How Many Trials Is Enough To Access Balance On The Biodex Balance System?

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HOW MANY TRIALS IS ENOUGH TO ACCESS BALANCE ON THE BIODEX BALANCE SYSTEM?

ZNANSTVENI RAD/DIPLOMSKI RAD

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SAŽETAK

KOLIKO ČESTICA MJERENJA JE POTREBNO ZA STABILIZACIJU REZULTATA NA BIODEX BALANCE SYSTEM-U?

Prijašnja istraživanja pokazala su da je Biodex Balance System (BBS) pouzdan uređaj za mjerenje dimenzija ravnoteže, ali nema konsenzusa među znanstvenicima koliki je broj čestica mjerenja ili pokušaja potreban kako bi se ispitanik familijarizirao, odnosno upoznao s testovima na BBS-u, pogotovo kada su u pitanju niže razine stabilnosti platforme. Cilj ovog rada je odrediti koliko pokušaja je ispitanicima potrebno kako bi se familijarizirali s testom ravnoteže na BBS-u. Uzorak ispitanika se sastojao od 66 muških (s prosječnih 13.42±0.50 godina) i 57 ženskih (s prosječnih 13.39±0.49 godina) koji nisu aktivni sportaši. Ispitanici su provedeni kroz 3 čestice mjerenja na BBS-u na Postural Stability testu ravnoteže te je promatran parametar Overall Stability Index. U statističkoj analizi korišten je t-test te su rezultati odvojeno promatrani za muške i ženske ispitanike. Statistički značajne razlike dobivene su među sve tri čestice mjerenja za muške ispitanike, dok za ženske ispitanike nije bilo statistički značajne razlike između druge i treće čestice mjerenja. Rezultati ovog rada upućuju da se stabilizacija mjerenja nije dogodila za muške ispitanike što upućuje na potrebu za više od tri pokušaja kako bi se izbjegli negativni utjecaji familijarizacije na rezultate. Za ženske ispitanike rezultati su se stabilizirali već na drugom mjerenju, što upućuje da je ženskim ispitanicima u ovom uzorku potreban samo jedan pokušaj prije testiranja kako bi se familijarizirali s testom ravnoteže na BBS-u. Preporuka za buduće radove jest da se dublje istraži problematika familijarizacije na testu ravnoteže na BBS-u i utvrdi koliko čestica mjerenja je potrebno dati da se rezultati stabiliziraju na ovakvom uzorku. Dobiveni rezultati mogu biti od važnosti za buduća istraživanja sa sličnim ženskim uzorkom ispitanika kako bi se smanjilo vrijeme testiranja te se proveo samo jedan familijarizacijski test, jer testiranje na BBS-u zahtjeva značajnu količinu vremena.

Ključne riječi: familijarizacija, utjecaji učenja, ravnoteža, adolescenti, testiranje, t-test

ABSTRACT

HOW MANY TRIALS IS ENOUGH TO ACCESS BALANCE ON THE BIODEX BALANCE SYSTEM?

While the Biodex Balance System (BBS) proved to be a reliable apparatus for testing balance, there is lacking evidence on the number of familiarization trials the subject must undergo before being tested, especially when lower stability levels are used on the BBS. The goal of this study was to determine after how many attempts the result of the balance test on the BBS stabilize. The sample consisted of 66 boys (13.42±0.50 years old) and 57 girls (13.39±0.49 years old) not active in sports. The subjects underwent the Postural Stability Test three times and the Overall Stability Index variable of the BBS was examined. In the analysis the results were separately examined for boys and girls using the t-test. Significant differences were found in all three measurements for boys while for girls there was no significant difference between the second and third measurement. The results of this study indicate that, for boys of this age, the results did not stabilize through the three trials conducted which could mean a need for more than three attempts so the negative effects of familiarization could be avoided. For girls it seems that the result stabilized at the second trial which could indicate that only one trial is needed for them to familiarize themselves with the test. These findings can be important for future studies with a similar female sample to save time and conduct just one test trial before the actual testing, since testing balance on the BBS requires a significant amount of time.

Key words: familiarization, learning effects, balance, adolescents, testing, t-test

Introduction

Although there is no universal definition of balance and postural control among scholars, one mechanical definition reads that the state of an object with the resultant forces acting upon it equal to zero can be defined as balance (Pollock, Durward, Rowe, & Paul, 2000). Human balance, simply, could be therefore defined as the person's ability to not fall (Pollock et al., 2000). Postural control could be defined as the act of maintaining, achieving or restoring a state of balance during activity (Pollock et al., 2000). Strong evidence shows that the postural control and balance system develops during childhood and adolescent age, where young children before the age of 6 mostly rely on their visual and vestibular system and later more towards a somatosensory and vestibular control (Wälchli et al., 2018). In today's children it has become increasingly important to address insufficiencies in balance and postural control to prevent musculoskeletal pathologies (Azevedo, Ribeiro, & Machado, 2022). The training of balance proved to be effective in improving dynamic balance as well as maintaining static posture with applied oscillations in athletes and nonathletes (Zech et al., 2010). In clinical testing, a widely spread tool for assessing balance and postural control is the Biodex Balance System (BBS) that can provide relevant measures of the aforementioned motor skills (Cug & Wikstrom, 2014). The BBS proved to be a reliable and acceptable tool for clinical screening of balance capabilities (Hinman, 2000). However, some studies indicate a need for familiarization in one session testing on the BBS to mitigate learning effects that cause a disruption in the data interpretation (Cug & Wikstrom, 2014; Garcia et al., 2017). The amount of familiarization needed on the BBS varies from one author to another, where authors used two familiarization trials on twenty one healthy female adults aged 22.8±1.0 (Pereira et al., 2008), three familiarization trials on twenty sedentary university students (11 male aged 22±2.24 years old and 9 female aged 20.88±1.16 years old) (Cug & Wikstrom, 2014) and five familiarization trials on nineteen healthy university students aged 24.4±4.2 years old (Schmitz & Arnold, 1998). Given a lower stability level on the BBS, learning effects may be seen even at six trials on ten healthy non-athletic adults aged 25.0±1.74 years old (Bagheri, Sarmadi, & Arani, 2012). Authors of this paper could not find previous studies related to the effects of familiarization on the BBS in the population observed in this research. Previous studies also seem to be inconsistent regarding the amount of familiarization trials needed on different populations when testing balance on the BBS. In relation to this, the aim of this

research was to study the effects of familiarization on the BBS in adolescents during early and ongoing puberty.

Methods

Participants

All of the participants in this study (N=123; 66 males with an average age of 13.42±0.50 years old and 57 females with an average age of 13.39±0.49 years old) are students of the 7th and 8th grades (13-14 years of age) in Croatian elementary schools in Split. The participants that are included in this study have their legal guardians consent to participate in the study. The study was approved by the ethics committee of the University of Split, Faculty of Kinesiology (Approval number: 2181-205-02-05-22-0021; Approval date: 24.04.2022.).

Measurements

The measurement apparatus used for assessing balance was the BBS, which studies proved to be a reliable tool for assessing balance (Cachupe, Shifflett, & Wughalter, 2001; Parraca et al., 2011) and the observed variable for balance on the BBS was the Overall Stability Index (OSI) using the Postural Stability Test (PST). Due to the nature and the aim of this study (regarding familiarization) it is important that the participants were not familiar with the BBS and the specific balance test. The goal of the PST for the participants was to maintain balance on the dynamic platform. More specifically, the goal was to have the dot displayed on the BBS screen (which was the live representation of the projection of their center of mass on the platform) to stay in the center with as little deviation from it as possible. When the participants first step on the BBS platform, they were instructed to have a comfortable shoulder width stance with as a symmetrical stance as it was possible to achieve. The measurer then blocks the view of the display from the participants and adjusts the participants forward or backwards so that the dot on the BBS display is in the center. In this process it is important that the participant moves forward to correct the starting stance instead of leaning. When this was achieved, the measurer then lets the participants see the display in front of them and explains the goal of the PST. The participants went through three trials of the PST each lasting 20 seconds and with 10 seconds of pause in between trials. The stability level was selected to be 9 out of 12 (1 being the least stable and 12 being the most stable). All the three trials were done barefoot. Anthropometric measurements of body height and body mass were measured three times and the arithmetic mean of all three measurements was used as the representative body height and body mass of each participant.

Statistics

Descriptive statistics was applied to the variables: body height, body mass and OSI. The parameters observed for these variables were: number of valid participants, arithmetic mean, standard deviation, minimum, maximum, Kolmogorov Smirnov test, p-value. The t-test statistical analysis for dependent samples was applied to measure the statistical differences between each of the three trials (OSI1, OSI2 and OSI3). Significance level was set to 0.05. All statistical analyses were done separately on male and female subjects using the STATISTICA 14 by StatSoft (Europe) GmbH.

Results

The results of the descriptive statistical analysis (Tables 1 and 2) describe the participants in regards to their body height, and body mass. The number of valid male participants in this study is 66 (N=66) with the average body height of 170.48±7.80 centimeters, and average body mass of 61.64±13.5 kilograms. The number of valid female participants in this study is 57 (N=57) with the average body height of 165.99±5.35 centimeters, and average body mass of 56.28±9.97 kilograms. The Kolmogorov-Smirnov normality test indicates a normal distribution for the male participants in their body height and body mass ($p>0.20$), while the variable OSI is not normally distributed ($p<0.01$). The same can be observed with the female subjects in regards to the normal distribution of body height and body mass ($p>0.20$) as well as for the variable OSI ($p<0.10$).

Table 1. Descriptive Statistics For Boys

V	N	Mean+SD	MIN	MAX	KS	p
BH (cm)	66	170.48±7.80	151.00	185.33	0.07	p>0.20
BM (kg)	66	61.64±13.51	36.30	94.50	0.10	p>0.20

Note. V – variable; N – number of valid participants; Mean – arithmetic mean; SD – standard deviation; MIN – minimum; MAX – maximum; KS – Kolmogorov Smirnov test; p – p-value; BH - body height; BM - body mass.

Table 2. Descriptive Statistics For Girls

V	N	Mean+SD	MIN	MAX	KS	p
BH (cm)	57	165.99±5.35	152.00	178.50	0.10	p>0.20
BM (kg)	57	56.28±9.97	32.40	83.00	0.13	p>0.20

Note. V – variable; N – number of valid participants; Mean – arithmetic mean; SD – standard deviation; MIN – minimum; MAX – maximum; KS – Kolmogorov Smirnov test; p – p-value; BH - body height; BM - body mass.

The results of the t-test statistical analysis (Tables 3 and 4) show the differences between the three trials on the PST (observing the OSI variable), separately for male and female participants. Statistically significant differences can be observed in all the comparisons between trials in male and female participants except between the second and third trial in the female participant group (p=0.123).

Table 3. Statistical Analysis (t-test) For The Boys

V	N	Mean+SD	T	P	CI-95	CI+95
OSI1	66	1.27±1.18	2.889	0.005	0.042	0.228
OSI2		1.14±0.98				
OSI2	66	1.14±0.98	2.261	0.027	0.009	0.148
OSI3		1.06±0.81				
OSI1	66	1.27±1.18	3.571	0.001	0.094	0.333
OSI3		1.06±0.81				

Note. V – variable; N – number of valid participants; Mean – arithmetic mean; SD – standard deviation; T - t-test result; P – p-value; CI-95 – confidence interval of -95%; CI+95 - confidence interval of +95%; OSI1 - overall stability index (first trial); OSI2 - overall stability index (second trial); OSI3 - overall stability index (third trial)

Table 4. Statistical Analysis (t-test) For The Girls

V	N	Mean+SD	T	P	CI-95	CI+95
OSI1	57	0.90±0.40	2.313	0.024	0.012	0.170
OSI2		0.81±0.36				
OSI2	57	0.81±0.36	1.565	0.123	-0.017	0.136
OSI3		0.75±0.26				
OSI1	57	0.90±0.40	3.608	0.001	0.067	0.235
OSI3		0.75±0.26				

Note. V – variable; N – number of valid participants; Mean – arithmetic mean; SD – standard deviation; T - t-test result; P – p-value; CI-95 – confidence interval of -95%; CI+95 - confidence interval of +95%; OSI1 - overall stability index (first trial); OSI2 - overall stability index (second trial); OSI3 - overall stability index (third trial).

Discussion

When observing the results and the variable OSI, it is important to identify that the number representing OSI and test performance are inversely correlated. Meaning, the lower the OSI the better the performance on the test because OSI represents displacement from a level platform position in degrees. It is somewhat clear that the female participants have better performance overall on the PST in comparison to the boys. This is confirmed when observing the t-test analysis (the first and also on average the worst trial for the female participants is 0.90±0.40 while for the male participants the third and on average the best attempt is 1.06±0.81). Although, previous a study suggests small differences between genders in balance performance in adolescents and account for the differences being due to other factors as well (Valtr, Psotta & Abdollahipour, 2016). For the male participants significant differences were shown across all three trials. This indicates that the results on the PST did not stabilize and the male participants may have not been familiarized with the test by the third trial (test performance was significantly improved after each trial). Authors in previous research in different motor skills have acknowledged the utilization of familiarization trials and its importance in minimizing disturbance of data caused by this effect (Glaister et al., 2009). Utilization of familiarization trials has shown to be most beneficial in testing motor skills such as agility, muscular endurance and balance (Coledam & de Oliveira, 2020). Moreover, more research is needed on how many trials are enough for the results to stabilize on the BBS using the PST for the male population aged 13-14 years old on different stability levels on the BBS since in this study three trials were not enough for the results to stabilize and as of the knowledge of the authors of this paper, no studies have examined the familiarization effects on the BBS in this population group. For the female participants it seems that after only one trial the results on the PST stabilize. The reason for these gender differences can only be speculated. In regards to this, the authors of this paper recommend that future studies take into consideration if there are significant differences between variables or groups for choosing the appropriate method of condensing the results for

statistical analysis. Further research should also take into consideration the learning effects on the BBS with lower stability levels since this was not observed in this paper. The amount of familiarization trials varies in different studies, regarding balance and the BBS, with a different population observed and different platform instability levels used (Schmitz & Arnold, 1998; Pereira et al., 2008; Bagheri et al., 2012; Basar et al., 2012; Cug & Wikstrom, 2014). Finding studies with a similar population using the same instability level on the BBS has shown to be difficult because BBS has 12 different instability levels as well as a static level. Older versions of the BBS have 8 levels of instability and not 12 as the newer models (Schmitz & Arnold, 1998; Cachupe et al., 2001). Studies using the BBS tend to not give information if the subjects are already familiar with the apparatus or is this their first time being exposed to it (Inanir, Cakmak, Hisim & Demirturk, 2014; Sung & Kim, 2018). Some studies specify they used familiarization trials on the BBS but do not specify exactly how many trials and in what length (Hobbs, 2008).

Limitations of the study

The small number of measurement trials in men may represent a limitation of this study, as it was not possible to obtain stabilization of the results through (only) three trials. Therefore, it cannot be concluded how many trials men of this age need to familiarize themselves with this test. For future studies, the authors of this study recommend taking these findings into account when exploring balance on the BBS for the male population as they may disrupt the validity of the results if the learning effects are not taken into consideration. Also, it would be useful to investigate after how many attempts the effects of familiarization are not significant any more in men. Furthermore, differences in body height and mass between genders could have also played a factor since the morphological characteristics seem to have influence over balance results (Greve, Alonso, Bordini, & Camanho, 2008; Ku, Abu Osman, Yusof & Wan Abas, 2012). These differences could be seen when observing Table 1 and Table 2, but those characteristics were not included in the analysis since this is not in the scope of this study so further studies could take this into consideration when setting up their research.

Conclusion

To summarize, the BBS has shown to be a reliable tool for assessing balance and postural control, but authors should not underestimate the importance of familiarization with the BBS

when subjects are exposed to it for the first time. This paper focused on discovering if familiarization effects are present when testing on the BBS and how much of an effect it could have on the results. If studies involving the PST on the BBS do not take familiarization into consideration, the interpretation of results could be inaccurate, in other words, relations between balance and some other variable(s) are questionable. The female participants had better performance on the BBS and only one familiarization trial seems to be enough for them to get stable results on the BBS. These findings could be important for future studies involving a similar female sample to save time since testing and using the BBS can be a long and complicated process. Results for the male participants did not stabilize so more research is needed to conclude on how many familiarization trials are needed for the results to stabilize. Further, the authors of this paper recommend future studies to first see if there are significant differences between measurements and depending on that should choose the appropriate method of condensing the results.

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