CLINICAL STUDY

SIMPLE, FAST AND RELIABLE ASSESSMENT OF BALANCE ON SOFT SUPPORT SURFACE: BOBO WOBBLY BALANCE BOARD

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SUMMARY

Background: Force plate platforms are a reliable and valid testing method to assess balance and postural stability. However, these platforms are expensive, and it takes time to implement tests with these platforms. This study aims to investigate the relationship between BoBo Wobbly Balance Board and force plate platforms.

Methods: One hundred healthy individuals were included in this study. Balance tests were administered to these individuals using a Bertec force plate in six different conditions (eyes open and closed on firm and soft surfaces with both legs (TLST); eyes open on firm and soft surfaces with one leg (OLST) and using a BoBo Wobbly Balance Board in four different conditions (eyes open and closed TLST; eyes open OLST and eyes open dynamic balance).

Results: There was a positive correlation between the eyes open TLST on a soft surface administered with the force plate and the eyes open TLST administered with the BoBo Wobbly, as well as between the eyes closed TLST on a soft surface administered with the force plate and the eyes closed TLST administered with the BoBo Wobbly ($p<0.05$).

Conclusions: There is a relationship between tests performed with BoBo Wobbly and force plate tests applied to soft surfaces. The BoBo Wobbly can be used as a portable, low-cost posturograph to assess balance on soft surfaces. However, further studies are needed to investigate the threshold and normative values of BoBo Wobbly to evaluate the fall risk of individuals.

Keywords: BoBo Wobbly, force plate, balance, falling, postural stability

YUMUŞAK DESTEK YÜZEYİNDE DENGENİN BASİT, HIZLI VE GÜVENİLİR BİR ŞEKİLDE DEĞERLENDİRMESİ: BOBO WOBBLY DENGE TAHTASI

ÖZET

Amaç: Kuvvet plakası platformları denge ve postüral stabiliteyi değerlendirmek için güvenilir ve geçerli bir test yöntemidir. Ancak, bu platformlar pahalıdır ve bu platformlarla test uygulamak zaman alır. Bu çalışma, BoBo Wobbly Denge Tahtası ile kuvvet plakası platformları arasındaki ilişkiyi araştırmayı amaçlamaktadır.

Gereç ve Yöntem: Bu çalışmaya yüz birey dahil edildi. Bu bireylere Bertec kuvvet plakası kullanılarak altı farklı koşulda (sert ve yumuşak yüzeylerde gözler açık ve kapalı iki bacak üstünde durma testi (İBÜDT); sert ve yumuşak yüzeylerde gözler açık tek bacak üstünde durma testi (TBÜDT) denge testleri uygulandı. BoBo Wobbly denge tahtası kullanarak dört farklı koşulda (gözler açık ve kapalı İBÜDT; gözler açık TBÜDT ve gözler açık dinamik denge) denge testleri uygulandı.

Bulgular: Kuvvet plakasıyla uygulanan yumuşak yüzeydeki gözler açık İBÜDT ile BoBo Wobbly ile uygulanan gözler açık İBÜDT arasında ve kuvvet plakasıyla uygulanan yumuşak yüzeydeki gözler kapalı İBÜDT ile BoBo Wobbly ile uygulanan gözler kapalı İBÜDT arasında pozitif bir korelasyon vardı ($p<0,05$).

Sonuçlar: BoBo Wobbly ile yapılan testler ile yumuşak yüzeylere uygulanan kuvvet plakası testleri arasında bir ilişki vardır. BoBo Wobbly, yumuşak yüzeylerde dengeyi değerlendirmek için taşınabilir, düşük maliyetli bir posturografi olarak kullanılabilir. Ancak, bireylerin düşme riskini değerlendirmek için BoBo Wobbly'nin eşik ve normatif değerlerini araştıran daha fazla çalışmaya ihtiyaç vardır.

Anahtar Sözcükler: BoBo Wobbly, kuvvet plakası, denge, düşme, postüral stabilite

INTRODUCTION

Balance can be defined as the ability to keep the body's center of gravity on the base of support for the maximum duration with minimum body sway.[1] Balance disorders, especially in standing posture, cause falls and serious injuries. Severe injuries and falls are associated with major morbidities, loss of independence and increased mortality.[2] The risk of falling increases with ageing, and approximately half of the individuals over 80 experience a fall at least once a year.[3] Even if these individuals do not suffer a severe physical injury or fracture, they may develop a fear of falling, restricting physical and social activities, and a decrease in quality of life due to the psychological impact of the fall. It has been stated that the most effective method to reduce the risk of falling is a comprehensive rehabilitation program that includes strength, endurance and balance exercises.[4] However, individuals at risk of falling must be identified to apply this method. Therefore, systematic

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evaluation of fall risk is very important to reduce the incidence of falls.[5]

Falls may develop due to sensory disorders in the balance systems, diseases and medications, and inappropriate environmental conditions.[6] Considering the complexity of possible causes, screening and identifying individuals at risk of falling is challenging.[7] However, balance assessments are the ideal way to identify people at risk of falling due to poor balance or inadequate postural stability.[7]

Various questionnaires and instrumental and non-instrumental tests are recommended to assess fall risk.[8] Tools such as the Tandem Romberg, one-leg standing test (OLST), and functional reaching test can be easily used without special equipment. However, failure to detect variances and small changes due to ceiling effects in these tests negatively affects the success and distinctiveness of these tests.[9] To overcome these limitations and evaluate balance more objectively, force plate platforms that perform center-of-pressure (CoP) analysis are preferred. In this device, the vertical force applied by the body's centre of gravity to the platform is recorded, and thus, body oscillation is detected. These platforms, generally used to evaluate static balance,[10] are time-consuming and expensive. Additionally, force plate platforms are difficult to apply in clinical settings.[9,11] There is a need to develop user-friendly and inexpensive tools to facilitate simple and practical assessment of balance.[11]

The BoBo Wobbly Balance Board (BO&BO Ltd. Israel), priced at approximately $140, was developed for the assessment of static and dynamic balance and the implementation of game-based (14 games) balance exercises.[12] The device, which can be connected to Android and iOS systems via Bluetooth, is a cheaper, more accessible and easily applicable tool compared to force platforms. The system constantly provides visual feedback. The difference between the BoBo Wobbly Balance Board and the CoP platforms is that it is sensitive to movement, not force. The motion sensor located in the middle detects the tilt of the balance board and displays movement in the anteroposterior/mediolateral plane (Figure 1A). We have not found a study in the literature investigating the relationship between the BoBo Wobbly Balance Board and force platforms. Therefore, this study aimed to examine the relationship between the BoBo Wobbly Balance Board and force platforms.

MATERIAL and METHODS

This research has been approved by the authors" affiliated institutions. Verbal and written consent was obtained from all individuals included in the study.

One hundred twenty-one university students who filled out the participant information form and the Dizziness Handicap Inventory (DHI) participated in this study. These students were interviewed face to face, and their medical history was questioned. The participants' height, weight, age, and gender information were noted. Students who reported dizziness according to DHI (total score>0) and had systemic, orthopaedic and neurological disorders were excluded from the study. As a result, 100 healthy students were included in the study. All participants underwent static balance tests in 6 situations with the Bertec force platform (Bertec Corporation, Ohio, USA) (Figures 2A and 2B). These situations;

- Eyes open two-leg standing test (TLST) on firm surface
- Eyes closed TLST on firm surface
- Eyes open TLST on soft surface
- Eyes closed TLST on soft surface
- Eyes open OLST (with dominant leg) on firm surface
- Eyes open OLST (with dominant leg) on soft surface

BoBo Wobbly Balance Board (BO&BO Ltd. ISRAEL) was applied to all participants in 4 situations with an air cushion placed under the device (Figures 1A and 1B). These situations;

- Eyes open TLST
- Eyes closed TLST
- Eyes open TLST (dynamic balance)
- Eyes open OLST (with dominant leg)

Considering their fatigue, participants were given a one-minute rest period between each test.

IBM SPSS 21 software was used for statistical analysis. The significance level was accepted as 0.05. The normality distribution of the data was tested with Shappiro-Wilk. Normally distributed data were presented as mean±sd, and non-normally distributed data were presented as median (min-max), first

quartile "Q1"- third quartile "Q3". The relationship between groups was evaluated using the Pearson correlation test if the data were normally distributed and the Spearman correlation test if the data were not normally distributed.

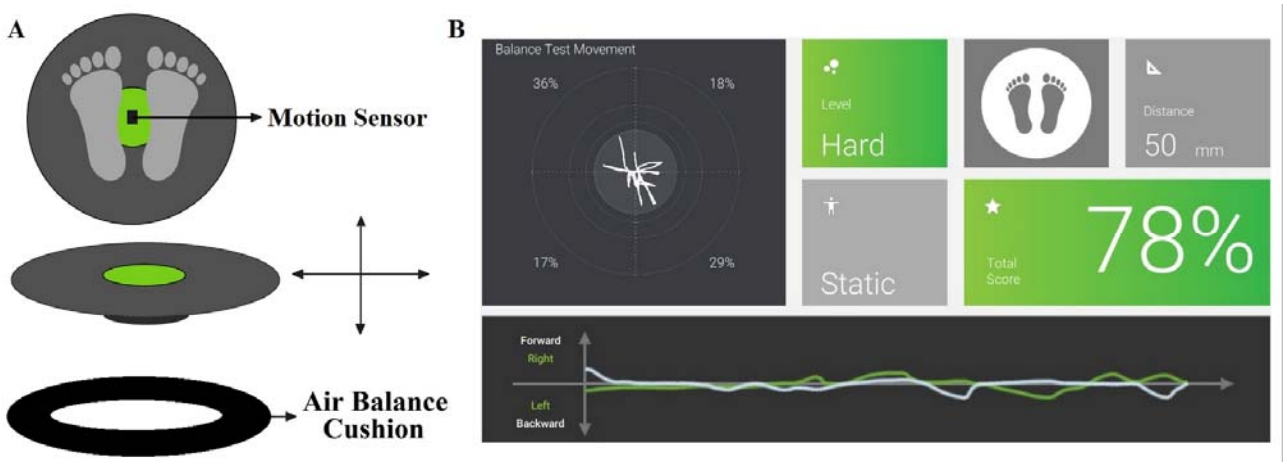
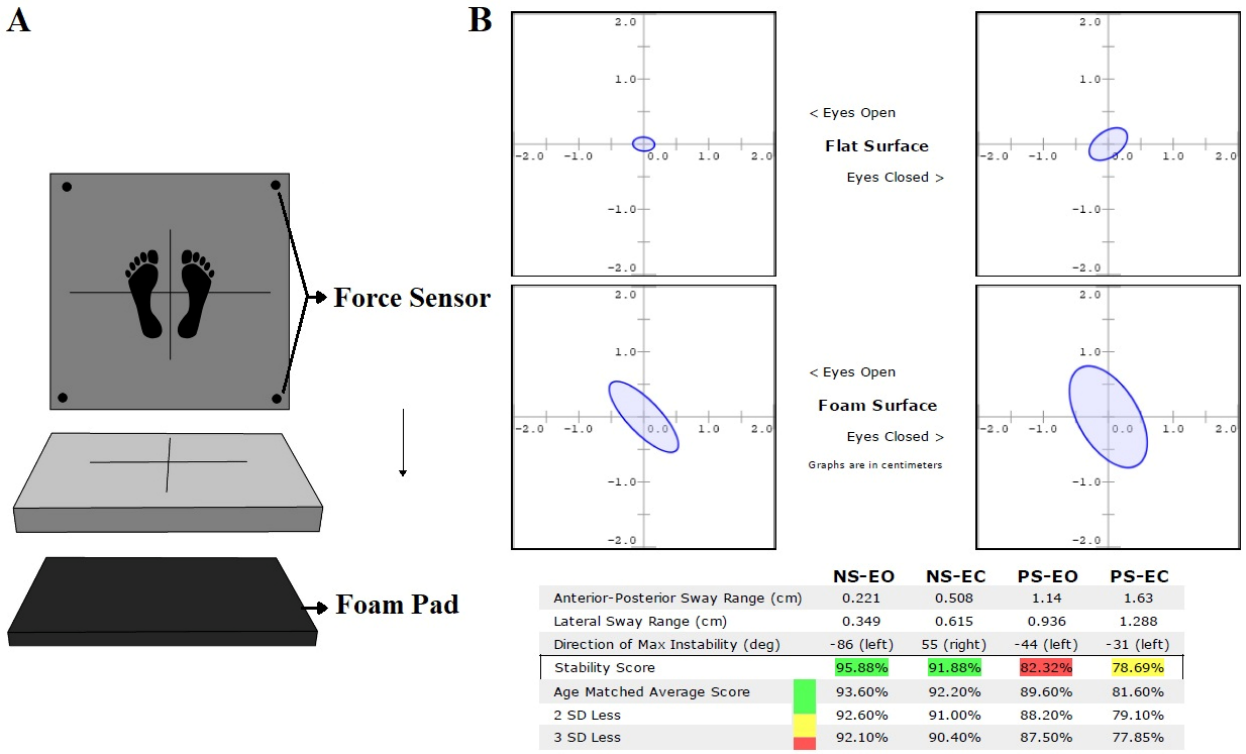


Figure 1: A: *BoBo Wobbly Balance Board device and parts, B: BoBo Wobbly Balance Board result report.*



	NS-EO	NS-EC	PS-EO	PS-EC
Anterior-Posterior Sway Range (cm)	0.221	0.508	1.14	1.63
Lateral Sway Range (cm)	0.349	0.615	0.936	1.288
Direction of Max Instability (deg)	-86 (left)	55 (right)	-44 (left)	-31 (left)
Stability Score	95.88%	91.88%	82.32%	78.69%
Age Matched Average Score	93.60%	92.20%	89.60%	81.60%
2 SD Less	92.60%	91.00%	88.20%	79.10%
3 SD Less	92.10%	90.40%	87.50%	77.85%

Figure 2: A: *Bertec Force Plate device and parts, B: Bertec Force Plate result report.*

RESULTS

Seventy-six (76%) of the participants were women, 24 (24%) were men, and the average age was 21.14±2.57 (18-35). The median height of the participants was 164.50 (150.00-185.00), 160-170 cm, the median weight was 60.00 (42.00-110.00), 53-70 kg, and the median body mass index (BMI) was 22.38 (16.41-33.06), 19.95-24.60. There was a statistically significant negative correlation between eyes open OLST on firm surface performed on the force plate and weight and BMI ($p<0.05$). There was a statistically significant negative correlation between eyes-

closed TLST and height, weight and BMI and between eyes-open OLST and weight and BMI ($p<0.05$). The relationship between height, weight, BMI and balance tests is presented in Table 1.

When looking at the scores of tests administered with the force plate platform: on a firm surface, the median score for eyes open TLST was 92.56 (50.00-96.83), 88.91-94.73, for eyes closed TLST it was 92.29 (50.00-96.94), 90.48-93.79; on a soft surface, the median score for eyes open TLST was 89.08 (50.00-95.93),83.72-92.34, for eyes closed TLST it was 84.62 (50.00-93.11), 81.27-87.55; on a firm surface, the median score for eyes open OLST was 88.49 (50.00-93.49), 83.58-90.59, and on a soft surface, it was 87.50 (50.00-95.19), 84.49-90.91. When looking at the scores of the tests applied with the BoBo Wobbly Balance Board, the eyes open TLST median score is 100.00 (35.00-100.00), 100.00-100.00, the eyes closed TLST median score is 99.00 (19.00-100.00), 75.00-100.00, the eyes open TLST (dynamic balance) median score is 21.00 (4.00-63.00), 17.00-28.00, and the eyes open OLST median score was 100.00 (5.00-100.00), 86,75-100.00. There was a statistically significant positive correlation between eyes open TLST on soft surface applied with force plate and eyes open TLST applied in BoBo Wobbly, and between eyes closed TLST on soft surface applied with force plate and eyes closed TLST applied in BoBo Wobbly ($p<0.05$, Figure 3). The relationship between the tests applied with the Force plate and the tests applied with the BoBo Wobbly Balance Board is presented in Table 2.

Table 1. Relationship between height, weight, BMI and balance tests.

Balance Tests	**Physical Properties**		
	Height	Weight	BMI
Force Plate	p, Correlation Coefficient (r)		
Eyes open TLST on firm surface	.947 (-0.007)	.439 (-0.078)	.337 (-0.097)
Eyes closed TLST on firm surface	.135 (-0.150)	.160 (-0.141)	.454 (-0.076)
Eyes open TLST on soft surface	.133 (-0.151)	.512 (-0.066)	.892 (-0.014)
Eyes closed TLST on soft surface	.178 (-0.136)	.060 (-0.189)	.098 (-0.166)
Eyes open OLST (with dominant leg) on firm surface	.314 (-0.102)	.031 (-0.216)*	.043 (-0.203)*
Eyes open OLST (with dominant leg) on soft surface	.935 (0.008)	.189 (-0.132)	.188 (-0.133)
BoBo Wobbly			
Eyes open TLST	.571 (0.057)	.793 (-0.027)	.540 (-0.062)
Eyes closed TLST	.036 (-0.210)*	.006 (-0.271)*	.044 (-0.202)*
Eyes open TLST (dynamic)	.206 (0.128)	.517 (0.066)	.429 (0.080)
Eyes open OLST	.563 (-0.059)	.028 (-0.220)*	.009 (-0.259)*

Spearman correlation test, TLST: Two leg standing test, OLST: One leg standing test, *$p<0.05$

Table 2. The relationship between the tests applied with the Force plate platform and the tests applied with the BoBo Wobbly Balance Board.

Force Plate	**BoBo Wobbly**			
	Eyes open TLST	Eyes closed TLST	Eyes open TLST (dynamic)	Eyes open OLST
	p, Correlation Coefficient (r)			
Eyes open TLST on firm surface	.172 (0.138)	.693 (0.040)	.567 (0.058)	.659 (0.045)
Eyes closed TLST on firm surface	.660 (0.044)	.056 (0.192)	.451 (0.076)	.901 (-0.013)
Eyes open TLST on soft surface	.013 (0.248)*	.222 (0.123)	.178 (0.136)	.764 (0.030)
Eyes closed TLST on soft surface	.993 (0.001)	.002 (0.312)*	.622 (-0.050)	.847 (0.019)
Eyes open OLST (with dominant leg) on firm surface	.156 (0.142)	.096 (0.167)	.993 (0.001)	.835 (-0.021)
Eyes open OLST (with dominant leg) on soft surface	.065 (0.185)	.149 (0.145)	.074 (0.179)	.619 (-0.050)

Spearman correlation test, TLST: Two leg standing test, OLST: One leg standing test, *p<0.05

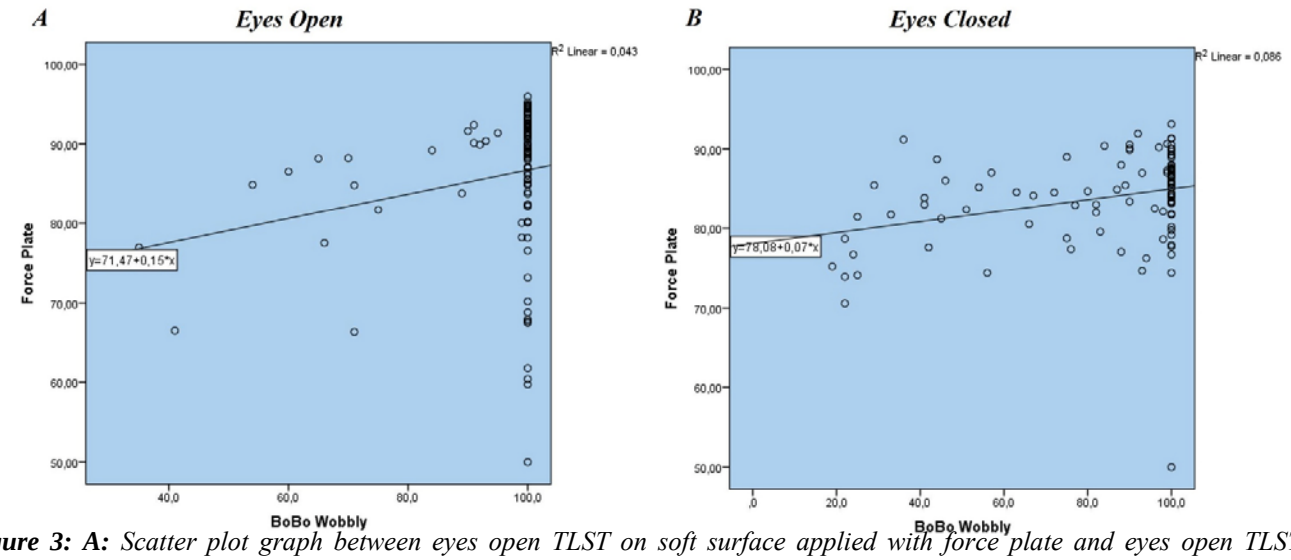


Figure 3: A: *Scatter plot graph between eyes open TLST on soft surface applied with force plate and eyes open TLST applied in BoBo Wobbly. B: Scatter plot between eyes closed TLST on soft surface applied with force plate and eyes closed TLST applied in BoBo Wobbly.*

DISCUSSION

This study, conducted with one hundred healthy participants, investigated the relationship between balance tests performed with the BoBo Wobbly Balance Board and balance tests performed with the force plate platform. Our study detected a weak-to-moderate positive relationship between soft surface eyes open TLST applied with force plate and eyes open TLST applied in BoBo Wobbly and between soft surface eyes closed TLST applied with force plate and eyes closed TLST applied in BoBo Wobbly. The reason why the correlation is not higher can be explained by the fact that both devices evaluate postural stability with different approaches. BoBo Wobbly detects postural stability with a motion sensor, and by its nature, there is a protrusion under the platform so that the balance board can move (Figure 1A). The air balance cushion placed under the platform makes the system more rigid and easy to apply. In force plate platforms, four force sensors are generally used. It analyzes the force on these sensors and thus calculates the CoP. A soft surface can be created if desired by placing a foam pad on the system.

Balance exercises are known to improve postural stability and reduce the risk of falling.[13] BoBo Wobbly evaluates balance in static and dynamic conditions and can be used for rehabilitation with 14 game-based exercises at different difficulty levels. A study reported that exercise programs administered through smart devices increase adherence to the program.[14] However, no study in the literature investigates the therapeutic effect of exercises performed with BoBo Wobbly, and studies on this subject are needed.

It is known that excess weight affects postural stability and causes falls.[15,16] According to the accepted theory, excessive fat accumulation in the body and an increase in BMI change body biomechanics and cause falls.[15,16] Son et al.[15] compared the postural sway amount of obese and normal-weight individuals on a firm and soft surface, with eyes open and closed. The authors found that the eyes-closed TLST performance of obese individuals on firm and soft surfaces was worse than that of individuals with normal weight. Our aim in this study was not to specifically investigate the effect of obesity (BMI≥30) on balance ability. However, according to our hypothesis, the fact that the force plate and Bobo Wobbly systems have a similar relationship with BMI strengthens the relationship between both test systems. It may show that balance can be evaluated with both systems in people with different BMIs. Our study found a relationship between BMI and eyes open OLST on firm surface in the force plate system. In the BoBo Wobbly system, a relationship existed between BMI, eyes-closed TLST, and eyes-open OLST. Our findings show BoBo Wobbly is more sensitive to BMI than force plate platforms. This can be explained by the fact that the BoBo Wobbly board is sensitive to movement/tilt.

In the literature, the effectiveness of some other low-budget balance platforms has been investigated, and their performance has been compared with that of traditional balance platforms. The Nintendo Wii Balance Board is the most important of these platforms.[7,9,11] Park et al.,[11] developed software for the Nintendo Wii Balance Board and evaluated the device's effectiveness with this software. The authors reported that the device had high inter-rater reliability, intra-rater reliability and concurrent validity in terms of COP path length and COP speed. Rohof et al.[7] applied yoga task (tree) and table tilt to individuals using the Nintendo Wii Balance Board and compared the scores of these games with the Sensory Organization Test (SOT). The authors found a relationship between the yoga task (tree) score and SOT. They also stated that the Nintendo Wii Balance Board can be used for postural stability assessment. The Nintendo Wii Balance Board is similar to force plate platforms in terms of its working system (it contains four force sensors). Therefore, it differs from the BoBo Wobbly. However, our study was similar to the study of Rohof et al. in terms of methodology. We investigated the relationship between BoBo Wobbly's balance assessment system and traditional force plate platforms. In future studies, similar to Park et al.'s study, specialized software for balance assessment can

be developed for use with BoBo Wobbly. In this way, the raw data provided by BoBo Wobbly can be accessed, and the relationship between these raw data and other balance platforms can be compared.

The general purpose of balance platforms is to assess postural stability and determine the risk of falling.[17,18] The primary purpose of our study was not to determine a cut-off value for the risk of falling with BoBo Wobby. However, our findings can be considered a pilot study and a study to assess preliminary thresholds for balance assessment (good and poor balance skills) with BoBo Wobby. The median values we determined in our study can be used to determine individuals with good or poor balance skills with BoBo Wobby.

BoBo Wobbly Balance Board can be considered an accessible, low-cost, and portable posturography system that evaluates the postural stability of individuals and follows developments. However, although both platforms (force plate platforms and BoBo Wobbly Balance Board) are designed to assess postural stability and sense of balance, both systems have their measurement approaches. Due to its structure, BoBo Wobbly must move to make measurements. Moreover, since BoBo Wobbly is sensitive to movement, it cannot be applied on fixed surfaces. It can be applied with or without an air balance cushion. For this reason, we think that there is a relationship between the tests performed with BoBo Wobbly and the force plate platforms only when the support surface is soft. This study is the first to indicate that the BoBo Wobbly Balance Board can be used to assess postural stability, and the system's limitations should be considered. In addition, to identify individuals at high risk of falling, the cut-off and normative values must be determined, and the system must be tested for different neurological and vestibular diseases.

This study has some limitations. This study is the first to investigate the relationship between the BoBo Wobbly Balance Board and traditional force plate platforms, and the participants were selected from healthy university students. Therefore, the average age of the participants was low. More studies are needed to investigate the relationship between BoBo Wobbly and general systems in different age groups (especially older individuals) to generalise the findings to the general population. Also, BoBo Wobbly does not provide raw balance data. Therefore, processed data of both platforms are considered.

CONCLUSION

Our findings show a relationship between tests performed with the BoBo Wobbly and force plate tests applied to soft surfaces and that the BoBo Wobbly can be used as a portable, low-cost posturograph to assess balance on soft surfaces. However, further studies are needed to investigate the threshold and normative values of BoBo Wobbly to evaluate the fall risk of individuals.

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Disclosure statement

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