International Journal of Sport Culture and Science
June 2021 : 9(2)
ISSN : 2148-1148
Doi : 10.14486/IntJSCS.2021.640

Reliability of Biomechanical Balance Platform Device Measurements

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Type: Research Article (Received:22.06.2021– Accepted: 06.07.2021)

Abstract

Background: Ankle inversion injures are frequently encountered in Sport and most time players go back to sport with some residual deficits in ankle joint like instability and inefficient motor control of the ankle segment. For prevention some balance tests and digital balance devices are used to improve motor control ankle segment and balance skill. But in these approaches, balance tests are not effective and digital devices are not affordable in general usage. Biomechanical Balance Platform Device (BBPD) is designed to measure reaction time of motions of the ankle segment during dynamic balance performance to monitor motor control of ankle segment. The aim of the study is to assess internal consistency of the measurements obtained from BBPD to determine reliability of the device.

Participants: Twenty athletes (19,2 ± 1,1 years) participated the study. Three measurement sessions were organized two days apart. It was told to the participants not to perform exercise with high intensity (non-tiring activity) until measurements complete.

Results: In statistical analyzing the interclass correlation coefficient (ICC) was used for estimating internal consistency of the measurements of tree trials. In determining best result of reaction time score, the Cronbach's Alpha (CA) was 0,89 value, in number of reaction movements the CA was 0,92 value. So the reliability of the device determined as highly reliable.

Discussions: The aim of the study was to determine level of the reliability of the BBPD. In the light of the results BBPD can be used as a rehabilitation or training device to rehabilitate injured athletes and to get athletes improve motor control in order not to encounter ankle injuries.

Keywords: Reaction Time, Ankle, Inversion Injuries.

Introduction

Lateral ankle ligament sprains (inversion injuries) are in the most common injuries seen in sport (Gribble, et al., 2010; Waterman, et al., 2010). After injury most symptoms like edema, proprioceptive deficit and muscle weakness are rehabilitated but frequently ankle instability called as functional ankle instability which results in secondary injuries for athletes remains (Lentell, Katzmann, & Walters, 1990; Hertel, 2008; Mackenzie, Herzog, Kerr, & Marshall, 2019; Fousekis, Tsepis, & Vagenas, 2012; Katzmann & Walters, 1990). Instant motor control loss of the ankle joint during physical activity is the main factor in the pathomechanics of the injury. So the studies have been designed to improve motor control of the ankle segment to prevent the injury (Konradsen, 2002a; Martin, et al., 2021; Bertrand-Charette, Dambreville, Bouyer, & Roy, 2020).

Motor control means to elicit proper muscle contractions after sensorial inputs. If any deficit occurs in muscle strength, biomechanics alignment of a joint, gait mechanics or reaction time parameters, inefficient motor control let the joint structures exposed to high stresses and injury occurs during physical activity (Milgrom, Shlamkovitch, & Finestone, 1991; Tyler, McHugh, Mirabella, Mullaney, & Nicholas, 2006; Chomiak, Junge, Peterson, & Dvorak, 2000). In the pathomechanics of the inversion injury, during landing on the ground after jumping or running on the playground, motor control is lost instantly and ankle joint remains in the position of plantar flexion and inversion. In that position, ground reaction forces aren't met by muscles and lateral ankle ligaments are damaged. In this situation, ankle dorsal flexion and eversion elicited in time are needed muscular actions to avoid this type of injuries (Baumhauer, Alosa, Renström, Trevino, & Beynnon, 1995; Beynnon, Renström, Alosa, Baumhauer, & Vacek, 2001).

Many balance tests and devices are used in sport and rehabilitation process to prevent inversion injuries or to determine risk factors (Filipa, Byrnes, Paterno, Myer, & Hewett, 2010; Hartley, Hoch, & Boling, 2018; Namazi, Zarei, Hovanloo, & Abbasi, 2019). The main purpose of these approaches is to evaluate and improve balance skill and motor control of the athletes (Gabbe, Finch, Wajswelner, & Bennell, 2004). But these methods are time-consuming or expensive. In this regard, the aim of the BBPD is to measure the reaction time of the ankle muscles practically, to evaluate specifically motor control of the ankle segment under dynamic balance performance and to present a low cost way for motor control test or training device to be used in specific fields regarding sport. In the study the reliability of the device was assessed and the content of the device was discussed.

Material and Methods

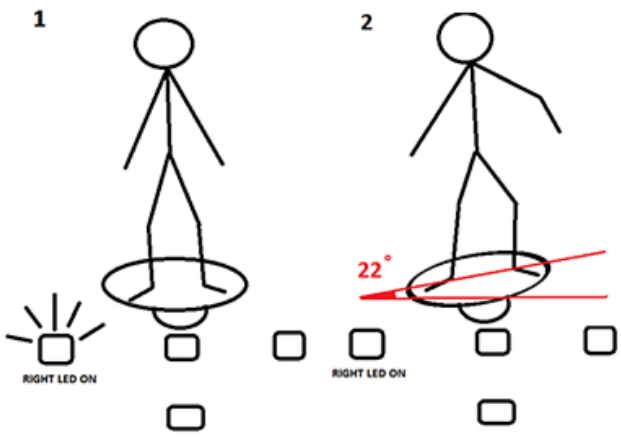
Participants

Twenty female (n: 10) and male (n: 10) amateur soccer players that have been studying in Duzce University participated in the study voluntarily. The exclusion criterion of the study is

to have a lower extremity injury, vestibular or visual problems in the 6 months before the study. All information about the scope of the study was given to the participants before the study. It was told that they shouldn't use any alcohol, make high intensity physical activity during the process of the study (4 days) and get any food intake in 2 hours before test application. The measurements of the study were conducted test in Duzce University Biomechanics Laboratory. The study was approved by Ethics Committee of Duzce University with the number of 2021/10 permission.

Procedure

Tanita SC-330 device was used for body composition and Seca brand stadiometre for height measurements. (Barbosa, Barros, Post, Waitzberg, & Heymsfield, 2003). BBPD consists of five components; a wooden balance board with 42 cm diameter -10 cm height, a MPU-6050 3 Axis Gyro Sensor Module which is sending signals about slope of the board, an Arduino Uno microcontroller board with ATmega328P chip between the balance board and computer, 4 led stand indicators having a arrow mark and a computer program. The guideline of the device is to measure ankle reaction times of an athlete standing on the balance board up in 30 seconds. Every led stand indicates four directions; back, front, right and left. The led stands are placed in front of the balance board and there is one meter and 70 degrees between right and left led stand from the pivot point of balance board, one-meter distance between back and front led stands. An athlete is placed over balance board. After set time starts, randomly selected led gets on. If led stand indicates back, the athlete makes dorsal flexion with ankle and gets the board sloped 22 degree rearwards or if a led stand indicates right, the athlete gets the board sloped 22 degrees toward right making ankle plantar flexion and inversion. When the board reaches intended slope, the led is off and the micro controller measures time between led on and off. For a new indicator to be on, the athlete should get the board 0 degree with the ground. After 30 seconds the test is over and the computer program monitors how many leds are on during the test and which is the best result.



Picture 1. A sectional view from measurement

Statistical Analysis

The recorded data were evaluated using IBM SPSS version 22 computer program. The reliability of the device was assessed using intraclass correlation coefficient calculated between the scores of three measurement sessions.The p significance value was determined as below 0.05.

Findings

Table 1. Demographic characteristics of the participants

	Body Weight (Kg, ± Std)	Body Height (Cm, ± Std)	Age (Years ± Std)
n=20	71±11,7	176,40±6,3	19,2±1,1

Std: Standard Deviation

Table 2. Mean reaction time scores of the three different tests

	n	Minumum	Maximum	Mean (second)	Std.	CA value	Sig. value
First Test	20	0,96	3,21	1,43	0,4		
Second Test	20	0,99	2,13	1,4	0,2	0,89	0,00*
Third Test	20	0,97	3,00	1,3	0,4		

Std: Standard Deviation, CA: Cronbach's Alpha, * : Significant level

Table 3. Mean number of reaction movements of the three different tests

	n	Minumum	Maximum	Mean (number)	Std.	CA value	Sig. value
First Test	20	17	30	20	3		
Second Test	20	15	29	20	3	0,92	0,00*
Third Test	20	17	29	22	3		

Std: Standard Deviation, CA: Cronbach's Alpha, * : Significant

In table 2 and 3, the scores of Biomechanic Balance Platform Device mesurements on reaction time and number of reaction movements between tests seems consistent according Cronbach-alpha coefficient values.

Discussion and Conclusion

Ankle injuries especially inversion injuries change normal biomechanics of the subthalar joint due to damaged ligaments which are passive stabilizers of the joints not to exceed normal range of motion. As a normal parameter subthalar joint tilt doesn't range to 23 degrees (Rubin, & Witten, 1960; Cox, & Hewes, 1979). After treatment the mechanical instability of the subthalar joint remains as a residual symptom (Hertel, Denegar, Monroe, & Stokes, 1999). During rehabilitation process disc training computerized or manual is the commonly-used methods for injured athlete to overcome mechanical instability and improve motor control of the ankle segment (Fusco, 2020; Verhagen, Van der Beek, Twisk, Bouter, Bahr, & Van Mechelen, 2004). Thus the muscles controlling ankle segment gains efficient motor reaction skill in perturbations of the segment during physical activities (Osborn, 2001). Balance deficit is seen as a risk factor for ankle injuries and for prevention some approaches are used to improve balance skill (McHugh, Tyler, Tetro, Mullaney, & Nicholas, 2006; Trojian, &

McKeag, 2006; McGuine, & Keene, 2006). Especially the balance board usage is highly popular and effective in training and rehabilitation field (Verhagen, 2004; Söderman, Werner, Pietilä, Engström, & Alfredson, 2000). Biodex Stability System is another option for measurement of balance skill and training but it is expensive and not affordable for many sport clubs and rehabilitation units (Arnold, & Schmitz, 1998; Testerman, & Griend, 1999). In the light of all these informations, the BBPD was designed to measure dynamic balance and motor control of ankle segment in a practical and low-cost way. The components of the BBPD are at an affordable price and the software is open-source. The measurement time was determined as 30 seconds due to performing movements with high velocity on a balance board requires fast energy consumption way and creates fatigue (Westerblad, Bruton, & Katz, 2010). So it is not intended for an athlete to get tired during measurement. To measure reaction time is prominent characteristic of the device. For example when a led stand is on for an intended inversion movement, participant should have to tilt the board in the slope of 22 degree as fast as possible. 22 degree is determined because it is the last degree of the subthalar joint in normal biomechanical range. How many a participant elicit reaction movements in 30 seconds or reacted the light stimulus as much as quick are parameters of the evaluation concept. Near that if the BBPD can be used in training for motor control of the segment, to train athlete for a fast neuromuscular reaction in a safe range of motion. In 30 seconds to get the leds off as much as quick is an indicator of the dynamic balance skill. So the BBPD is used for a balance training to keep athletes away from ankle injuries monitoring their balance skill with numbers. The aim of the study is to assess the reliability of BBPD evaluating the consistent of the scores obtained after three measurements. Value of the cronbach alpha coefficient determined as good. So BBPD is an option for people working in sport and rehabilitation field as a reliable device to measure and improve motor control of an athlete.

Conflict of Interest

There is no conflict of interest intellectually or financially.

Funding

No funding to declare.

*The study was derived from the PhD thesis of A Digitial Biomechanic Test and Training Platform for Prevention and Rehabilitation of Ankle Injuries in Athletes.

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