A Proposed Modification to the Ankle Dorsiflexion Lunge Measure in Weight Bearing: Clinical Application with Reliability and Validity

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ABSTRACT

The weight-bearing lunge test (WBLT) is a common approach to measure ankle dorsiflexion motion. Because this approach requires multiple repositioning of the foot, when measured with a tape measure, a modified approach is proposed. In this approach the foot position is such that no repositioning is needed. **Purpose:** To determine the reliability and validity of a modified WBLT (mWBLT) to measure ankle weight-bearing motion. **Methods:** Healthy adult subjects were measured using the WBLT and the mWBLT. In addition, the subjects' ankle joint position was measured with a standard goniometer. Intra-class correlation coefficient, standard error of the measure, and validity correlations were tested. **Results:** The mWBLT yielded strong intra-rater reliability and test re-test reliability (ICC > 0.90) with low measurement error and sufficient correlation to the goniometer (r > 0.60), all comparable to the standard WBLT. **Conclusion:** The mWBPT provides reliable data and a valid measure of ankle motion, in weight bearing, while also being more efficient than the standard WBLT.

Key Words: dorsiflexion, functional, lower extremity

INTRODUCTION

Incorporating standardized, objective measures into clinical practice is important for all health care practitioners as a principal of evidenced-based practice and to demonstrate patient success. Ankle dorsiflexion is a key lower extremity objective measurement often altered through injury or surgical intervention that can have great impact on lower extremity functional tasks. While ankle dorsiflexion can be measured in a non-weight-bearing extremity using a goniometer, nonweight-bearing measures have had variable, even poor, inter- and intra-rater reliability, with intraclass correlation coefficient (ICC) values falling as low as 0.29 for inter-rater reliability.[1-3] Weight-bearing methods of measurement have demonstrated higher levels of reliability, with lower end ICC values of 0.90.1,[4,5] Additionally, the weight-bearing aspect of this method more directly informs the clinician of a patient's ability to perform lower extremity functional tasks.

Bennel et al[1] first described the weight-bearing lunge test (WBLT) wherein ankle dorsiflexion motion is measured based on movement of the tibia, over the fixed foot, toward a wall. It is measured with the great toe and the center of the calcaneus along a tape measure positioned along the floor. This position is monitored by the therapist throughout the duration of the lunge to ensure the calcaneus maintains contact with the ground. The patient lunges forward until the knee touches a vertical line placed on the wall. A trial is considered successful if the patient can achieve contact with the wall while maintaining proper foot alignment. The measurement recorded is the distance from the great toe and the wall measured in millimeters. The foot is then moved backwards and repositioned up to 5 times until maximum dorsiflexion is achieved. In the original version of the test, the entire series is repeated 3 times and the mean distance was recorded.

In an alteration of the original test protocol presented by Chisolm et al,[4] a single series trial was compared to the previous multiple 3 series and found to be equally reliable and valid. The authors proposed the change from a 3 series trial to a single series trial in an effort to streamline the exam and reduce the overall time of completion to make the test more appealing and user friendly for the busy clinician. However, both versions of the weight-bearing lunge test still require multiple repositions of the foot, adding time and difficulty to the test administration.

This current study looked at a modification to the traditionally proposed WBLT in which no foot reposition is necessary. The test position is similar to the original, with the great toe and midline of the calcaneus positioned along a fixed tape. However, rather than initiating the exam with the foot close to the wall and progressively repositioning and moving the foot backwards, the test is initiated with a fixed starting position of the foot 35 cm from the wall. This distance was determined based on prior testing of individuals; it was determined that 35 cm sufficiently prevented any individual from making knee contact with the wall while squatting. This foot location allowed full ankle dorsiflexion for all subjects. The total lunge distance is then recorded as the distance of the knee to wall rather than the great toe to wall. While detailed procedures for the test will be discussed in the methods section of this paper, the authors feel this simple alteration to the standard WBLT, both maintains the reliability of the test while improving the ability for the test to be administered in the clinical setting. The authors hope this will be the first step to exploring the modification of this important clinical tool.

Purpose

To estimate the test re-test reliability of the modified weight-bearing lunge test (mWBLT) for the measurement of weight-bearing ankle dorsiflexion, provide the standard error of the measure, and to establish criterion validity evidence based on goniometric measurement of ankle dorsiflexion.

METHODS

Subjects

Healthy adult subjects from the University campus participated in this study with 21 males (mean age = 28.19 yrs + 6.19, height = 1.76 m + 0.06, weight = 79.59 kg + 13.24) and 20 females (mean age = 27.25 yrs + 7.07, height = 1.61 m + 0.07, weight = 64.99 kg + 12.63),

for a total of 41 subjects. All subjects signed an informed consent document and this study was approved by the West Coast University's Institutional Review Board for the oversight of ethical treatment of human subjects.

Apparatus and Procedures

A standard long arm goniometer and cloth tape measure were used to acquire the distance and angular data for the ankle range of motion positions. The individuals acquiring the data consisted of trained Doctor of Physical Therapy graduate students, who were blinded to the measures obtained from each other.

Each subject was measured 2 times, in each of the 2 weight-bearing conditions, the standard lunge test and the modified lunge test (Figure 1), for a total of 4 trials. Ankle joint dorsiflexion angle was measured using a standard goniometer, consistent with the technique and criterion of Norkin and White.[6] During the WBLT, the distance from the foot (great toe) to the wall was measured with the cloth tape measure, as described by Bennell et al.[1] The foot location, relative to the wall, was re-positioned accordingly until the knee flexion produced full ankle dorsiflexion with minimal contact of the knee to the wall.

In the mWBLT, all measurements occurred with the foot prepositioned exactly 35 cm from the wall, as measured from the great toe to the wall. This distance assured that all individuals could complete maximum weight-bearing dorsiflexion without the wall impeding the movement of the knee into flexion. The cloth tape measure was then used to measure the distance of the anterior knee (patella) to the wall, while maintaining the tape measure horizontal to the floor.

This study used 2 different measurers for each measurement obtained. One individual was responsible for all goniometric measures, one person was responsible for all foot to wall measurements (standard weight-bearing lunge) and for all knee to wall measurements (modified weight-bearing lunge).

Data Analyses

All measurement data (ie, tape measure values, goniometric values) were tested to determine compliance with normalcy. To estimate test retest reliability, the ICC was applied based on Model 2. The standard error of the measures (SEM) was calculated using the unbiased estimate approach based on the square root of the mean square error from the repeated measures analysis of variance table. From the SEM, minimal detectable change (MDC) at 95% confidence were also calculated (MDC_{95}). Coefficient of variance (CV) were determined for both methods of the lunge test in order to draw appropriate comparisons between the WBLT and the mWBLT. The CV is typically reported as a ratio of the standard deviation with the mean of the measures (CVm); we also estimated the CV based on the ratio of the standard deviation with the range of the measures (CVr). The use of the range was included to minimize the bias created by different means with similar ranges. The means approach creates a bias that favors the modified technique. Finally, the tape measure values were correlated with the goniometric measures of ankle dorsiflexion to establish basic criterion validity evidence.

RESULTS

The average tape measure distance of the toe to the wall, in the WBLT, was 10.54 cm (sd = 3.11); the average tape measure distance of the knee to the wall, in the mWBLT, was 25.66 cm (sd = 3.01). The average goniometric ankle joint position, in either position, was 30.39° (sd = 8.14). Both measures produced correlations with the goniometer of -0.67 and -0.61, respectively for the standard and modified techniques. Table 1 provides the results of the reliability study, including the ICC (with CI95), the SEM, MDC_{95}, the CVm, and the CVr.

DISCUSSION

The average measurement distance, reliability, and standard error for the WBLT in our study compared similarly with the values obtained by Konor et al,[3] Chisholm et al,[4] and by Bennell et al.[1] Our mean toe-to-wall distance was measured at 10.54 cm, which compares with 9.5 cm for Konor et al, Chisholm et al at 8.9-9.1 cm, and Bennell et al at 13.6-13.9 cm. The test retest reliability, as measured with the ICC all exceeded 0.90 for these studies. In addition, the SEM was 0.40 – 0.60, 0.47, 0.40, and 0.63 cm respectively for Konor et al,[3] Chisholm et al,[4] Bennell et al,[1] and our study.

The mWBLT approach yielded similar reliability estimates when compared with those values obtained using the standard lunge approach, with ICCs that also exceeded 0.90 from a test retest perspective. The SEM for the mWBLT (0.70cm) was comparable to the SEM for the WBLT approach and yielded a lower CV (0.12 for the mWBLT and 0.29 for the WBLT), when expressed as a ratio of the mean. However, when expressing the standard deviation relative to the range for both techniques, the CV is similar (0.21 for both).

In order to explore validity of the mWBLT a comparison of these linear measures with ankle angular position was similar to the method by Bennell et al[1] and Hall and Docherty.[5] While our correlations (-0.67 and -0.60 for the traditional and modified techniques respectively) are lower than Bennell et al, who reported values of 0.93-0.96, our correlations are comparable to those obtained by Hall and Docherty (r = 0.74). The authors feel that this relationship is sufficient to provide early validity evidence. In addition, the current study used a larger sample (n = 42), similar to Hall and Docherty (n = 50), in comparison to Bennell et al (n = 13).

The WBLT has been shown to be strongly associated with measures of functional performance, balance, and injury risk.[7-9] For

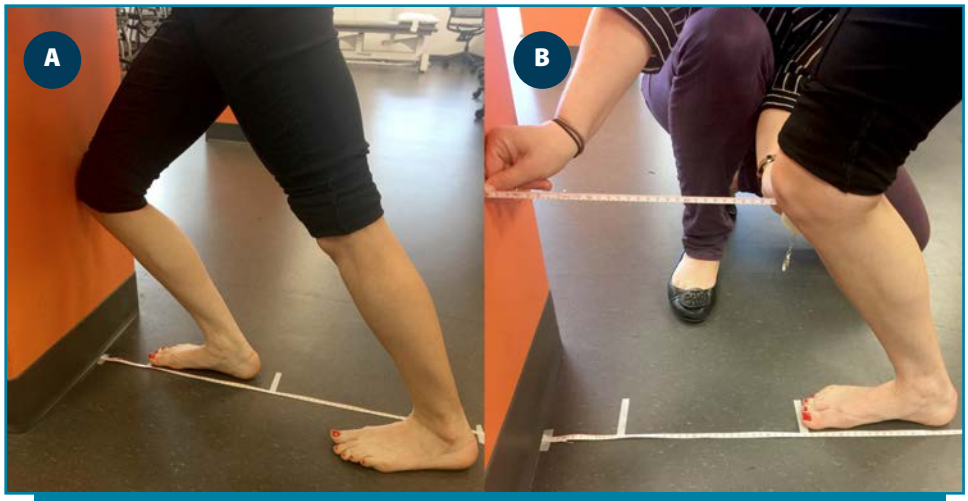

Figure 1. The standard lunge test. A, The foot is required to be adjusted based on knee contact with the wall. B, The modified technique in which the foot is positioned at a fixed 35 cm from the wall.

Table 1. Reliability Study Results

Lunge Technique	ICC (CI95)	SEM	MDC_{95}	CVm	CVr
WBLT	0.95 (0.92, 0.98)	0.63	1.75	0.29	0.21
mWBLT	0.95 (0.91, 0.97)	0.70	1.95	0.12	0.21

Abbreviations: ICC, intraclass correlation coefficients with 95% confidence intervals; SEM, standard error of the measures; MDC, 95% minimal detectable change; CVm, coefficient of variation from the mean; CVr, coefficient of variation from the range; WBLT, weight-bearing lunge test; mWBLT, modified weight-bearing lunge test

instance, a study by Hoch et al[7] found a significant correlation between landing kinematics and ankle dorsiflexion as measured in weight bearing. Further, in studies by Hoch et al[8] and Kang et al[9] ankle dorsiflexion measured in weight bearing was strongly correlated with standing balance and lunge ability in healthy and injured adults. Finally, a study by Burns et al[10] found significant differences in the range of motion measured at the ankle, in the weight-bearing position, when comparing individuals with distinct foot types. Namely, pes planus feet and normal feet demonstrated greater range compared with pes cavus feet. These strong associations provide support for the use of a WBLT to measure ankle range of motion, regardless of using the standard approach or this proposed modified approach.

The findings from this study suggest that the mWBLT, in which the foot is pre-positioned a sufficient distance from the wall to eliminate the need for repositioning, provides a reliable of data and minimal error, when compared with the traditional WBLT. The elimination of needing to reposition the foot improves the time efficiency of the mWBLT. This approach has been applied in previous studies in which a goniometer alone is the measurement tool of choice, rather than the tape measure approach, however the reliability had not been established.[7-9] The results of the current study demonstrate that reliable measures can be obtained with this mWBLT using either the tape measure or the goniometer, depending on the clinician's preference. In either case, the mWBLT is likely more time efficient requiring only one set position for measurement, compared with the traditional WBLT.

An obvious limitation to this study is the involvement of only healthy adults. This study requires replication with individuals with ankle range of motion issues and/or knee related issues. In addition, it will be helpful to provide additional validity evidence in terms of patient reported outcome measures. Further, this study used a convenience sample, which allows for bias in subject selection. Repeating this study by drawing from the clinical community will improve the external validity of this study. Finally, this study only tested the utility of linear measures (ie, tape measure distance), whereas others have included inclinometers and tiltmeters as a part of the measurement process during the lunge.[4] Future research can determine the reliability of these tools while performing the mWBLT.

CONCLUSION

Given the efficiency of the modified technique, compared with the standard lunge technique, in terms of eliminating the need for repeated repositioning of the foot, this study provides early evidence of the reliability and validity of the modified lunge technique as an alternative to the standard lunge technique for measuring linear based ankle dorsiflexion motion. Clinicians may find that the mWBLT is more time efficient, and potentially less prone to variability, compared with the traditional WBLT. The mWBLT allows the ability to complete a trial without repositioning the foot, which may provide clinicians with an approach that is less challenging for the patient, when determining ankle lunge mobility, compared with approaches that require the potential for numerous repositioning of the foot in order to achieve a single measure.

KEY POINTS

FINDINGS: The mWBLT provides comparable test retest reliability and sufficient validity evidence as a measure of ankle motion during the weight-bearing lunge motion. Beginning from a fixed distance from the wall, sufficient to allow full lunge, minimizes the need to frequently reposition the foot as required by the WBLT.

IMPLICATIONS: Clinicians may feel safe to use the mWBLT in place of the tradition WBLT when measuring ankle motion in weight bearing. The SEM for both is low, allowing for sufficient determination of change over time.

CAUTION: These data are based on healthy adult subjects. The mWBLT requires repeated testing with patients presenting with conditions affecting the knee or ankle.

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