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Short title: *Stability in Women with Knee Osteoarthritis*

Reproducibility of the dynamic balance test of lower limbs with reduction of the body weight in individuals with knee osteoarthritis

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The dynamic balance of the lower limbs has shown great importance in the accomplishment of activities of daily living, especially for walking and maintenance in the orthostatic position. In this context, individuals with knee osteoarthritis have changes in their physical capacity, mainly due to joint changes and muscular wear. The instrument called OctoBalance® is one of the most used for the evaluation of this balance, which analyzes four different executions of movement in the limbs. However, individuals with knee osteoarthritis cannot perform this eva-luation due to the need for single limb support during movements. Objective: To verify whether it is reproducible to perform the dynamic balance evaluation of lower limbs with a re-duction of 10% of body weight through a suspension system. Methods: A cross-sectional study was carried out with 2 collections with a 48-hour interval between them, using the Lower Bo-dy Test performed with OctoBalance®. The dynamic balance test followed the protocol of 3 re-petitions observing the learning factor and then 3 repetitions where the values were collected, for all 4 diagonals in both limbs, with the suggested adaptation. The interclass correlation in-dex (ICI), coefficient of variation (CV), estimative standard error (EEE) and minimum detecta-ble difference (MDD) were calculated as indicators of reproducibility. Also, Bland-Altman Gra-phs were used for visual verification of the agreement between the means. Results: The reliabi-lity tests showed a very high interclass correlation through the ICI, and low variation values for all the movements evaluated through the CV. The EEE and MDD calculations showed posi-tive responses for greater reliability, and the Bland-Altman graphs showed an agreement between the means. Conclusion: Reproducibility was positive for Lower Body Test with the Octobalance® platform for the evaluation of lower limb dynamic balance in women with knee osteoarthritis.

Keyword: Knee Osteoarthritis, Balance Test, Reproducibility.

INTRODUCTION

For a good dynamic balance, the integrity structures of the body are necessary, such as bone, cartilage, ligaments and efficient performance of stabilizing muscle structures. A deficit in some of these structures may gene-rate a change in dynamic balance. To evaluate this balance, the literature has some functional tests such as the Timed Up and Go (TUG) and the Berg Balance Scale that are widely used for balance evaluation, besides the pressure platforms (Kim, et al., 2011).

Also, another widely used instrument is the Star Excursion Balance Test (SEBT), measuring the dynamic balance and quantifying muscle control deficits related to musculoskeletal diseases (Gribble, Hertel, & Plisky, 2012). More recently, the Octobalance® platform has been used to evaluate the dynamic balance of lower limbs. This instrument analyzes five different movements of the lower limbs with single limb support to measure the maximum distance reached, resulting in values that qualify their balance (Gonzalo Skok, Serna, Rhea, & Marín, 2017) (Gonzalo Skok, . Serna, Rhea, & Marín, 2015). These instruments are used in the general population without any comorbidity and it is believed that some health conditions may generate changes in the dynamic balance by influencing body structures such as knee osteoarthritis.

Osteoarthritis (OA) is a degenerative joint disorder with musculoskeletal implications. Its symptoms range from joint pain to crunching, edema (Burgos-Vargas, et al., 2014) and muscle weakness (Minshull & Gleeson, 2017). However, pain is considered the main limiting factor for this condition, directly affecting the activities of daily living (ADL), reducing the quality of life and generating biopsychosocial impacts (Coudeyre E. , et al., 2016).

Considered as the main cause of musculoskeletal disability in the world, OA has multifactorial etiology that may be idiopathic or arise from traumas, congenital formations, postoperative, aseptic osteonecrosis, and metabolic, endocrine and postural disorders that generate direct impact between the joint degeneration and its synthesis (Loures, Góes, Labronici, Barretto, & Olej, 2016).

The knee joint is the most commonly affected (Burgos-Vargas, et al., 2014), which is essential for weight support and balance maintenance. Individuals with osteoarthritis have a higher proprioceptive loss when compared to people of the same age without the disease (Kim, et al., 2011) (Tamura, et al., 2016), increasing the risk of falls and consequent morbidity (Kim, et al., 2011) (Takacs, Krowchuk, Goldsmith, & Hunt, 2017). Also, it is known that the deficit of muscle strength, especially of the quadriceps, causes important changes in the knee, contributing to the loss of functionality, in which the reduction of dynamic balance is within this functionality (Alnahdi, Zeni, & Snyder-Mackler, 2012).

Directed evaluations are necessary to receive clinically relevant information. There-fore, the Lower body test is highlighted, that is an adaptation of the SEBT with the insertion of a platform and a cart. However, the execution of this test with people with knee osteoarthritis is not feasible due to the difficulty of the total discharge of weight in a single member, as in the initial protocol. Those people with osteoarthritis have difficulty remaining in single limb support since overloading on only one joint can cause an increase in symptoms, especially pain (McAlindon, et al., 2014). Also, because of the deficits of this population, adaptations are necessary so important clinical information is not neglected (Martins, Gonçalves, Mayer, & Schiviski, 2014) (Kanko, et al., 2019).

These individuals have difficulty remaining in a single limb position due to all the joint wear and reduction of the strength of the supporting muscles. This deficit is a barrier in the evaluation of the dynamic balance, so a weight-bearing system was developed for partial reduction of the body weight when doing the evaluated movements. Thus, the hypothesis of this study is that the suggested adaptations, with the partial discharge of body weight with a suspension system, make the test feasible and with good reproducibility.

METHODS

This is a cross-sectional study aimed at evaluating the reproducibility of the Lower Body Test (LBT) through the OctoBalance® (Check your MOtion, Albacete, Spain) with partial reduction of body weight through suspension system in individuals with knee Osteoarthritis.

Sample

Thirty women with a previous diagnosis of knee osteoarthritis were selected. They were screened in an orthopedic outpatient clinic and classified by x-ray between grades 2 and 4, according to Alback's classification (Ahlbäck, Osteoarthrosis of the knee. A radiographic investigation., 1968) (Keyes, Carr, Miller, & Goodfelow, 1992).

Female individuals, aged between 30 and 80 years old, who presented their cognitive functions preserved and availability for the evaluation days were included in the study. Those women who did not agree with the ICF; with previous surgical procedures in the knee or a current indication and that they were not able to carry out the evaluations were excluded from the study. The data collection only started after approval by the Ethics Committee in Research with Hu-man Subjects (CEP) of the Federal University of Sergipe (FUS). CAAE: 06219219.3.0000.5546.

Two days of testing were performed, with a 48-hour interval between them, to determine the reproducibility of the test with body weight reduction in individuals with knee osteoarthritis. Participants were also asked not to perform physical activities in the 24 hours before the sessions, so there was no influence of fatigue on the uptake of values (Cramer, et al., 2017).

Procedures

The participants were characterized according to age, weight, height, body mass index (BMI, kg/m2), and the graduation of knee osteoarthritis according to Alback.

The Lower Body Test was performed using the OctoBalance® (Check your Motion, Albacete, Spain). It is a multidirectional dynamic balance evaluation instrument using colored arrows to indicate the directions to be evaluated and a metric scale to verify the distance reached in each one (Figure 2). Also, the instrument enables to observe compensations or deviations during the movement since the magnets that connect the platform with the metric scale are sensitive to excessive displacements.

Figure 1: Octobalance®

Following the protocol, the length of the lower limbs was measured before the test, with the patients in the orthostatic position, using a tape measure, following the reference of the anterosuperior iliac crest to the medial malleolus. The limb length was used to normalize the measurements of the OctoBalance® (Gonzalo-Skok,. Serna, Rhea, & Marín, 2015) (Gonzalo-Skok, Serna, Rhea, & Marín, 2017).

Before the test, the patients were instructed on the evaluation process. Three measures were taken in each diagonal of familiarization of the movements, respecting a rest of 30 seconds between them. Then, three more measurements were performed, and all these values were used as results.

The evaluation was performed in four diagonals for each member: 1) Anterior; 2) Medial; 3) Posteromedial; 4) Posterolateral. For the initial performance of the tests, a distance of 20 centimeters was adopted, being able to be reduced to 10 centimeters for those that presented more difficulties.

For greater fidelity, the evaluations were carried out by a single evaluator and an assistant was responsible to write the values in an evaluation form. Through the three replicates of each diagonal, the final values were calculated, in which the average of the values collected in each direction was divided by the length of the member corresponding to each side evaluated, and finally multiplied by 100.

$$LBT = \left(\frac{((r1 + r2 + r3)/3)}{LL}\right)x100$$

The equation shows the LBT representing the range value, relative to the length of the evaluated lower limb, “r” is the range value for each repetition, and LL is the length of the lower limb.

Suspension System

The suspension system was created after no success in previous attempts made to perform the test with this population due to all the difficulties presented by them. This problem has suggested the creation of a sus-pension system.

This system has two pulleys fixed to the ceiling with a rope of support, with a distance of one meter between them. At one end of the rope, there is an adjustable vest to be worn by the patient and at the other end, there is a weight of 10% of the body weight placed in the form of washers. Figure 2 shows the scheme used for the suspension system.

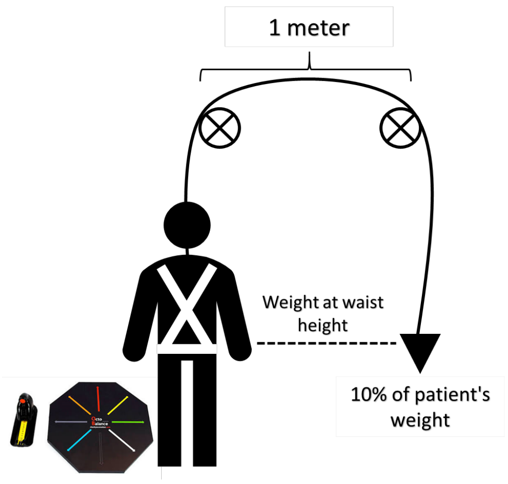


Figure 2: Scheme showing how the body weight reduction system with weight suspension was performed.

Initially, the patients remained in the orthostatic position and they were instructed to leave their hands on their waist so they did not interfere with the upper limbs during the evaluation. The evaluation was done with the movement of the lower limb contralateral to what was being evaluated, pushing the metric scale to the maximum distance reached. First, the right lower limb was evaluated, followed by the left one, with an interval of 1 minute between them. In this way, when the right lower limb was evaluated, it remained in contact with the platform, with support on the black arrow of OctoBalance® (OctoBalance, Check your MOtion, Albacete, Spain) and the left limb performed the diagonals anterior movement (red arrow), medial movement (gray arrow), posteromedial movement (blue arrow) and posterolateral (white arrow).

The test was considered invalid when the patient did not obey the following recommendations: 1) do not push the platform abruptly; 2) maintain the balance during the test and be able to return to the initial position; 3) keep the movement rectilinear and diagonally, not loosening the movable plat-form; 4) keep the hand at waist height; 5) remain the heel of the evaluated limb always supported on the platform.

Statistical analysis

The SPSS software version 22.0 was used for the statistical tests. The data collected were expressed by the mean and standard deviation. The Shapiro-Wilk test was per-formed to verify normality. Student's T-Test was performed to verify the possibility of a difference between the groups and to de-characterize the reproducibility. As for indicators of reproducibility, the interclass correlation index (ICI) was calculated, using the calculation suggested by Koo & Li, 2016 (Koo & Li, 2016). ICI values were considered small when presented up to 0.25, considered low when presented between 0.26 and 0.49, considered moderate between 0.50 and 0.69, considered high between 0.70 and 0.89 and considered very high above 0.90, according to a previous study (Jonson & Gross, 1997). The calculation of the Coefficient of Variation was performed according to the Wang 2002 study with the following formula: SD = standard deviation (diff)/mean (av1)*100 (Wang, Olson, & Protas, 2002). For the calculation of the estimated standard error (EEE), the equation $EEE = SD \times \sqrt{(1 - ICI)}$ and the mini-mum detectable change (MDD) with 95% confidence interval by the equation $MDD = 1{,}96 \times \sqrt{(2 \times EEE)}$. Bland-Altman Graphs were used for visual verification of the agreement between the means. The value of $p<0.05$ was adopted as statistical significance.

RESULTS

A total of 30 female individuals with a diagnosis of knee osteoarthritis (age = 59.7 ± 11.1 years old, body weight = 76.2 ± 15.2 kg, height = 1.6 ± 0.1 m and body mass index = 30.7 ± 6.6) participated in the research. The evaluations performed between the first and second day showed no difference in the statistics performed (p-value between 0.09 and 0.84), showing that the learning effect was contemplated previously.

The flowchart of the individuals is shown below.

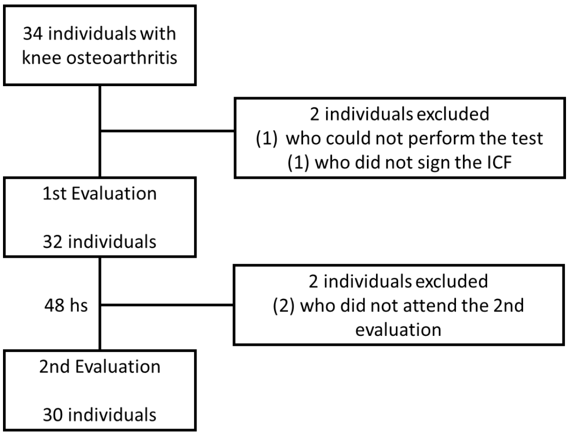
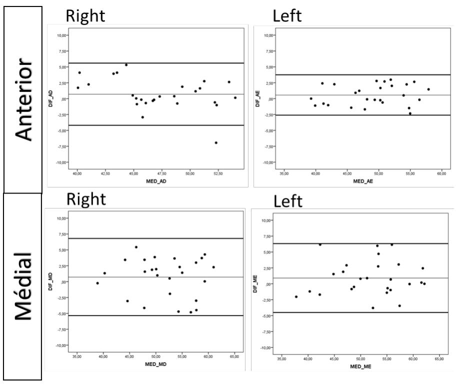


Figure 3: Volunteer flowchart

The reliability tests performed demonstrated a very high interclass correlation through the ICI, and through CV values with a low variation for all the movements evaluated. The EEE and MDD calculations showed positive responses for greater reliability. The values are shown in table 1.

The Bland-Altman graphs showed agreement between the means, which are presented in Figure 4. A bias range close to zero and an acceptable agreement interval between the evaluations and practically all patients evaluated within the confidence limits were observed.



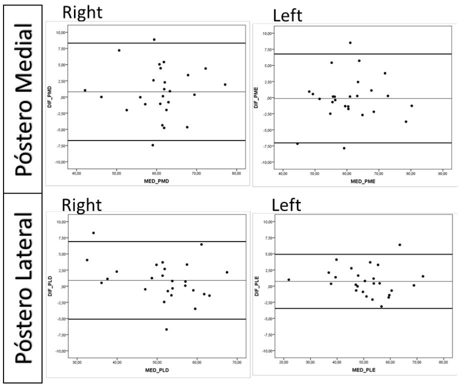


Figure 4 - Visualization of Bland-Altman for the differences and averages between the evaluations obtained by the UBT.

Table 1: lower body Test values, T-test, Interclass Correlation Index (ICI), Coefficient of Variation (CV), Estimative Standard Error (EEE) and Minimum Difference Detectable (MDD).

Movements	1st day	2nd day	1st and 2nd day				
	Mean ± SD	Mean ± SD	p	ICI	CV	EEE	MDD
Anterior – R	49.94 ± 4,6	47.64 ± 3.7	0.16	0.90	5.3%	0.79	2.46
Anterior – L	48.71 ± 5,3	49.28 ± 5.6	0.09	0.97	5.3%	0.28	1.47
Medial – R	51.48 ± 6,3	52.19 ± 6.1	0.25	0.93	6.0%	0.82	2.51
Medial – L	51.42 ± 6,8	52.32 ± 6.9	0.11	0.96	5.4%	0.55	2.06
Posteromedial – R	60.30 ± 7,6	61.10 ± 7.6	0.30	0.93	6.4%	1.02	2.79
Posteromedial – L	60.97 ± 8,8	60.83 ± 9.1	0.84	0.96	5.8%	0.71	2.33
Posterolateral – R	51.15 ± 9,7	52.05 ± 8.7	0.15	0.97	6.0%	0.53	2.02
Posterolateral – L	50.68 ± 10,8	51.41 ± 10.6	0.09	0.99	4.2%	0.21	1.28

Legend: R - Right; L - Left; SD-Standard Deviation; $EEE = SD \times \sqrt{(1-ICI)}$; $MDD = 1{,}96 \times \sqrt{(2 \times EEE)}$

DISCUSSION

The aim of this study was to verify the reproducibility of the Lower Body Test performed with Octobalance®, for individuals with knee osteoarthritis. The main finding of this study was the confirmation of reproducibility with suggested adaptation, verified by high values of ICI, low CV, and good agreement, and Bland-Altman charts were considered satisfactory.

Reproducibility studies have proved sufficiently capable of proving the efficacy of similar tests (Murray, Salvatore, Powell, & Reed-Jones, 2014) (Plisky, et al., 2009). In the literature, there is variability between how many repetitions are necessary to obtain good results. Unlike Gribble, Tucker, & White, 2007 who performed 3 replicates at one-week intervals, this study showed reliable results with only two replicates within a 48-hour interval between them, potentially being simpler and more agile in obtaining results (Gribble, Tucker, & White, Time-of-day influences on static and dynamic postural control., 2007). Also, the study by Kanko et al., 2019, showed the same for the same population studied but with another balance test (Kanko, et al., 2019).

Performing only two repetitions can be explained through the adaptive neuromuscular process of the patients. Also, emotional factors such as fear may have been reduced, increasing safety and overcoming ability. During the reproducibility of the 6-minute walk test, several authors (Lacasse, Goldstein, Lasserson, & Martin, 2006) (Redelmeier, Bayoumi, Goldstein, & Guyatt, 1997) (Rodrigues, Viegas, & Lima, 2002) showed that it is possible to obtain good results with two tests, and there is no statistically significant difference between them through the learning process.

Another relevant factor was the characteristics of this sample, which had mostly individuals with high BMI. A recent study showed that overweight is directly linked to a deficit of balance and consequently functionality, making it essential to adapt to this study. Also, senescence is directly linked to the advancement of osteoarthritis and loss of function, as seen in the studies of Rebellato et al in 2008 and Shane Anderson, A .; Loeser, R.F. in 2010 (Rebelatto, Calvo, Orejuela, & Portillo, 2006) (Shane Anderson & Loeser, 2010).

Among the analyses carried out, the values of the minimum detectable difference were highlighted that despite not generating reproducibility indicators, they demonstrated important data for clinical and labor practice (Haley & Fragala-Pinkham, 2006) (Paço & Cruz, 2011). Therefore, through a reassessment with this instrument for individuals with knee osteoarthritis satisfactory modifications will only be demonstrated, with clinical improvements and values above the MDD.

CONCLUSIONS

It is reproducible to perform the Lower Body Test with the Octobalance® platform for the evaluation of the dynamic balance of lower limbs in women with knee osteoarthritis. It was also possible to identify values of minimum detectable difference, values to be used as a form of prognosis and improvement of these individuals.

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