Journal of Science and Medicine in Sport 20 (2017) 2–5

Contents lists available at ScienceDirect

Journal of Science and Medicine in Sport

journal homepage: www.elsevier.com/locate/jsams

Original research

Leg lateral reach test: The reliability and correlation with thoraco-lumbo-pelvic rotation range

Si-hyun Kim [a], Oh-yun Kwon [b,*], Kyue-nam Park [c], Ui-jae Hwang [d]

[a] Department of Physical Therapy, College of Tourism & Health, Joongbu University, South Korea
[b] Department of Physical Therapy, College of Health Science, Laboratory of Kinetic Ergocise Based on Movement Analysis, Yonsei University, South Korea
[c] College of Medical Science, Department of Physical Therapy, Jeonju University, South Korea
[d] Department of Physical Therapy, Graduate School, Yonsei University, South Korea

ARTICLE INFO

Article history:
Received 23 June 2015
Received in revised form 12 April 2016
Accepted 14 April 2016
Available online 2 May 2016

Keywords:
Leg lateral reach test
Range of motion
Thoraco-lumbo-pelvic rotation
Tape measurement
Trunk

ABSTRACT

Objectives: The aim of the present study was to examine the intra- and inter-rater reliabilities of the leg lateral reach test as a screening tool for thoraco-lumbo-pelvic rotation and to assess the relationship between leg lateral reach distance and thoraco-lumbo-pelvic rotation range in a supine position.
Design: Controlled laboratory study.
Methods: Thirty-six physically active participants were recruited. The leg lateral reach test was performed over 2 days. In the first session, two testers measured the distance of the leg lateral reach to determine the within-day inter-rater reliability, and one tester repeated the measurement on day 2 to determine the intra-rater reliability between days. The leg lateral reach test was performed three times per leg, and the mean value was used for data analysis. Reliability was determined using the intraclass correlation coefficient, standard error of measurement, and minimal detectable change. The correlation between leg lateral reach distance and thoraco-lumbo-pelvic rotation range was determined using Pearson correlation.
Results: Almost perfect intra- and inter-rater reliabilities were shown for the test [intraclass correlation coefficient$_{2,3}$ = 0.97 (95% confidence interval = 0.914–0.984) and 0.99 (0.974–0.996), respectively]. The within-day inter-rater standard error of measurement was 1.40 cm, and the minimal detectable change was 3.87 cm. The between-day intra-rater standard error of measurement was 2.66 cm, and the minimal detectable change was 7.37 cm. The Pearson correlation showed a moderate to good correlation between the leg lateral reach distance and the thoraco-lumbo-pelvic rotation range (r = 0.73).
Conclusions: The leg lateral reach screening test is reliable for measuring thoraco-lumbo-pelvic rotation range and allows for practical measurement of the thoraco-lumbo-pelvic rotation range in a supine position.

1. Introduction

Many sports activities, such as golf and tennis, require extreme trunk rotation.[1–3] Decreased flexibility in trunk rotation can induce abnormal patterns of trunk movement and may result in low back injury or pain.[3,4] Thus, continuous observation of trunk flexibility in athletes who perform repetitive trunk rotation is necessary to prevent sport injuries as well as to provide rehabilitation guidance and monitor performance.

Clinicians and athletes need evaluation tools to assess trunk rotation flexibility and to monitor changes in trunk rotation flexibility for effective rehabilitation.[5–7] For athletes who use repetitive trunk rotation, measurement of the trunk rotation range of motion (ROM) should be performed using a method that is reliable both within a session and across multiple testing days. Among the non-invasive methods for measuring ROM, three-dimensional (3D) motion analysis systems using reflective markers (VICON and Qualysis Medical AB) and electromagnetic tracking systems (Liberty and Fastrak) are excellent technological devices, but these devices are expensive and require considerable space.[6,8,9] In addition to these methods, axial rotation of the trunk can be measured using goniometry.[10–12] Goniometric methods are inexpensive and convenient; however these methods have a potential procedural error because of inability of the examiners to consistently maintain a device at the points of contact and the compass not remaining at zero level when measuring rotation.[12]

A number of measurement techniques have been developed to quantify trunk axial rotation ROM in a range of positions.[13–15] In

* Corresponding author.
E-mail address: kwonoy@yonsei.ac.kr (O.-y. Kwon).

http://dx.doi.org/10.1016/j.jsams.2016.04.006
1440-2440/

some studies, the axial rotation of the thoracolumbar level was measured with participants in a sitting position using a compass and thoracolumbar rotameter.[16] Johnson et al.[17] suggested measuring thoracic spine rotation ROM in sitting, half-kneeling, and lumbar-locked positions and showed good reliability and low levels of measurement error. These studies focused on measurement of isolated trunk rotation with pelvic fixation in order to differentiate between pelvic and spine mobility. However, Olson and Goehring[18] emphasized the importance of the functional axial rotation of the trunk; i.e., the integrated motion of the thoraco-lumbo-sacral-pelvic complex. Complex rotation of the spine occurs during movements such as kicking the ball in soccer or football, walking, or running. Although this study measured the axial rotation of the thoraco-lumbo-sacral-pelvic complex,[18] the measurement of lower lumbar axial rotation was limited.

Thus, there was no study to measure rotation ROM of the thoraco-lumbo-pelvic structure in the previous studies and the purpose of our study was to design a new method for measuring thoraco-lumbo-pelvic axial rotation. Leg lateral reach test is newly designed to measure thoraco-lumbo-pelvic rotation without the need for technology to perform the test, and add the hip joint, gluteal muscles and hamstrings to the test to enable the full scope of lumbo-pelvic structure to be tested. We investigated the intra- and inter-rater reliability to conclude that the leg lateral reach test could provide a convenient alternative means of measuring thoraco-lumbo-pelvic rotation ROM.

2. Method

Thirty-six physically active males ($n = 16$) and females ($n = 20$) were recruited from the Yonsei university, South Korea. The leg lateral reach screening test was performed with both legs, yielding 72 total measurements (36 participants $\times$ 2 legs each). To establish the reliability of the testing protocol, 10 participants participated in additional testing. Volunteers were excluded if they (1) reported low back pain, (2) had a history of lower extremity injuries or orthopedic surgery within the last 6 months, or (3) had been diagnosed by a physician as having a medical problem, such as muscle strain or neurological signs, in the lower extremity. This study was approved by the Yonsei University Wonju institutional review board. All participants provided written informed consent and were supplied with information sheets prior to participation.

Prior to data collection, all participants were given practice trials to familiarize them with the experimental procedures. For the actual study, participants were instructed to lie on the floor, and a wooden bar with a tape measure attached was placed perpendicular to and outside the knee opposite the side being tested (Fig. 1A). To perform the leg reach test, the participants assumed a starting position with their arms at their sides. Then, they were instructed to lift the leg being tested and reach that foot across the opposite leg to touch the wooden bar using trunk rotation (Fig. 1B). Throughout each trial, participants were encouraged to keep both shoulders on the floor and to reach as far as possible along the wooden bar with the tested leg. If participants failed to maintain their foot on the wooden bar for 5 s at the point of maximal reach or if both shoulders were off the floor, the trial was not counted. The participants performed three repetitions of this test on each side (right and left), and the mean of the reach distances was calculated.

A Polhemus Liberty electromagnetic tracking system (Polhemus, Inc., Colchester, VT, USA) was used to measure the angle of thoraco-lumbo-pelvic rotation in the horizontal plane. Two sensors were attached, one each at the jugular notch of the sternum and the pubic symphysis of the pelvis. Trunk and pelvic kinematics were obtained from a global coordinate system in the horizontal plane, with zero displacement being the start position. The angle of thoraco-lumbo-pelvic rotation was defined as the absolute angle of the pelvic segment relative to the sternal segment. The 3D rotation angle of the thoraco-lumbo-pelvic was analyzed relative to the origin of the global coordinate system. Kinematic data were collected at 120 Hz and mean value of the three trials was used for statistical analysis.

Two physical therapists underwent a 1-hour training session prior to initiating data collection for the screening test. Two raters independently measured the leg reach distance three times per session for each participant. Participants were allowed 5 min to rest comfortably prior to testing by the second examiner. All measurements were recorded to the nearest 0.1 cm. The order of examiners was randomized by drawing lots. Repeated leg reach tests using the same protocol were performed on two days separated by an interval of 5–7 days to assess intra-rater reliability.

Data analysis was conducted using the SPSS version 12.0 for Windows (SPSS Inc., Chicago, IL, USA). As the first step in data analysis, an independent t-test was performed to determine whether there was a difference between males and females in scores on the leg reach test ($p > 0.05$). As no significant difference was found, all participants were grouped for further data analysis, resulting in 72 study limbs overall.

A two-way analysis of variance (ANOVA) was used to test for systematic differences between the first and second sessions and between the two raters.[19] Intraclass correlation coefficients ($ICC_{2,3}$) were used to determine the intra- and inter-rater reliabilities of the leg reach test. An ICC > 0.80 was considered "*almost perfect*", 0.60–0.79 was "*substantial*", 0.40–0.59 was "*moderate*", 0.20–0.39 was "*fair*", and 0.00–0.19 was "*slight*" reliability.[20] The standard

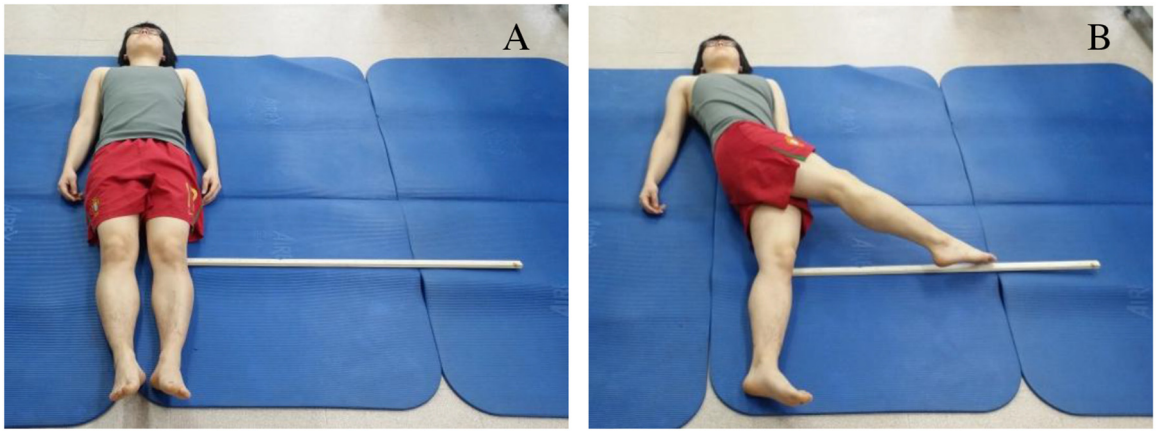

Fig. 1. The leg lateral reach test. A: starting position. B: end position.