Comparison of Isometric Portable Fixed Dynamometry to Isokinetic Dynamometry for Assessment of Hip Strength

Roger O. Kollock Jr., PhD, ATC, CSCS • Northern Kentucky University; Bonnie Van Lunen, PhD, ATC, FNATA • Old Dominion University; Jennifer L. Linza, MSEd, ATC • The Apprentice School; James A. Onate, PhD, ATC, FNATA • The Ohio State University

Context: Assessment of hip strength can be performed with either isokinetic or isometric testing procedures, but the degree of association between values derived from the alternative testing methods has not been previously documented. Objective: To investigate the relationship between isometric peak torque and isokinetic peak torque at 60°·s⁻¹ for various hip motions. Participants: Eighteen physically active males (N = 9) and females (N = 9) participated (22 ± 3 years, 173.0 ± 10.5 cm, 73.8 ± 16.7 kg). Intervention(s): Three isokinetic repetitions at 60°·s⁻¹ and three isometric contractions of 5 s each for the hip flexors (HFs), hip extensors (HEs), hip abductors (ABs), hip adductors (ADs), hip external rotators (ERs), and hip internal rotators (IRs). Outcome Measures: Pearson correlation coefficients and coefficients of determination were calculated for both absolute and allometric-scaled peak torque values. Results: Meaningful associations between isometric and isokinetic peak torque values were found for each hip motion. Allometric-scaled strength values demonstrated stronger correlations than absolute strength values. Conclusions: The results suggest that portable fixed isometric testing of hip strength is an alternative to isokinetic testing at 60°·s⁻¹.

Hip muscle weakness may be a risk factor for various musculoskeletal injuries (e.g., noncontact anterior cruciate ligament ruptures, patellofemoral pain syndrome, and iliotibial band syndrome).¹⁻⁷ Dynamic stabilizers of the trunk and hip are believed to prevent aberrant movement patterns during functional activities, such as running¹⁻¹¹ and landing from a jump.⁷,¹² Theoretically, the proximal musculature works synergistically to provide stability within the frontal and transverse planes, which restrains excessive hip adduction and internal rotation during weight-bearing activities.³,⁹ Several studies have demonstrated that both dynamic (e.g., isokinetic or isotonic)¹,⁵,¹³ and static (i.e., isometric)³,⁶,¹⁴,¹⁵ strength levels are associated with movement mechanics. Individuals diagnosed with patellofemoral pain syndrome have been documented to present weakness of the hip abductors,⁴,¹¹ extensors,¹¹ and external rotators,⁴ and those diagnosed with iliotibial band syndrome present weakness of the hip abductors.²

The apparent importance of hip muscle function for injury avoidance makes its assessment important,¹⁶⁻¹⁹ which has been advocated as a component of the preparticipation physical examination²⁰,²¹ and postinjury return-to-play evaluation.¹⁹,²²⁻²⁴

Clinicians can evaluate hip strength through isometric or isokinetic devices. The high cost and lack of portability of an isokinetic dynamometer typically limit
such testing to large outpatient clinics. Furthermore, the amount of time required to complete an isokinetic test makes it unfeasible as an injury risk screening component of a preparticipation physical examination that involves a large number of athletes.

A cost-effective and efficient option for hip muscle strength assessment is the use of portable fixed dynamometry (PFD), which is essentially a hybrid of a hand-held dynamometer and a strain gauge that attaches to a fixed structure. This device eliminates the hand-held dynamometer tester-patient interaction at the point of force application, thereby eliminating the need for the tester to exert an equivalent counter-force to the force generated by the patient. Research evidence has established PFD as a reliable method for assessment of hip strength. The existing literature pertaining to comparison of isokinetic dynamometry with PFD has been focused on assessment of the knee extensors and flexors, which has demonstrated good correlation between measurement derived from the 2 methods ($r > 0.70$). We hypothesized that there would be a correlation ($r > 0.50$) between isometric and isokinetic hip strength measurements, both in terms of absolute and normalized peak torque values.

**Procedures and Findings**

Eighteen physically active males ($N = 9$) and females ($N = 9$) participated in the study ($22 \pm 3$ years, $173.0 \pm 10.5$ cm, $73.8 \pm 16.7$ kg). All participants were recreational athletes who regularly engaged in a moderate level of physical activity. Exclusionary criteria included $< 18$ years of age, any lower extremity injury within the previous 6 months, and history of lower extremity surgery within the previous 2 years. The participants were asked to refrain from any rigorous lower extremity exercise during the 24-hour period that preceded testing. The dominant limb was tested, which was determined by asking the subject which leg they would use to kick a ball as hard as possible. Approval from the university institutional review board was obtained, and all participants read and signed an approved institutional review board informed consent document prior to participation.

Subjects reported to a laboratory for two testing sessions: (1) an isokinetic testing session and (2) an isometric testing session. Following participant warm-up exercise on a stationary cycle, isokinetic testing was performed (Primus RS, BTE Technologies, Hanover, MD). The participants performed three orientation trials at $30^\circ \cdot s^{-1}$, which were followed with performance of three maximum effort trials at $60^\circ \cdot s^{-1}$ for each muscle group tested. A 1-min rest period was provided between each hip motion tested. The muscle groups were tested in a counter-balanced order, which included the hip flexors (HFs), hip extensors (HEs), hip abductors (ABs), hip adductors (ADs), hip external rotators (ERs), and hip internal rotators (IRs). Single-session intra-class correlation coefficients (ICC$_{3,1}$) among repetitions were as follows: $HF$ ICC = 0.66, $HE$ ICC = 0.92, $AB$ ICC = 0.90, $AD$ ICC = 0.90, $ER$ ICC = 0.88, and $IR$ ICC = 0.78.

To evaluate isokinetic HE and HF, the greater trochanter was aligned with the dynamometer axis of rotation (Figure 1). The lower margin of the dynamometer extremity attachment pad was positioned at 5 cm above the superior pole of the patella (anterior placement for HF; posterior placement for HE). For AB and AD testing, the dynamometer axis of rotation was aligned with the bisection of a vertical line extending...
from the anterior superior iliac spine with a horizontal line at the level of the greater trochanter. The lower margin of the dynamometer extremity attachment pad was positioned at 5 cm above the superior pole of the patella (lateral placement for AB; medial placement for AD).

For the ER and IR, the participants were in a seated position, with both the hip and knee joints at 90° of flexion. The center of the patella was aligned with the dynamometer axis of rotation. The lower margin of the dynamometer extremity attachment pad was positioned above the lateral malleolus for IR testing and above the medial malleolus for ER testing (Figure 2).

The participants performed warm-up exercise on a stationary cycle prior to isometric testing, which consisted of three trials (Evaluator Portable Evaluation System, BTE Technologies, Hanover, MD). Each trial was 5 s in duration with 15 s of rest between each trial.66 The muscle groups were tested in a counterbalanced order, and 1 min of rest was provided between each hip motion tested. The testing was performed in a standing position (Figure 3) for AB, AD, HF, and HE. Testing for ER and IR was performed in a seated position. The reliability of measurements derived from the same procedures has been previously reported: AB ICC = .96–.99, AD ICC = .92–.94, HF ICC = .91–.96, HE ICC = .96–.97, IR ICC = .93–.96, and ER ICC = .90–.93.25

Isometric force was recorded in lbs, which was mathematically converted to N. Peak torque values were derived from multiplication of the measured moment arm (m) by the maximum recorded force (N) for a given motion. All peak torque measures were normalized using an allometric scaling process: PT (Nm)/body mass (kg)0.792 for males and PT (Nm)/body mass (kg)0.482 for females.33

The data were interpreted to be normally distributed,34 and Pearson product moment correlations were calculated to evaluate the strength of associations between peak torque values derived from isokinetic and isometric test modes, both in terms of absolute and allometric-scaled values. The alpha level for statistical significance was set a priori at 0.05, and the coefficient of determination ($r^2$) was used to evaluate the meaningfulness of the proportion of shared variance between pairs of isokinetic and isometric peak torque values.35 An $r^2$ value $\geq$ 0.50 was interpreted as a meaningful relationship.36 Table 1 presents means and standard deviations for the isometric and isokinetic strength values, and Table 2 presents $r$ and $r^2$ values for each muscle group tested. Each of the correlation coefficients was associated with a p-value < 0.05.

**Discussion**

The most important finding of this study is that isometric and isokinetic hip strength measurements shared a significant portion of variance, both in terms of absolute and allometric-scaled values. Our findings for isometric and isokinetic measurements of hip strength appear to be similar to those reported for other muscle groups and differing isokinetic test velocities.28–30 A previous study that compared isometric values to
isokinetic values acquired at 36, 108, and 180°·s⁻¹ documented r-values ranging from 0.71–0.83 for knee extension and 0.49–0.80 for knee flexion, with the correlation strongest at the lower velocities. A previous study that compared hand-held dynamometry and isokinetic dynamometry at 60°·s⁻¹ reported very strong correlations for knee flexion and extension (r = 0.77 to 0.82). The correlation coefficients we found for hip motions are comparable to those reported by others for
knee motions,28,29 but PFD offers advantages that cannot be obtained with hand-held or isokinetic dynamometry. Hand-held dynamometry can require the clinician to produce a high level of manual force to effectively counter the force exerted by the patient, which can also make stabilization of the extremity difficult.26,27,37 The high cost and lack of portability of an isokinetic dynamometer present limitations in many settings that make PFD an attractive alternative. Although an isokinetic dynamometer permits testing at a wide variety of test velocities, our finding of a high degree of association between isometric peak torque (0° · s⁻¹) and low-velocity isokinetic peak torque (60° · s⁻¹) was consistent with the findings of other studies.28-30

The participants in this study were derived from a sample of convenience, which may limit the generalizability of our findings. Although each of the participants was a recreational athlete, varied levels of physical activity may have contributed to variability in the strength values we measured. Differences in the mechanical designs of the two strength testing devices preclude the use of identical lever arm lengths for the hip motions of AB, AD, HE, and HF. The PFD device utilized an ankle strap that was positioned above the lateral malleolus, whereas the dynamometer extremity attachment pad was positioned 5 cm above the superior pole of the patella. The more distal point of lower extremity force application for the PFD procedure may have allowed a greater number of muscles to contribute to HE and HF.

The findings of our study suggest that clinicians may be able to substitute isometric testing for isokinetic testing at 60° · s⁻¹ for reliable assessment of hip strength. The magnitude of association quantified by a correlation coefficient can be highly influenced by the variability of subjects’ measurements, which can be converted to a less variable set of values through the use of allometric scaling. Thus, our finding of higher isometric-isokinetic correlations for normalized strength values than absolute strength values supports the use of allometric scaling, which also provides an optimal means for comparing the performances of individuals with differing amounts of body mass.

**Conclusion**

Our results suggest that isometric PFD testing of hip strength can provide an alternative to isokinetic testing at 60° · s⁻¹.

**References**

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Roger O. Kollock, Jr. is an assistant professor in the Department of Kinesiology and Health at Northern Kentucky University in Highland Heights, KY.

Bonnie Van Lunen is an associate professor in the School of Physical Therapy and Athletic Training at Old Dominion University in Norfolk, VA.

Jennifer L. Linza is an assistant athletic trainer at The Apprentice School in Newport News, VA.

James A. Onate is an associate professor in the School of Health and Rehabilitation Sciences at The Ohio State University in Columbus, OH.

Jatin Ambegaonkar, PhD, ATC, OT, CSCS, George Mason University, is the report editor for this article.