevant in strengthening the lower limb muscles, rehabilitation of operative lateral ankle joint sprain, and anterior cruciate ligaments [7,18].

However, the improvements with respect to symmetry in the weight distribution in the lower limbs still lack scientific explanation. We hypothesize that the factors responsible for the improvements in balance performance also help in regard to the symmetry of the weight distribution. The increase in balance performance following wobble board training was attributed to an improved joint mechanoreceptor functioning [1]. Thereby, balance ability, proprioception and kinesthetic awareness have been reported to be dependent on the joint mechanoreceptor integrity [19]. With improved sensory feedback from the lower limbs of amputees studied by Sabolick and Ortega [13] recorded weight distribution symmetry core increased by 7 percent.

### Table 2

<table>
<thead>
<tr>
<th>Variables</th>
<th>Experimental group</th>
<th>Control group</th>
<th>F-ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-training</td>
<td>$88.7 \pm 5.9^a$</td>
<td>$91.8 \pm 5.9$</td>
<td>0.68</td>
</tr>
<tr>
<td>Week 2</td>
<td>$93.4 \pm 2.8$</td>
<td>$91.5 \pm 7.4$</td>
<td>0.367</td>
</tr>
<tr>
<td>Week 4</td>
<td>$95.5 \pm 2.3^a$</td>
<td>$92.9 \pm 9.2$</td>
<td>0.065</td>
</tr>
<tr>
<td>Week 6</td>
<td>$97.5 \pm 4.8^{ab}$</td>
<td>$93.5 \pm 3.8^b$</td>
<td>0.000*</td>
</tr>
</tbody>
</table>

*$P < 0.001$.*

Instant of time averages with the same superscripts are significant within the experimental group. For example, pre-training is significantly different from week 4 and week 6 ($P < 0.05$). Superscript 'b' indicates moreover that a significant difference was found after the 6th week weight distribution between the two groups.
Apart from increase in the strength of the low limb muscles that usually follow wobble board training as reported in the earlier study there may also be an increase in the core strength and stability of the trunk and pelvic girdle, which may lead to a good posture, which can enhance the symmetry of the weight distribution on the lower limbs.

4.1 Clinical implications

Patients with neurological and musculoskeletal dysfunctions are usually faced with ambulatory problems. This is because these patients tend to bear less weight on the affected side due to factors such as muscle weakness and pain. A poor gait performance may adversely affect activities of daily living; in some occasions, it may even result also in falls. Also, an amputee who loads less weight on the prostheses of the affected limb may have his/her gait deviated which could result into halting gait pattern [13]. Furthermore, in bilateral lower limbs amputees, asymmetry in the weight distribution on the prostheses may cause an unusually frequent need for changing the prostheses, as the area subjected to more pressure is likely to exhibit more wear.

Our findings suggest that a prolonged wobble board exercise training program may be helpful in improving the symmetry of the weight distribution in the lower limbs of apparently healthy persons. Wobble board training may also serve as a prophylactic measure against the incidence of fall among the elderly.

4.2 Conclusion

The results of our study revealed a significant improvement in the symmetry of the weight distribution on the lower extremities of sedentary subjects following a six-week wobble board-training program. Accordingly, we recommend the use of wobble board exercise in clinical setting during rehabilitation of hemiplegics and amputees using lower limbs prostheses. However, our results should be interpreted with caution. The recruitment of young normal adults instead of patients limits the validity of this study. Also, many factors that may affect the asymmetry of the weight distribution, like physical characteristics of the subjects and effect of limbs dominance were not considered in this study. Follow up studies involving patients with neurological and musculoskeletal disorders and associated with problems regarding the symmetry of the weight distribution are necessary.

References