Instrumented Wobble Board for Testing Functional Ankle Instability

Nicolaj Mentz Larsen[1], Niclas Hvolby Andersen[1], Mathilde Hansen[1] and Uffe Laessoe[1,2]
[1]*Department of Physiotherapy, University College of Northern Denmark, Selma Lagerloffsvej, Aalborg, Denmark*
[2]*Research and Development Department, UCN, Aalborg, Denmark*

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Abstract: Lateral ankle distortion is one of the most frequent sports injuries. In approximately 40% of the incidents, the individual will develop chronic ankle instability. Ankle instability is not detected consistently using traditional balance measures and alternative approaches are warranted. It was hypothesized that an instrumented wobble board may serve as a tool to detect people with functional ankle instability.
Twenty-two young people with perceived ankle instability and a gender and age-matched control group were included in the study. The participants were standing on one leg for 30 seconds on an instrumented wobble board - with and without visual performance feedback. The primary outcome measures were the standard deviations of the tilt angle in the medio-lateral and the anterior-posterior directions.
The tilt variation in medio-lateral direction was significantly larger in the instability group: with feedback 1.65 (0.72) vs. 1.14 (0.31) and without feedback: 1.95 (1.01) vs. 1.20 (0.35). Similar, but not statistically significant, differences were seen in anterior-posterior direction.
Participants with chronic ankle instability display increased tilt variation when challenged in one-leg stance on a wobble board. The tilt inclination measured by an instrumented wobble board may serve as a supplementary objective measure for the clinical identification of people with functional ankle instability.

1 INTRODUCTION

Lateral ankle distortion is one of the most frequent sports injuries and may be associated with recurrent distortions, pain and other symptoms (Hertel, 2002). In approximately 40% of the incidents, the individual will develop chronic ankle instability, which is defined as recurrent distortions and episodes of instability over a period exceeding six months (Hubbard, 2007).

Chronic ankle instability may appear as a mechanical or a functional instability, or as a combination of these types (Levin et al., 2012). Mechanical ankle instability refers to laxity of the joint after an injury to the stabilizing structures (Munn et al., 2009). Functional ankle instability (FAI) is also a widely used term, but the definition of this condition is not as well established (Delahunt et al., 2010). In the present study, FAI is defined as one or more episodes of lateral ankle sprain followed by experiences of instability.

It is not clear what causes the functional instability, but it is proposed that the condition may be a result of a dysfunctional sensorimotor system (Hertel, 2002). A recent review provides guidelines for the examination and treatment of ankle instability, but this review also states that the role of the neuromuscular elements in subjective instability is controversial and needs further study (Martin et al., 2013).

Functional impairment in people with chronic ankle instability has not been detected consistently by the use of traditional instrumented outcome measures for evaluating balance (McKeon and Hertel, 2008). The use of other measures than postural sway, more closely linked to functional ankle stability, has therefore been suggested (Hupperetset al., 2009). In the present study, we used an instrumented wobble board (also called ankle disc). Standing on one leg on a wobble board represents a task that requires dynamic stability of the ankle.

The aim of this study was to investigate whether a test on an instrumented wobble board could identify impairment in ankle stability. It was hypothesized that the performance, while standing on one leg on a wobble board, would be less stable for people with self-reported functional ankle instability.

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2 METHODS

The study was designed as a case-control study to evaluate the construct validity of the test. A convenience sample of 22 people with functional ankle instability was recruited for the case group through public announcement.

Inclusion criteria were: aged 18-30 years; several episodes of lateral ankle distortions or experiences of instability within the previous six months and a minimum score of 11 on a questionnaire on functional ankle instability (IdFAI) (Gribble et al., 2014). Exclusion criteria were: previous fractures of lower extremities; pain, edema or movement restrictions within the last six weeks. The control group was an age and gender matched group of 22 healthy people with IdFAI score below 11. All participants reported physical activity for at least four hours a week.

The study was conducted in accordance with the guidelines of the regional research ethics committee of Northern Denmark and informed consent was obtained from all participants in accordance with the Declaration of Helsinki.

2.1 Outcome Measures

Questionnaire

The case group was characterized by the "Identification of Functional Ankle Instability questionnaire" (IdFAI). This questionnaire is developed to detect whether individuals meet the minimum criteria necessary for inclusion in a FAI population (Simon et al., 2012). It defines functional ankle instability as the tendency of the foot to 'give way'. This is described as a temporary uncontrollable sensation of instability or rolling over of one's ankle. The reliability of the questionnaire has been established in other studies (Gurav et al., 2014). The questionnaire consists of ten questions, which are ranked on the experienced severity of the impairment. The questions address one ankle only.

Instrumented Wobble Board

The ankle stability was evaluated while the participant was standing for 30 seconds on one leg on an instrumented wobble board, SensBalance Mini board (Sensamove, Netherland). This tool is a wooden wobble board with two accelerometers placed horizontally in anterior-posterior plane (AP) and medio-lateral plane (ML) respectively. Any tilt in the direction of the sensor is detected as an acceleration signal with reference to the earth' gravity. In this way the accelerometers reflect the tilt movements of the board.

It is possible to get a continuous feedback on the balance performance from a monitor where a dot on a target represents the tilt of the wobble board. With no tilt, the dot will be in the center of the target. In this way a visual performance feedback may be provided for the participant.

Several levels of difficulties may be chosen for the board. In this study, the maximum tilt of the board was 15 degrees and the accelerometer sample frequency was 22 Hz.

The custom software presents the averaged tilt of the wobble board by a 0-100% score in a user interface. These averaged figures may be misguiding, however, as an otherwise stable position in a five degrees tilt position will give a low score. Furthermore, they are not representative for the ongoing corrections representing the ankle stability. The data representing the wobble board angular tilt in AP and ML direction for all samples was therefore exported from the SensBalance custom software to MS Excel for further analysis.

The standard deviation of the tilt positions during the 30 seconds of testing was calculated for the two directions and this variance measure represented the outcome measure for the stability performance.

2.2 Procedure

The participants were allowed time to get accustomed to standing on the wobble board. They were asked to stand on the board on one leg with bare feet. The case group stood on the leg with the impaired ankle and the control group stood on their dominant leg.

They were tested with open eyes under two conditions. One condition provided continuous target feedback from a monitor placed in 1.5 meters height 1.5 meter away. In the other condition, they were asked to look at the same spot, but with no target feedback. The sequence of the tests was randomized. If they lost their balance, they were allowed another try up until three trials.

2.3 Data Analysis

The baseline data for the two groups was compared by independent T-test and Chi-test to evaluate the match of the control group to the case group on age, gender, BMI and IdFAI.

The performance scores (i.e. the standard deviation of the wobble board angular tilt) were presented by mean and sd. for the anterior-posterior and medio-lateral directions. The group performance

was compared by Mann-Whitney U-test as some data displayed lack of normally distribution.

Correlations between the IdFAI scores and the stability scores were evaluated for the common score of the two groups by Spearman's correlations coefficients. The statistical analyses were done in SPSS and the level of statistical significance was set at 0.05.

3 RESULTS

The two groups were comparable with respect to age, gender, height and weight. The IdFAI score was higher in the case-group (Table 1).

Table 1: Group characteristics.

	Control	Case group
Gender (female/male)	17 / 5	18 / 4
Age (years)	23.6 (1.8)	23.6 (2.1)
Height (m)	1.72 (0.11)	1.72 (0.08)
Body mass (kg)	71.2 (13.5)	70.9 (10.2)
IdFAI score	2.6 (2.1)	17.6 (4.3) *

Mean values and SD. $p<0.01$

3.1 Performance

The case group showed increased instability when standing on the wobbleboard compared to the control group. This was, however, only statistically significant in the medio-lateral direction. The difference was seen in the condition with visual target feedback as well as in the condition without target feedback. There was no difference between the two feedback conditions in either group (Table 2).

3.2 Correlation with Id FAI

There were only weak correlations between the FAI score and the instability measures, and these correlations were significant only for the medio-lateral instability in the two tasks (Table 3).

The instability measures in the two directions antero-posterior and medio-lateral correlated significantly. In addition, these instability measures correlated for the two conditions with and without target feedback.

4 DISCUSSION

4.1 Identification of Stability Impairment

Compared to a healthy control group, the participants with chronic ankle instability displayed increased instability when challenged in one-leg stance on a wobble board.

It is uncertain what causes functional ankle instability (FAI), but it may occur due to a dysfunctional sensorimotor system. Damage to capsular and ligamentous structures may result in impaired proprioception and consequently reduce the ability to maintain postural control and balance (Hertel, 2002). Larger deviations in the tilt of the wobble board is seen with reduced sensory input (closed eyes) and this suggests that a large standard

Table 2: Instability while standing on wobble board.

	Control group	Case group	Difference
Performance with target feed-back			
Anterior-posterior tilt variation	0.97 (0.26)	1.20 (0.55)	0.23
Medio-lateral tilt variation	1.14 (0.31)	1.65 (0.72)	0.51 *
Performance with no target feed-back			
Anterior-posterior tilt variation	0.96 (0.24)	1.24 (0.61)	0.28
Medio-lateral tilt variation	1.20 (0.35)	1.95 (1.01)	0.75 *

Group mean values and SD representing the variation in tilt (degrees) of the wobble board (i.e. standard deviation of the angular tilt during 30 seconds of testing).
* $p<0.05$

Table 3: Correlations between the IdFAI questionnaire and the instability measures.

	AP_target	ML_target	AP_no-target	ML_no-target
IdFAI	0.14	0.32*	0.28	0.34*
ML_no-target	0.43**	0.51**	0.62**	
AP_no-target	0.64**	0.53**		
ML_target	0.77**			

Spearman's correlations coefficients (r)
* $p<0.05$; ** $p<0.01$

deviation of the tilt angle reflects reduced postural capacity (Williams and Bentman, 2014).

The instability and higher adjustment activity observed in the case-group in the present study was most likely a consequence of impaired ankle control, but the study design allows no unequivocal conclusion in this respect.

Although a statistically significant difference was observed in the performance of the two groups, no strong correlation between idFAI and the stability performance was seen. This may mainly be ascribed to a high variation in the performance of the case-group. Some of the participants with high idFAI score performed just as well or better on the wobble-board as participants from the control group. A possible explanation could be, that more individuals in the case-group had experiences with the wobble board, as this tool is often used for rehabilitation after an ankle sprain. The control of the wobble board tilt is naturally related to ankle stability, but also other aspects of balance control may influence this performance. Still, the test may provide objective data to supplement the self-reported condition of the individual.

As lateral ankle distortion may be associated with recurrent distortions (Hertel, 2002) athletes with functional ankle instability should be identified in order to offer them training and restore function (Oliveira et al., 2013). The use of traditional instrumented outcome measures for evaluating balance may not always be sufficiently challenging in order to detect ankle instability (McKeon and Hertel, 2008). Measures, more closely linked to functional ankle stability, may therefore be warranted to identify ankle instability (Hupperets et al., 2009). The unstable support surface of a wobble-board will increase the level of difficulty of maintaining postural control in a standing position and the ankle stability control will be particularly challenged in this task (Ogaya et al., 2011; Shumway-Cook and Woollacott, 2007). Compared to a test on a stable balance platform or a force plate the test on a wobble board represents a more difficult stability challenge, and this may avoid a possible ceiling effect when testing an individual with minor impairment.

4.2 Instrumentation of Wobble Board

Different types of instrumented wobble boards have become commercially available on the market, and these tools may prove helpful in the assessment of balance impairment and ankle instability (Williams and Bentman, 2014). According to the findings in the present study, the user-interface of such instruments should provide a presentation of variability measures for the evaluation of the performance. Furthermore, it must be emphasized that there is a need for a standardization of the procedures for wobble board testing. To compare different recordings, the length of the testing sequence, the visual fixation, the placement of non-supporting leg etc. must be standardized.

The development of new technologies provides new possibilities for clinical testing. With respect to instrumented wobble boards, one cheap option may be suggested here. With a smartphone is attached to the wobble board the accelerometer sensors in the smartphone will measure the movements of the wobble-board. This data may be sufficient for further analysis by an app.

The participants were tested during two conditions: with and without target feedback. It is well known that the balance is depending on visual, proprioceptive and vestibular input and that the balance is more challenged with closed eyes (Isakov and Mizrahi, 1997). It was expected that a similar difference could be seen between conditions with and without visual target feedback. This was not evident in this study, however. In both conditions, the participants had open eyes and the difference in target feedback had apparently no discriminating influence on the performance in either of the two groups.

5 CONCLUSION

Participants with chronic ankle instability display increased tilt variation when challenged in one-leg stance on a wobble board. The tilt variation measured by an instrumented wobble board may serve as a supplementary objective measure for the clinical identification of people with functional ankle instability and as a measure for performance improvement.

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