Reliability and Validity of Isometric Knee Flexion and Extension Measurement Using Three Methods of Assessing Muscle Strength

INTRODUCTION:
Physicians and clinicians need portable, efficient and cost-effective assessment tools to determine the efficacy of rehabilitation programs following knee injury. Isokinetic dynamometers have been suggested to be the “gold standard” when assessing lower extremity strength; however, they do not provide a means of portability for clinicians. Hand-held dynamometers may provide a more efficient and cost-effective method to assess knee strength but it is unknown whether hand-held dynamometry provides valid measures of knee strength. It has been shown that portable fixed isokinetic dynamometry is a reliable tool for measuring knee strength but it is unknown how well portable dynamometry compares to the “gold standard” isokinetic dynamometry. The purpose of this study was to determine the intra-examiner reliability of the Cybex isokinetic dynamometer (CD), BTE Evaluator portable fixed dynamometer (BTE), and hand-held dynamometer (HH) in assessing quadriceps and hamstring isometric strength over two sessions. We also sought to examine the differences in force production output of the quadriceps and hamstrings and compare those differences among the three devices. It was hypothesized that the CD would have the greatest reliability, HH would have the lowest reliability, and CD and BTE would exhibit similar measures of force output.

METHODS:
The convenience sample population consisted of 16 healthy participants both males (N=5) and females (N=11) (29.3 ± 7.2 years, 167.4 ± 8.04 cm, and 73.7 ± 20.0 kg) without history of injury to the lower extremity during the previous six months, ACL injury within the past 2 years, diagnosed patellofemoral pain syndrome or a neurologic disorder. We obtained approval for this study through the university institutional review board for the testing of human subjects. All volunteers read and signed an approved consent document prior to testing. The dominant knee was tested with the CD, BTE and HH on the same day in a counterbalanced order. Measurements of knee flexion and knee extension strength were tested isometrically at 90° of knee flexion. Joint position was quantified through goniometric measurement. Participants were instructed to perform three maximal voluntary isometric contractions (MVIC’s) for five seconds on each device. Peak force of three trials for each muscle group was recorded. Testing using the same protocol, order, and examiner was repeated approximately 24 hours after the first session. The dependent variables for this study were knee flexion (KF) and knee extension (KE) force; the independent variables were day (Day 1, Day 2) and instrument (CD, BTE and HH). All measurements were converted to Newton-Meters and normalized to body weight for analysis. Intra-class Correlation Coefficients (ICC) were used to assess reliability between testing sessions and devices. A paired-samples t-test was used to evaluate differences in force production between the three mechanisms. The alpha level was set a priori at p ≤ .05.

RESULTS:
Intra-examiner reliability assessed between days for knee extension was 0.93, 0.91 and 0.75 for CD, BTE, and HH, respectively. Intra-examiner reliability assessed between days for knee flexion was 0.90, 0.92, and .50 for CD, BTE, and HH, respectively. A paired-samples t-test with a confidence interval of 95% was used to compare the average peak isometric strength of the knee flexors and extendors for each of the three devices. There were no differences in isometric strength (Nm) between the CD and BTE for knee extension on day 1 (20.9 ± 0.42 vs. 2.14 ± 0.53) and day 2 (2.11 ± 0.42 vs. 2.24 ± 0.51). There were also no differences noted between CD and BTE for knee flexion on day 1 (1.04 ±0.29 vs. 1.04 ± 0.26) and day 2 (1.06 ± 0.26 vs. 1.14 ± 0.26). However, significant differences (p=0.001) in force production were observed between the CD and HH in knee extension for day 1 (2.09 ± 0.42 vs. 1.39 ±0.39) and day 2 (2.11 ± 0.42 vs. 1.26 ± 0.36) as well as in knee flexion for day 1(1.04 ± 0.29 vs. 0.74 ± 0.16) and day 2 (1.06 ± 0.26 vs. 0.70 ± 0.19). Significant differences (p=0.000) in force production were also observed between the BTE and HH in knee extension on day 1 (2.14 ± 0.53 vs. 1.39 ±0.39) and day 2 (2.23 ± 0.51 vs. 1.26 ± 0.09) and in knee flexion on day 1 (1.04 ± 0.26 vs. 0.74 ± 0.16) and day 2 (1.14 ± 0.26 vs. 0.70 ± 0.19).

DISCUSSION:
The results of this study provide support for our hypotheses that intra-examiner reliability was high for both the CD and BTE devices while fair to poor reliability was demonstrated with the HH. This study also demonstrated that the BTE Evaluator provides similar measures of force production as the Cybex isokinetic dynamometer. This indicates that the BTE portable fixed dynamometer is an efficient, portable and accurate tool for assessing isometric knee strength. The hand-held dynamometer did not provide similar comparisons to either the BTE Evaluator or the Cybex isokinetic dynamometer. Although hand-held dynamometers are the most portable and cost-efficient tools available for clinicians, this study demonstrated that hand-held dynamometry does not produce similar force output as fixed dynamometers and may also be less reliable over time. One limitation of this study was the assessment of single limb strength rather than bilateral assessment of quadriceps and hamstring strength. In addition, this study evaluated knee flexion and knee extension strength in healthy subjects. It is unknown whether similar results would be found in a pathological population.

SIGNIFICANCE:
Assessment of hamstring and quadriceps strength following knee injury is an important decision-making tool in determining return to function, especially when comparing patients between various therapy clinics. The ability to provide accurate and reliable measures of strength is important and devices that over- or under-estimate strength may either place patients at risk of further injury or delay return to function. This study demonstrated that the BTE portable fixed dynamometer provides reliable measures of strength and also demonstrates similar output measures as the Cybex isokinetic dynamometer. Its portability, ease of use, and cost provide clinicians an effective means of measuring strength.