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Reliability of the K-Force Muscle Controller Dynamometer on Eccentric and Isometric Hip Adduction Strength

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Abstract

Hip adduction strength tests are commonly used in clinical practice to provide an accurate diagnosis of groin injuries. Athletes with reduced adductor muscle strength are at risk of developing groin injuries. Our study aimed to evaluate the relative and absolute test-retest reliability of the side-lying eccentric hip adduction strength test and the long-lever adduction squeeze test using the K-Force hand-held dynamometer. Twenty physically active male individuals with a mean age (±SD) of 30.7 (±7.3) years were included. Both tests presented excellent test-retest reliability (Intraclass Correlation Coefficient: 0.77 - 0.95). The best and mean scores of the eccentric and isometric tests presented the smallest test-retest variation (MDC%: 12.8 - 14.9 and MDC%: 14.6 - 18.7, respectively). Our study showed that the K-Force dynamometer has excellent reliability for assessing hip adduction strength in two different testing positions. We suggest the best and mean of three repetitions for clinical practice as they present the lowest variability. Further research evaluating its clinimetric properties in different populations and gender is recommended.

Keywords

Adductor, Groin, Strength Testing, Dynamometer, Reliability

1. Introduction

Groin injuries are common in sports, particularly those that involve change of direction, kicking and increased levels of acceleration and deceleration [1] [2]. Groin injuries are the third most common injury per season in soccer, American football and ice hockey, showing a prevalence between 4% and 16% [2]-[4]. Adductor muscle injuries constitute 63% of all groin injuries and occur at a rate between 0.6 per 1000 exposure hours in professional soccer [1]. The most important risk factors include previous injuries in the groin area, age, decreased hip range of motion, reduced strength of the adductors and abductors and muscle fatigue [5]-[7]. Evidence suggests a strong correlation between low levels of hip adduction strength and groin injuries [8]-[11]. Therefore, accurately measuring hip adduction strength is strongly recommended to improve the prognosis of groin injuries and provide accurate monitoring of athletes towards return to play [12] [13].

Several methods are used in measuring hip adduction strength in both research and clinical settings, such as isokinetic dynamometers, hand-held dynamometers (HHD) and manual muscle testing [14] [15]. Although isokinetic dynamometers are considered the gold standard for measuring muscle strength [16], they are costly, difficult to administer and time-consuming. Alternatively, using hand-held dynamometers, which are inexpensive, portable and user-friendly has been proposed as a valid and reliable method for hip strength testing [17] [18]. Notably, evidence suggests moderate to excellent concurrent validity between hand-held and isokinetic dynamometers when measuring hip extension strength [19] [20].

Several studies evaluating the reliability of hand-held dynamometers in measuring hip adduction isometric strength have reported excellent results (intraclass correlation coefficient [ICC]: 0.76 - 0.97) [21]-[24]; however, most of these reports included isometric strength tests in supine and seated positions. The long-lever isometric test has been previously used as a valid indicator of hip and groin function [25], while the side-lying eccentric test evaluates the contraction type most related to groin injuries presented in sports [26]. Therefore, our study aimed to evaluate the reliability of a hand-held dynamometer for measuring eccentric and isometric hip adduction torque.

2. Materials and Methods

2.1. Participants

Twenty healthy male individuals with a mean (range) age of 30.7 (19 - 45) years, weight 74.3 (66 - 94) kg, height 177 (170 - 187) cm, and leg length 99 (89 - 110) cm, were recruited for the current study. Before participation, the purpose and methods were explained to participants and they signed an informed consent form describing the purpose and risks of the study, in compliance with the standards of the Declaration of Helsinki. Ethical approval was granted by the University of West Attica Ethics Committee (7682/26-10-2023). Participants were included if they were athletes aged 18 - 60 who engaged in any form of exercise at least once a week. Participants were excluded from the study in the presence of a history of hip injury within the last six months, hip pain during the adduction strength tests, neurological diseases, cardiovascular problems, and history of surgery in the lower limb. Participants were asked to avoid any hip resistance exercise for one week before measurements.

2.2. Study Design and Procedure

A power analysis was conducted before the initiation of the study using G* power software (v. 3.1, Heinrich-Heine-Universität, Düsseldorf, Germany). The expected ICC was set at 0.75 to ensure excellent reliability (0.80 power and a significance level of 0.05) [27]. A sample size of 18 participants was considered adequate for the study, and 20 participants were included to account for dropouts.

All participants visited the same laboratory setting (Physiotherapy Department, University of West Attica), and an independent assessor (CP) recorded their demographic characteristics, including age, body weight, height, lever length, and type and frequency of activity. The lever length was measured from the anterior superior iliac spine to the point of placement of the hand-held dynamometer, allowing for torque calculation normalised to body weight (Nm/kg) [18] [28].

Test-retest reliability was determined by two identical testing sessions performed at the same time of day with one week between them. The K-Force Muscle Controller (Kinvent Hellas) was used for the measurement of hip adductor muscle torque following standardised procedures [18] [24]. The rater (AE), a male physiotherapist with five years of clinical experience, attended a two-hour training session before study initiation and performed a pilot application of the measurements on three individuals not included in the main study. During testing, the rater was blinded to the scores obtained and performed all measurements following the same sequence of tests and setups. The experimental procedure included 1) the side-lying eccentric hip adduction strength test and 2) the long-lever hip adduction squeeze test at both extremities. Before testing all participants performed a warm-up on a static bicycle ergometer for ten minutes at a low intensity. Then familiarisation with the testing procedure was achieved by performing three submaximal repetitions as initially determined in the original protocol. These were followed by three maximal efforts for each test. The rater verbally encouraged all participants to ensure maximal effort during testing. A two-minute beak was included between the tests to avoid any fatigue effects on strength results [28].

2.3. Side-Lying Eccentrichip Adduction Strength Test

Participants laid on the side of the leg being tested, as shown in **Figure 1**. The hip and knee of the lower leg were in a neutral position, while the opposite hip and knee were in 90 degrees of flexion on a pillow for stabilisation. The participants held onto the side of the examination table with the upper hand, with their heads placed on the lower arm [29]. The examiner brought the tested extremity into full adduction and placed the HHD 5 cm proximal to the lower edge of the medial malleolus. The participants were asked to push as hard as possible, "bringing their leg towards the ceiling", with the examiner applying a downward force to the limb. Then, the examiner broke the participant's resistance, bringing the hip to abduction. Each measurement lasted five seconds [18] [29]. The procedure was performed three times with a 30-second break between the repetitions [12] [18].

Figure 1. Side-lying eccentric hip adduction test.

2.4. Long-Lever Hip Adduction Squeeze Test

Participants laid in a supine position with hips and knees in 0 degrees of flexion (**Figure 2**). The rater placed the hand-held dynamometer 5 cm above the medial malleoli. The participants' legs were abducted to the length of the rater's forearm [28]. The participants held onto the sides of the table with both hands. The participants were asked to push as hard as possible for five seconds, trying to bring both legs into adduction with the examiner resisting that movement. The procedure was repeated two more times with a 30-second break between the repetitions [28].

Figure 2. Long-lever hip adduction squeeze test.

2.5. Statistical Analysis

Participants' demographic characteristics and baseline measurements are presented with mean (±standard deviation, SD) and range of values. Tests of normality (Shapiro-Wilk test and QQ plots) showed a normal distribution of the data. The first, best and average values of the three repetitions of both legs are presented, along with baseline-follow-up mean differences. Aiming at generalization of the reliability results to raters with similar characteristics as the rater of the current study, an $ICC_{2,1}$ with a two-way random effects model was used for relative reliability to be assessed. Reliability was considered excellent for ICC > 0.75, fair for ICC between 0.4 and 0.75, and poor for ICC < 0.4 [30]. Data are presented in 95% confidence intervals (CIs). Absolute reliability was assessed using the standard error of measurement $\left[SEM = SD \times \sqrt{1 - \text{test retest reliability coefficient}}\right]$ and minimal detectable change $\left[MDC_{95} = 1.96 \times \sqrt{2} \times SEM\right]$. One sample t-test was used to assess statistically significant differences between eccentric and isometric adduction torque of each leg for each test, using the mean scores. Statistical analysis was performed using SPSS Statistics (version 29, IBM Corporation) and statistical significance was set at $p \leq 0.05$.

3. Results

Twenty healthy individuals were included in the study, with no dropouts recorded. Participants reported no discomfort or pain during or after testing. Table 1 presents the demographic characteristics of the participants.

Table 1. Demographic characteristics of participants (N = 20).

Characteristic	Mean ± SD (range) or No (Percentage)
Age (years)	30.75 ± 7.5 (19 - 45)
Sex (men)	20 (100%)
Height (cm)	177 ± 6.4 (170 - 187)
Weight (kg)	74.3 ± 8.6 (66 - 94)
Leg length (cm)	99 ± 5.8 (89 - 110)
Exercise type (no of individuals)	weightlifting (6), climbing (5), running (3), soccer (3) cycling (1), volleyball (1), basketball (1)
Exercise frequency per week	4.45 ± 0.88 (3 - 6)

Abbreviations: SD, standard deviation; kg, kilograms; cm, centimeters; N, sample

Table 2 presents the first, best and mean scores (±SD) of the torque tests for both legs. Follow-up measurements showed excellent reliability for the side-lying eccentric hip adduction strength test for both legs (ICC: 0.95; 95% CI: 0.88 - 0.98). Similarly, excellent reliability was recorded for the long-lever hip adduction squeeze test for both the right (ICC: 0.92; 95% CI: 0.56 - 0.97) and left legs (ICC: 0.90; 95% CI: 0.57 - 0.97) (Table 2). There was no statistically significant variation between test and retest values for both test positions (MDC%: 12.8% - 27.1%). The best and mean scores of the side-lying eccentric hip adduction strength test presented the smallest test-retest variation (MDC%: 12.8 - 14.9), while the best and mean scores of the long-lever hip adduction squeeze test showed slightly higher variation (MDC%: 14.6 - 18.7) (Table 2). The first repetition of both hip adduction strength tests showed the highest test-retest variation (MDC%: 17.7 - 27.1).

Table 2. Torque values (Nm/kg) and reliability measures of the side-lying eccentric hip adduction strength test and long-lever hip adduction squeeze test.

Test position	Test mean (±SD)	Retest mean (±SD)	Difference mean (±SD)	ICC (95% CI)	SEM (95% CI)	SEM% (95% CI)	MDC% (95% CI)
Side-lying eccentric hip adduction test (R)							
First of 3 reps	3.71 (0.85)	3.74 (0.82)	0.04 (0.52)	0.91 (0.78 - 0.96)	9.78 (5.04 - 17.02)	7.38 (2.77 - 12.85)	20.46 (7.70 - 35.76)
Best of 3 reps	4.14 (1.04)	4.07 (1.03)	−0.07 (0.53)	0.96 (0.89 - 0.98)	5.28 (2.86 - 9.07)	6.61 (2.67 - 11.30)	18.33 (7.41 - 31.28)
Mean of 3 reps	3.68 (0.94)	3.74 (0.94)	0.06 (0.39)	0.95 (0.87 - 0.98)	5.32 (2.97 - 9.29)	5.38 (2.67 - 9.11)	14.92 (7.41 - 25.28)
Side-lying eccentric hip adduction test (L)							
First of 3 reps	3.57 (0.84)	3.62 (0.76)	0.05 (0.45)	0.84 (0.22 - 0.95)	0.27 (0.08 - 0.47)	6.41 (2.58 - 11.22)	17.78 (7.17 - 30.98)
Best of 3 reps	3.98 (0.94)	3.97 (0.89)	−0.01 (0.37)	0.91 (0.56 - 0.97)	0.27 (0.07 - 0.46)	4.65 (2.3 - 7.89)	12.88 (6.41 - 21.70)
Mean of 3 reps	3.6 (0.85)	3.6 (0.76)	−0.01 (0.35)	0.90 (0.57 - 0.97)	0.2 (0.05 - 0.34)	4.94 (2.46 - 8.39)	13.69 (6.81 - 23.27)
Long-lever hip adduction squeeze test (R)							
First of 3 reps	3.29 (0.74)	3.71 (0.71)	0.41 (0.53)	0.77 (0.24 - 0.92)	0.34 (0.08 - 0.58)	9.78 (5.04 - 17.02)	27.13 (13.01 - 47.7)
Best of 3 reps	3.86 (0.67)	4.13 (0.71)	0.27 (0.32)	0.90 (0.56 - 0.97)	0.21 (0.05 - 0.36)	5.28 (2.86–9.07)	14.63 (7.92 - 25.04)
Mean of 3 reps	3.56 (0.69)	3.82 (0.7)	0.26 (0.29)	0.92 (0.56 - 0.97)	0.2 (0.05 - 0.35)	5.32 (2.97–9.29)	14.75 (8.23 - 25.72)
Long-lever hip adduction squeeze test (L)							
First of 3 reps	3.43 (0.84)	3.88 (0.75)	0.44 (0.45)	0.89 (0.73 - 0.95)	0.31 (0.12 - 0.54)	6.41 (2.58 - 11.22)	23.65 (9.10 - 41.01)
Best of 3 reps	3.75 (0.93)	4.1 (0.85)	0.34 (0.4)	0.93 (0.82 - 0.97)	0.26 (0.07 - 0.47)	4.65 (2.31 - 7.89)	18.73 (7.83 - 32.61)
Mean of 3 reps	3.55 (0.83)	3.86 (0.77)	0.31 (0.37)	0.95 (0.88 - 0.98)	0.24 (0.06 - 0.42)	4.94 (2.46 - 8.39)	18.11 (7.49 - 31.87)

Abbreviations: SD, Standard Deviation; ICC, Intraclass Correlation Coefficient; CI, Confidence Interval; SEM, Standard Error of Measurement; MDC, Minimal Detectable Change; R, right; L, left; reps, repetitions.

There was no statistically significant difference in the mean torque between the eccentric and the isometric hip adduction tests (mean difference: −0.08; 95% CI: −0.45, 0.28; p = 0.64). **Figure 3** shows the mean torque of each test position.

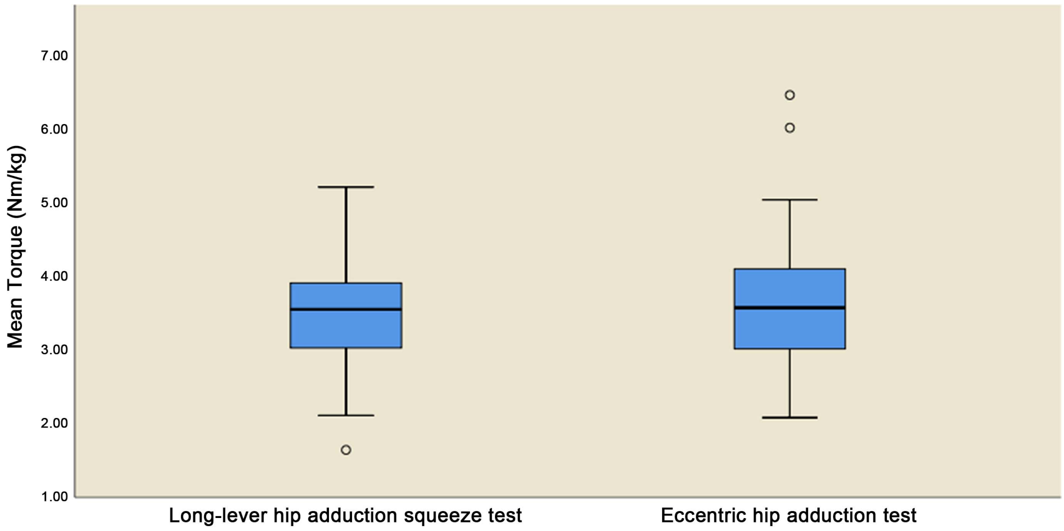

Figure 3. Mean torque values presented in (Nm/kg) Dots represent individual measurements.

4. Discussion

Our study evaluated the relative and absolute reliability of the hand-held dynamometer K-Force in measuring hip adduction torque in two different positions in 20 healthy male athletes. Both the side-lying eccentric hip adduction strength test and the long-lever hip adduction squeeze test showed excellent ICC values and acceptable test-retest measurement variations, supporting their further clinical use.

The results regarding the relative reliability of the K-Force dynamometer were in line with previous reports that also presented excellent ICC values for measuring hip adduction strength with other hand-held dynamometers in the side-lying (ICC: 0.75 - 0.78) [30] and supine positions (ICC: 0.76 - 0.98) [18] [31] [32]. Evidence suggests a moderate-to-high correlation between handheld and isokinetic dynamometers for measuring muscle strength during different types of joint movements [21]. Notably, hip adductor strength tests consistently present the highest correlation between the two types of dynamometry [21]. Hence, the present device, along with other handheld dynamometers, can be a practical, inexpensive and accurate assessment tool of hip adduction strength in the clinical setting.

Based on the present findings, the best of the three repetitions showed the lowest test-retest variability, suggesting the highest absolute reliability for both testing positions. Similar variability was reported for the mean scores of the two strength tests, indicating that using either the best or the mean scores can be reliable. On the other hand, the highest variability was observed in the first repetition measurement, especially for the long-lever hip adduction test (MDC%: 23.6

- 27.1). Our findings significantly differed from previous studies that suggested a precise measurement with only one trial (MDC% = 13.6 - 13.7). Therefore, we propose that clinicians should rely on the best or mean of three repetitions rather than the score of one repetition when applying the current tests with the K-Force device.

According to the study results, the mean torque score of the long-lever hip adduction squeeze test using the K-Force dynamometer was similar to previous reports evaluating the same testing position using other devices in healthy athletes [28] [29] [33]. Hip adduction strength during the squeeze test in the supine position has been widely used to accurately diagnose and monitor patients with groin injuries and to effectively identify athletes who are at risk of developing this type of injury [5] [34]. The literature shows that a wide variety of tests were used, including long- and short-lever (with or without examiner stabilisation), presenting excellent reliability for variation [14] [22]-[24] [28]. However, the long-lever squeeze test produced significantly higher torque output compared to the short-closed positions [28] [29] [33]. Thus, the current test is considered clinically more efficient to facilitate the hip adductor muscle elongation and in turn, to produce higher anatomical stress on the musculature and pubic complex [28] [33].

Our findings suggest that the side-lying eccentric hip adduction test showed higher reliability (ICC: 0.89 - 0.95) compared to the long-lever squeeze test (ICC: 0.77 - 0.92). Also, no difference was found in the mean torque output between the tests, which may be attributed to the inclusion of healthy athletes without groin injuries. Notably, the eccentric hip adduction test presented significant deficits in soccer players with adductor-related groin pain compared with asymptomatic soccer players, while no strength differences were found in the long-lever hip adduction squeeze test between the same groups [35]. Eccentric hip adduction torque should, therefore, be measured to monitor healthy individuals and patients with adductor-related groin pain [35].

Limitations and future research

The present study results should be viewed in light of some limitations. Our study sample included only men and amateur athletes, which limits the general ability of the study findings to clinical populations. With regards to the participants' participation in different sports, their homogeneity might have increased the levels of variability in the final reliability results. In addition, although we included an adequate rest phase between the tests, the testing order was the same, and increased muscle fatigue following the eccentric contraction might have influenced the results of the maximal isometric torque. Further evaluation of the psychometric properties of the K-Force muscle controller dynamometer for measuring hip strength in elite athletes and patients with groin pain is necessary.

5. Conclusions

The present study showed that the K-Force dynamometer has excellent test-retest reliability for assessing hip adduction torque with side-lying eccentric and long-lever isometric squeeze tests. The best and mean of the three repetitions presented the least variability for both testing positions and should be considered for clinical use in male athletes. Further research evaluating the inter-rater reliability and validity of the current hand-held dynamometer for measuring hip adduction muscle torque in different populations is recommended.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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