Reproducibility of a Trunk Stability Evaluation Instrument in Individuals with Non-Specific Chronic Low Back Pain

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1. INTRODUCTION

Approximately 80% of the population suffers from low back pain at some point in their lives, and less than 60% of them seek treatment.[1]In Brazil, this condition affects more than 50% of the adult population, with a large functional disability.[2]Despite the high prevalence of low back pain at a global and national level, a specific diagnosis of its possible causes is not determined in 90% of the cases, characterizing it as “non-specific low back pain”.[3]

According to HODGES & MOSELEY (2003), a hypothesis for the persistence of non-specific low back pain is the impaired function of the trunk muscles that are important in the process of stability and control of the movement of the spine. Stability refers to the body's ability to maintain or regain the position of the torso when it is subjected to external and/or internal forces of origin.[4,5]There is a relationship between the trunk stability deficit and the lower columnar limb and lower limb injuries, but the reduction of proprioceptive acuity and trunk control in individuals with low back pain is still inconsistent in the literature due to indirect methods of evaluation.[6]

The methods of trunk stability evaluation most used by the scientific community are divided into two types: biomechanical tests, such as isokinetic and isometric strength, proprioceptive control and center of pressure (CoP) evaluation; and functional field tests, which include of muscular condition, body balance, and posture control tests[7,8].The functional field tests are more common in clinical or laboratory settings, such as Biering-Sorense, unipodal support test, and frontal abdominal power test and prone instability. The biomechanical tests such as unidirectional and/or CoP behavior on unstable and stable surfaces are more commonly used within the context of sports performance.[8–10]Also, the field tests have important limitations especially due to the lack of studies on the validity of these measures and to measure the trunk stability in an indirect way.[8]

Evaluations that minimize the lower extremities compensation in postural control titled “unstable seat paradigms” have recently been used by the need to make the evidence stronger for the evaluation of trunk stability.[11-15]In this paradigm, individuals are asked to sit on a dynamically balanced unstable surface only by trunk movement, while the center of pressure is measured.[16]CoP is defined as the point where the force vector of soil reaction and it is considered one of the most common measurements for body response in a certain equilibrium situation.[17]

As a way to determine which parameters should be measured in the CoP evaluation through this paradigm, some evaluation protocols have already been proposed to improve their reliability to trunk stability.[16,18]BARBADO et al. (2016a) proposed a protocol based on this paradigm that allows evaluating how the CoP behaves in static and dynamic situations, with and without visual feedback. This protocol has already been applied in different populations, such as judo, canoeing, and physically active individuals, but there are no studies that evaluated individuals with non-specific chronic low back pain.[11,19]

The objective of this study was to observe the reproducibility of the protocol “Unstable Seat Paradigm" proposed by BARBADO et al. (2016a) in individuals with non-specific chronic low back pain. It is hypothesized that the instrument is reproducible in this population.

2. METHODS

2.1. Experimental design

This is a cross-sectional study. The subjects were evaluated in two sessions with an interval of 48 hours to calculate reproducibility. This study was conducted between July and November 2018. The study was submitted to the Human Research Ethics Committee of the Federal University of Sergipe, Brazil (CEP/UFS) and approved under number 2.704.321/2018.

2.2. Subjects

Fifteen individuals between 18 and 35 years old were recruited, with a diagnosis of non-specific chronic low back pain (reported through anamnesis and imaging tests), pain level between 3 and 7 according to the Numerical Pain Scale, and BMI ≤ 30 kg/m^2, without a surgery in the back region in the last year without diagnosis of spondylolisthesis and/or malignant, neurological and inflammatory diseases. The exclusion criterion adopted was: the absence of the individual in an evaluation session or prolongation of rest for more than 48 hours.

Table 1. Demographic characteristics

	Mean (SD)
Age(Years)	23.24 (4.24)
Weight (Kg)	65.18 (15.69)
Height (m)	1.70 (0.08)
BMI (kg/m^2)	22.34 (3.62)
NPS (0-10)	5 (1.4)

The subjects were evaluated in two sessions with an interval of 48 hours and they were previously advised not to practice moderate to vigorous physical activities during the 24 hours before the evaluation. The control of physical activity practices was performed through a reminder.

2.3. Procedures

For the characterization of the sample, all participants in this study answered a socio-demographic questionnaire and the body mass and height were measured to calculate the BMI. All tests were applied in the same shift, in the same environment, and by the same evaluators.

For the stability evaluation, the "Stable Seat Paradigm" protocol proposed by Barbado et al. (2016a) was used that evaluates the postural control and trunk movement in sedestation, both in a stable and unstable seat. The stable seat is of a hardwood wood frame with leg and foot support. The foot support is adjusted for each participant (90º knee flexion) and the participants´ legs are tied to the seat to avoid lower limb movements keeping the hip flexed at 110º.[20]The unstable seat has the same structure with a wood attached to the bottom (diameter of the hemisphere: 35 cm, height of the seat relative to the lowest point of the hemisphere: 12 cm). Both seats are placed on a force platform at a 100 Hz sampling, located 0.9 m above the ground on a rigid, stable and flat surface. The pressure center displacement was provided to the participants in real time through data show projection (Benq®, MP515, Brazil) connected to a notebook (Acer Aspire® 5750 series, P5WE0, Brazil) at a distance of 2 m from the evaluation structure. The CoP calculation and the presentation of the target point were performed through a MatLab program developed together with the Electronic Engineering Department of the Federal University of Sergipe, whose interface is shown in figure 1.

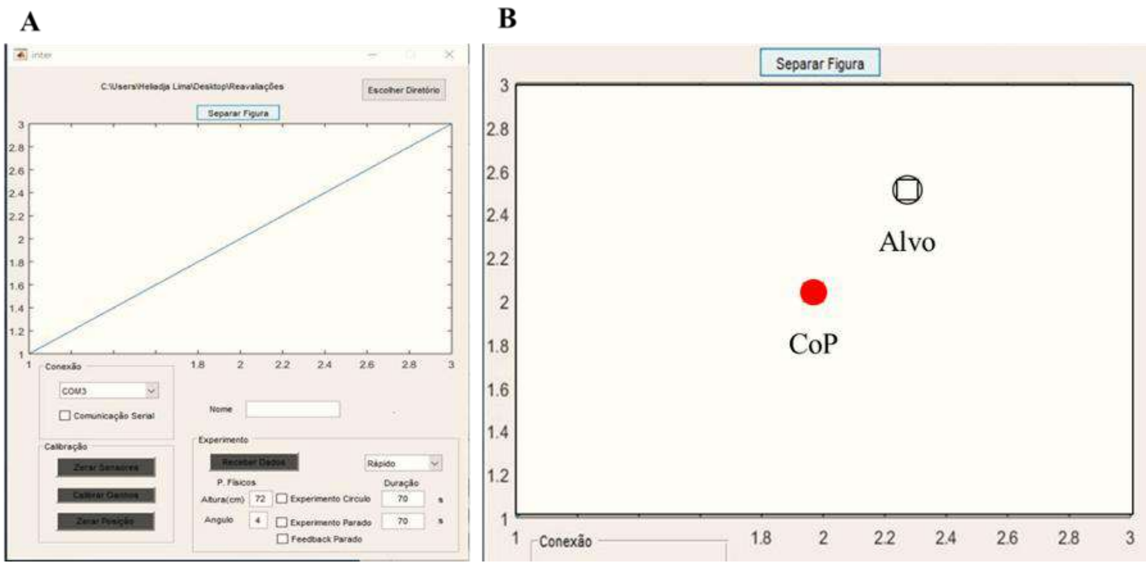

Figure 1. A) Program interface used for CoPevaluation. B) Interface illustranting feedback duringdynamic test.

During this protocol, the participants performed six tests in the sequence presented below:

- Stable sitting without feedback (SSNF): individuals were invited to sit in a position in which they felt comfortable and to keep in the stable seat;
- Stable sitting with feedback (SSWF): the same orientation as the SSNF was also given in a stable seat, but the COP displacement was monitored in real time;
- Stablesittingwhileperforming circular displacementswith feedback (SSCD): individuals were guided to align the position of the pressure

center to the target design along a circular path through the trunk movement in the stable seat;

- Unstablesittingwithout feedback (USNF): SSNF guidelines were repeated, but the test was performed in the unstable seat;
- Unstablesittingwith feedback (USWF): SSWF guidelines were repeated, but the test was performed in the unstable seat;
- Unstablesittingwhileperforming circular displacementswith feedback(USCD): SSCD guidelines were repeated, but the test was performed in an unstable seat.

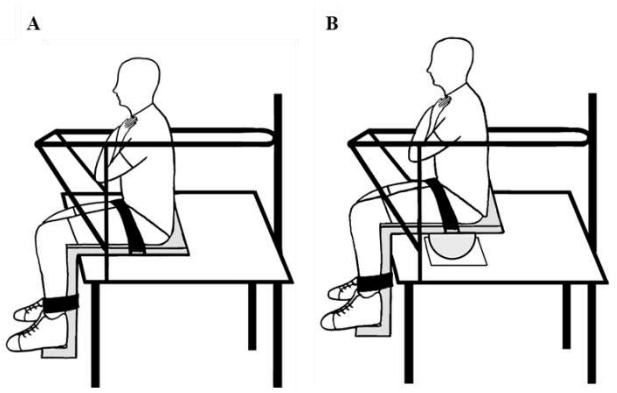

Figure2. A) Stableseat. B) Unstableseat

During the dynamic condition, the target point displacement amplitude corresponds to an angle of inclination of 4° from the center of mass whose calculation was the result of the distance between the acromion and the greater trochanter of the femur multiplied by a constant (0.626). The target point took 20 s to complete a cycle (0.05 Hz). The duration of the test was 70 s and the rest period between assays was 1 minute. There was a circular test with 60 s feedback for each seat to familiarize the individuals with the instrument. All participants remained with their arms crossed over their breasts touching the opposing shoulders during the tests.

2.4. Statistical analysis

The normality of the data was verified through the Kolmogorov-Smirnov test and homogeneity of the variances through the Levene test. To calculate the CoP through the software, the MRE (Mean radial error) calculated using the equation $\frac{\sum_{i=1}^{n} d}{n}$, where d represents the distance between the CoP and the desired target en represents the number of measurements taken.

To compare the values of the trunk stability assessment tests between the two days of evaluation, the T-Test for paired samples was performed. As indicators of reproducibility, the Intra-class Correlation Coefficient (ICC) was calculated as being small (up to 0.25), low (0.26-0.49), moderate (0.50-0.69), high (0.70-0.89) and very high (above 0.90).[21] To verify the agreement between the measures, Bland-Altman graphs were used.[22] The coefficient of variation (CV) was calculated from the standard deviation by the mean of the measurement, considering low dispersion (≤ 15%), medium dispersion (15%> 30%) and high dispersion (> 30%). Statistical analyzes were performed using SPSS software version 22.0® and the value of p ≤ 0.05 was considered.

3. RESULTS

No statistical differences were observed between the first and second evaluation days in any of the evaluation trials (Table 2). Additionally, the reproducibility analysis between the measurements indicates very high values (0.94 for Unstable sitting with feedback) and high (0.77 for Stable sitting without feedback, 0.82 for Stable sitting while performing circular displacements with feedback, 0.8 for Unstable sitting without feedback and 0.87 Unstable sitting while performing circular displacements with feedback) for five of the six trials and moderate value for only one test (0.65 for Stable sitting with feedback).

Table 2. Reproducibility Parameters of the "Unstable Seat Paradigm" in individuals with non-specific chronic low back pain

Sittingprotocol (MRE)	**Day 1**	**Day 2**	**ICC**	***P***	**CV**
	Mean (SD)	**Mean (SD)**			
Stable sitting without feedback	0.23 (0.18)	0.23 (0.15)	0.77	0.99	10.8%
Stable sitting with feedback	0.18 (0.07)	0.19 (0.08)	0.65	0.45	9.8%
Stable sitting while performing circular displacements with feedback	29.25 (4.06)	29.36 (3.49)	0.82	0.85	12.1%
Unstables itting without feedback	0.21 (0.10)	0.23(0.09)	0.8	0.22	7.1%
Unstable sitting with feedback	0.25 (0.12)	0.24 (0.12)	0.94	0.4	8.4%
Unstable sitting while performing circular displacements with feedback	32.20 (5.37)	31.41 (4.5)	0.87	0.26	10.4%

MRE: Mean radial error; **ICC:**Intra-classCorrelationCoefficient; T-Test for pairedsamples(***P***); **CV:**Coefficientofvariation.

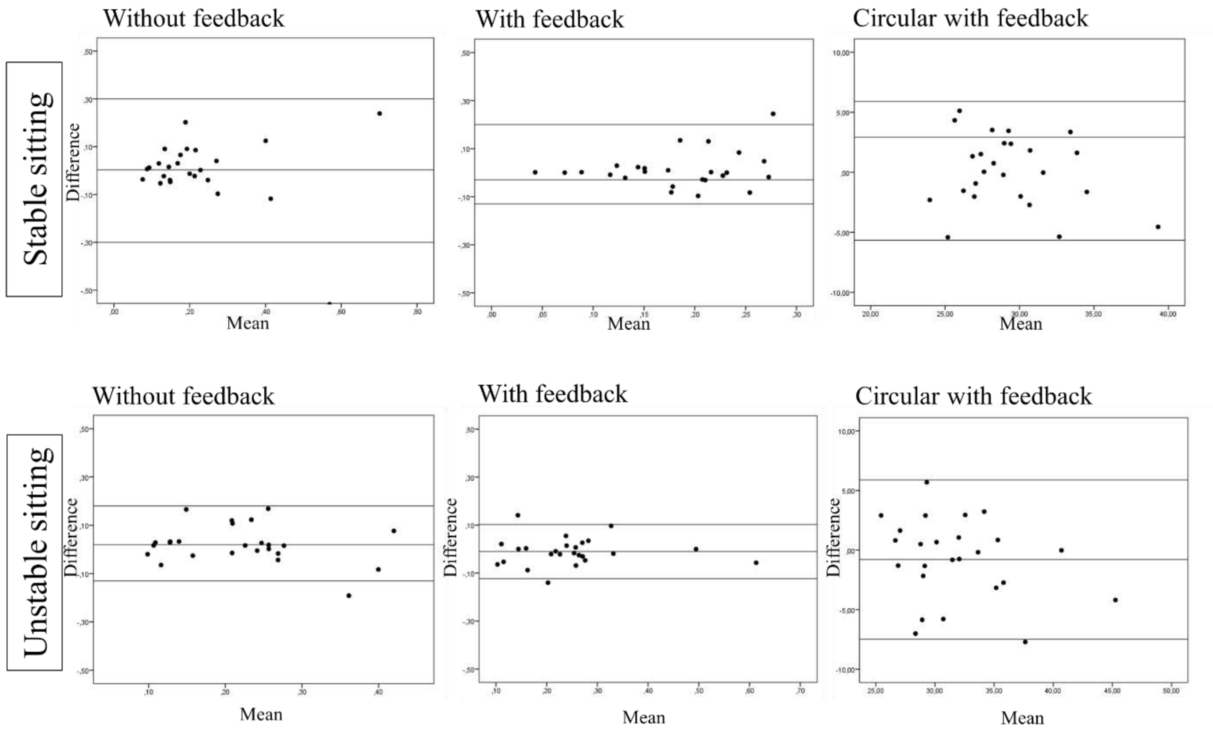

Figure 3. Bland-Altman graphs for visualization of differences and averages between the "Unstable seat paradigm"

The variation was considered low in all the tests, suggesting homogeneity among the measurements. The concordance analysis between the evaluation days is represented in figure 3, in which bias close to zero and acceptable agreement interval between the stability assessment tests performed in the study are observed. The agreement between the measurements was not influenced by the extreme values.

4. DISCUSSION

The evaluation of trunk stability through the variation of CoP has been used in some neuromuscular disorders, therefore, the reproducibility of this tool becomes an important factor.[15,18]In this article, the reproducibility was considered high in four of the six tests and very high in one test, showing that this protocol is adequate for assessing trunk stability in this study health condition.

Also, at least two evaluation sessions are required to observe the reproducibility of the “unstable seat paradigm” in individuals with low back pain corroborating the findings of Barbado et al. (2016a) in his study with elite and recreational athletes. In addition, all the tests showed low dispersion indicating homogeneity of measurements and it is possible to observe the measurement bias approaching to zero in the Bland-Altman graphs.[23]

In agreement with the findings of BARBADO et al. (2016a), more difficult conditions presented higher ICC and this can be justified by the greater requirement of neuromuscular control of these activities, resulting in a smaller variability in the measures.[24]

The researches suggests that the presence of low back pain may be associated with greater latency in the muscular response, lower postural control of the subject in standing, muscle weakness of the trunk and insufficient motor control of the deep muscles of that region with impact under the individual's functionality.[12,13,25]The clinical practice guidelines for the management of this chronic low back pain, affirm that it is necessary to perform a physical evaluation in this health condition to investigate its cause and guide decision making of the treatment. Based on these factors and the ratio of non-specific low back pain to trunk stability, it is also important to evaluate this variable based on its mechanical concept, which includes strength, power, endurance and proprioceptive control of the core muscles.[4,8]

From this need, methodologies for the stability evaluation were proposed through the CoP, but there is a lack of studies that aim to analyze the reproducibility of these instruments and, mainly, through the protocol used in this article.[6,18,24]Van Daele et al (2007) observed moderate values of reproducibility in the evaluation of postural control in individuals with chronic low back pain through the unstable seat, attributing these values to the absence of pre-test familiarization. On the other hand, VAN DIEËN, KOPPES e TWISK (2010b)found low reproducibility values in the parameters in the evaluation of the postural control of healthy individuals. Both studies performed the evaluation through protocols that differ as much as they differ from the one used in this study, since none of them evaluated the adjustment of the CoP to any target, but they approach this study in the aspect of the evaluation of the stability of the trunk in sedation, canceling out any interference of the lower limbs in the results.

BARBADO et al. (2016a) was the only study we found that evaluated the reproducibility of a CoP evaluation instrument using the same methodology of this article, with a different population (elite and recreational athletes) and performing the subtraction and retest on the same day. The use of this methodology differs from the others, mainly regarding the adjustment of CoP to a trajectory in a stable and unstable surface, allowing to observe this behavior in different situations and, consequently, in a more complete way.

The “Unstable Seat Paradigm" is a direct and objective evaluation that allows not only to observe how the individual's CoP works in situations of instability but also to allow evaluating the ability to adjust this variable to a target characterizing a measure from the mechanical concept of stability and which is independent of the evaluator's perception.[18,26]Thus, from this study, it is concluded that this instrument is reproducible in individuals with non-specific chronic low back pain and can be used in cross-sectional studies or clinical trials to evaluate trunk stability directly in this population. Also, it is suggested to compare different populations as well as observations on the effects of possible interventions to enrich the literature regarding the topic.

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