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RELIABILITY OF TWO ALTERNATIVE METHODS FOR THE STANDARD MID-THIGH ISOMETRIC PULL

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The purpose of this study was to determine the reliability of two new alternative portable methods for measuring maximal isometric force measures while performing the standard mid-thigh pull. One method, the bar grip method, required the use of the trunk and upper extremity muscles, while the second method, the pelvic belt method, did not. Both methods demonstrated good test-retest reliability via randomized repeated measures over 24-36 hours. Interestingly, the pelvic belt method generally demonstrated average maximal forces up to 65% higher than the bar method. There was a good relationship between both methods. These new alternative methods could provide strength coaches an option for a more efficient, cost-effective, portable means for the mid-thigh pull test.

KEY WORDS: peak force, lower extremity strength, kinetic chain.

Introduction: At present, the multi-joint isometric force production standard method (SM) commonly uses the isometric mid-thigh pull bar grip method while standing on a force plate (Haff, Stone, O'bryant, et al. 1997; Kawamori, Rossi, Justice, et al. 2006; Kraska, Ramsey, Haff, et al., 2009; McGuigan, Newton, Winchester, & Nelson, 2010). This SM is manpower intensive, requires expensive equipment, has a large footprint, not portable, and it is not readily available for use in many environments such as in middle or high schools, or other field testing. Additionally, the necessary involvement of the trunk and upper extremities with the SM limits its use if athletes have weakness or other dysfunctions of the upper extremity, trunk, or spine. Previous studies have demonstrated common gender strength differences, especially of the upper body, so the standard method often puts females at a potential disadvantage in demonstrating lower extremity strength (Sharp, Patton, Knapik, et al. 2002; Knapik, Sharp, Darakjy, et al., 2006; Yanovich, Evans, Israeli, et al., 2008). Two similar, but alternative portable mid-thigh pull methods are proposed. First, the portable bar method (BM) is similar to the standard isometric mid-thigh pull that requires the use of the trunk and arms to pull up on a bar. Whereas the second method, the pelvic belt method (PBM), uses a modified dip belt around the waist that is attached directly to a force transducer, thereby eliminating the need to use the trunk and arms. These proposed portable methods are less expensive, affordable, and more efficient relative to time and manpower than the standard isometric method presently being used. So, the question is whether or not these two new alternative methods for the mid-thigh pull demonstrate reliable measures and good correlation between the two methods.

Methods: Thirty healthy participants (13 males and 17 females) age 18-45 attending a southeastern United States university was recruited by a convenience sample. They were tested using both the standard bar method and a modified pelvic belt isometric mid-thigh pull. Participant demographics are presented in Table 1. Exclusion criteria for this study included pregnancy or any current pathology/dysfunction of the systems of the body, particularly the musculoskeletal system. Participants took part in two sessions of randomized methods sequence of mid-thigh pull measurements with a window of 24-36 hours between sessions. The order of methods testing was determined by a coin flip. Testing procedures were approved by East Tennessee State University's Institutional Review Board with written informed consent obtained from all participants prior to testing.

Table 1
Participant Demographics

Variable	Mean \pm Standard Deviation	Range
Age	27.3 \pm 6.2	21-45
Height (centimeters)	170.9 \pm 9.7	170.2-193.04
Weight (kilograms)	70.1 \pm 15.5	49.9-99.7
Body Mass Index	23.7 \pm 3.4	17-32
Verbal Pain Scale (belt)	2.9 \pm 1.5	0-6
Activity Level (IPAQ)	1.8 \pm 0.8	1-3

Activity level: 1=low, 2=moderate, 3=high (International Physical Activity Questionnaire)

All mid-thigh pulls were performed using the Jackson Strength Evaluation System (JSES, Lafayette Instrument Company, Lafayette, IN), model number 32628, figure1. The BM utilized a straight metal bar handle (1.36 kg, 60.96 cm) connected to the force dynamometer initially with a nylon climbing rope, figure 2. The PBM utilized a nylon six inch wide lifting belt (for padding) and a four inch wide leather lifting (dip) belt connected to a rope/chain, figure 3. Both the bar grip and pelvic belt methods were tested at each of the two testing sessions with a minute rest interval.



Figure 1: JSES



Figure 2: Bar Grip

Figure 3: Pelvic Belt

The first session consisted of completing and signing of an informed consent (with inclusion and exclusion criteria), demographics form, and activity questionnaire. Following completion of forms, participants were given a demonstration of each method and were allowed a familiarization trial immediately prior to testing for each method. Randomization was performed in the first session to determine which method would be tested first; order of method reversed for second session. General and task specific warm ups followed the protocols previously published (Haff et al., 1997, Kraska et al., 2009) prior to testing each day. Participants were fitted with the appropriate gear (described above) and the length of the resistance rope/chain attached to the JSES was adjusted to allow for a bilateral bent knee squat angle of 125 ± 5 degrees. This angle corresponds to the angle used in a previous study of force output with the mid-thigh pull (Kraska et al., 2009). Constant positioning was meticulously maintained to minimize variations in peak force within the “two-joint muscles” involved. Participants incrementally progressed with two practice lifts at 50% and 75% of their perceived maximal isometric pull. Finally two 100% isometric peak maximum pulls were performed with each method were sustained for 5 seconds and recorded if they were within 250 Newtons of each other, otherwise a third pull would be requested (Kraska, et al., 2009). A rest period of one minute was given between pulls (Brown & Weir, 2001).

Participants progressed from one testing protocol to the next with a one minute interval on each test day. Outcome measures recorded were maximum force output (day, trial, and

average), and numerical pain scale (0-10) score (indicator of relative discomfort of the pelvic belt).

Statistical analysis was performed using SPSS version 20.0: IBM company, New York, NY). Descriptive statistics were performed to describe the mean forces recorded by day, trial, and average for each method. To evaluate test-retest reliability, intraclass correlation coefficients, ICC (2,2) for the average of two trials for both methods, and ICC (2,1) for single trials of each method were calculated. The standard error of measure for both methods on day 1 and 2 were also determined. The Pearson correlation coefficient for the two methods was determined for day 1 and 2 ($\alpha < 0.05$).

Results: All participants were able to complete the protocol in the allotted 24-36 hour time frame. Descriptive statistics of forces by day/trial and group are presented in Figure 4 below and show max forces recorded for the pelvic belt method on average 65% higher than the bar grip.

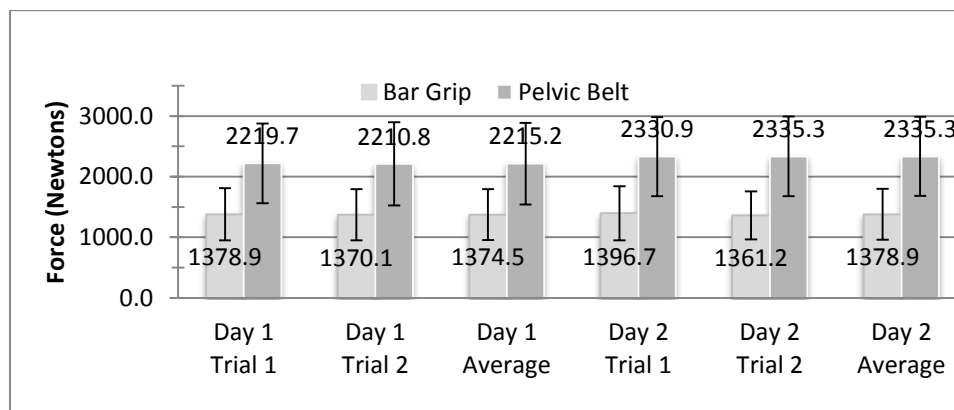


Figure 4: Results of maximal effort force for Bar Grip and Pelvic Belt methods.

Test-retest reliability of the average of two trials of bar method demonstrated good reliability (ICC (2,2) = 0.964, 95% CI = 0.925- 0.983). Test-retest reliability of the average of two trials of pelvic belt method also demonstrated good reliability (ICC (2,2) = 0.821, 95% CI = 0.624 - 0.915). Test-retest reliability of a single trial of the bar method demonstrated good reliability (ICC's (2,1) > 0.895 for all attempts). Test-retest reliability of a single trial of the pelvic belt method demonstrated moderate to good reliability (ICC (2,1) attempt 1 on the first day to attempt 1 on the second day = 0.669; attempt 2 on the first day to attempt 2 on the second day = 0.705). The mean average force maximum for the bar method was 1373.7 N on the first day and 1378.64 N on the second day, whereas the mean average force maximum for the pelvic belt method was 2215.5 N on the first day and 2333.8 N on the second day. The standard error of measure (SEM) for the first day bar method maximum average was 76.4 N and on the second day it was 76.189 N. However, the SEM for the first day pelvic belt method maximum average was 122.3 N and on the second day it was 119.0 N. Pearson's correlation coefficient revealed a moderate association between both methods ($r = 0.558$ for day 1; and $r = 0.761$ for day 2).

DISCUSSION: The purpose of this study was to examine the reliability of two alternate methods of the standard mid-thigh pull utilizing the JSES, a 1.36 kg bar, and a pelvic belt in a population of healthy individuals. The protocol dictated that trials would be within 250 Newtons of each other in order to be recorded so this created an inherently reliable intra-session data.

The test-retest reliability data (ICC and SEM) indicates that the BM is more reliable than the PBM. Although the pelvic belt method required less multi-joint involvement, the movement pattern may be less familiar to the participants, and possibly the comfort level was variable.

However, more force was generated when using the PBM in spite of some discomfort from the pelvic belt at higher loads that was indicated by the verbal pain scale. Most participants identified “pinch points” on the anterior thighs during pelvic belt trials. Future testing should include a more ergonomically designed pelvic belt which is wider across the pelvis. Additionally, the climbing rope used for the pelvic belt method failed during day one testing and was replaced with a chain; future testing should include chains or strong adjustable straps for both methods to minimize equipment variability and make it more efficient to adjust the position of the subject with controlled hip and knee angles. Furthermore, a more in-depth comparison between the portable BM and PBM will need to be done relative to such variables as the resistance force vector angle, center of gravity line, and positioning of the body.

CONCLUSION: Employment of reliable alternative objective and low cost methods to accurately quantify lower extremity strength while replicating lower extremity mechanics is desirable for all athletic populations. Hopefully the two new alternative methods, BM and PBM, can provide additional options for strength coaches to test their athletes in an efficient, cost-effective manner. However, more studies will need to be done to test the validity between the SM and the new portable BM. In addition, further studies will need to be done to determine the influence of trunk and upper body strength when testing the mid-thigh pull with either the SM or portable BM. Likewise, a more in-depth comparison between the portable BM and PBM will need to be done relative to the resistance force vector angle, center of gravity line, and positioning of the body.

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