You don't run lying down - A novel tool to assess standing isometric hip-extension strength: A pilot study

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Football | **Gluteus Maximus** | **Hamstring** | **Monitoring** | **Soccer** | **Testing**

Headline

Team sports have a high number of acceleration, deceleration, jumping and landing actions or change of directions. These actions can induce high levels of fatigue via rapid braking and explosive development of large forces (1) and increases the risk for hamstring strain injuries (2). To assist in supporting the hamstrings in the stance phases of running, the hip has to produce high forces, especially during sprinting and higher running speeds (3). Edouard et al. (4) found that the gluteus maximus, a hip extensor muscle, plays a compensatory role to protect the hamstrings from too much overload when they are fatigued. Thus, assessing their capacity could be paramount in reducing non-contact injuries attributable to fatigue.

Aim

Several different tests and devices are used to examine deficits in hip extensor strength and limb imbalances, under acute and chronic fatigue (5). Typically, hip extension strength is measured via isokinetic dynamometers, handheld dynamometers or force plates. These methods to assess hip extensor strength in athletes, tend to lack ecological validity, as they are either conducted in seated or lying positions (1,5). In contrast to the current methodologies, most sports and hamstring strain actions take place in upright positions (6), which should also be mirrored by the testing procedure. Therefore, there is a need for a novel test measuring hip-extensor strength in a standing position that should be easy to use, quickly applicable, and ecologically valid. Therefore, the aim of this study was to assess the reliability of an isometric assessment of standing hip extensor strength.

Design

Observational, cross-sectional test-retest reliability.

Methods

Nine participants were recruited to participate in this study and consisted of healthy male and female sports students (Age = 22.6 ± 4.0yrs). Exclusion criteria were stated as any disease, disorder, or injury in the past three months that could cause any significant decrement in isometric hip extensor strength. All participants were informed of the requirements, risks and benefits of the study, and of their right to withdraw, and subsequently gave written informed consent for participation. The study was approved by the institutional ethics committee (University of Gloucestershire, School of Sport and Exercise - Research Ethics Panel code [JHUGHES 21-22]).

Procedures

The study consisted of seven measurements taking place at different time points, on different days, planned without a standardised order. The seven sessions were split into three familiarisation sessions followed by four measurement sessions. The familiarisation sessions consisted of 12 maximal contractions per day, with six pulls of the dominant and six of the non-dominant leg.

The Hip extension test took place in a standing position with force determined through a strain gauge (Model AST500, Precision Transducer Ltd., Auckland, New Zealand). The strain gauge was connected to an amplifier (CED1902, CED Ltd., Cambridge, United Kingdom) and translated through a data acquisition unit (Micro3 1401, CED Ltd., Cambridge, United Kingdom). The resulting data was read and saved by the associated CED-software package (3). The strain gauge was fixed to the participant's ankle via an ankle strap with their knees in full extension during testing and their feet directly next to each other and arms crossed over their chests. This foot position ensured balance was maintained while doing the pull. Every contraction was initiated after asking for readiness and counting down "3, 2, 1, PULL!" and ended after the experimenter told the participants to relax. The contraction time was standardised to three seconds. A recovery period of 40 seconds was used in-between maximal contractions (9). During the first second of the pull, the participant had time to build up maximal force, without losing balance. Consequently, the initial second was excluded from any further analyses. While doing the measurement, they were not allowed to flex the knee or put any body weight into the movement at any time. A picture of the testing position can be seen in Figure 1.

Statistical Analyses

All data were analysed by using R studio software (7). Reliability calculations were done on both the average and maximum value of each pull. Normality was assessed using the Shapiro-Wilk test with the Levene's test used to test for homogeneity of variance. The selection of the associated ICC models followed the guidelines of Koo and Li (8). ICCs and their 95% confidence intervals were calculated based on single measurements, with absolute agreement, two-way mixed-effects model. ICC values lower than .50 were defined as low, .50 - .75 as moderate, .75 - .90 as high, and values bigger than .90 as excellent reliability (8). Test-retest reliability was estimated by using the same intraclass correlation coefficient for every measure (ICC3.1) and was calculated using the R-software package "psych" (9). The coefficient of variation (CV) was used as a measure of relative reliability, which allows for the comparison of error variances between each variable (10). Acceptable limits of the CV were set to < 10%. ICC and CV calculations were established for all 12 measurements per leg independently, without considering the testing day (k = 12), and for all testing days separately, according to three measurements done per leg (k = 3). The level of significance for all calculations was set to $\alpha \leq .05$.

Fig. 1. Testing procedure in standing position.

Table 1. Intraclass correlation coefficient scores and coefficient of variation values across four test sessions for isometric peak force.

	Method	Leg	Force (kg)	ICC [90% CI]	CV (%)
Overall	Mean	D	11.86 ± 2.75	.79 [.63 - .92]	11.85
		ND	10.94 ± 2.69	.79 [.63 - .92]	12.44
	Max	D	13.46 ± 2.94	.81 [.67 - .94]	10.58
		ND	12.50 ± 2.91	.81 [.67 - .94]	10.38
Day 1	Mean	D	11.70 ± 3.03	.85 [.66 - .96]	11.93
		ND	11.04 ± 2.99	.70 [.39 - .90]	11.86
	Max	D	13.36 ± 3.06	.95 [.86 - .98]	7.81*
		ND	12.60 ± 3.12	.75 [.46 - .92]	9.50*
Day 2	Mean	D	11.69 ± 2.86	.59 [.24 - .86]	11.56
		ND	11.03 ± 3.04	.85 [.65 - .96]	7.83*
	Max	D	13.32 ± 3.24	.66 [.33 - .89]	9.92*
		ND	12.63 ± 3.30	.96 [.90 - .99]	5.51*
Day 3	Mean	D	11.68 ± 2.45	.71 [.41 - .91]	11.59
		ND	10.53 ± 2.25	.86 [.65 - .96]	7.45*
	Max	D	13.21 ± 2.62	.74 [.44 - .91]	10.27
		ND	12.17 ± 2.48	.90 [.74 - .97]	7.17*
Day 4	Mean	D	12.36 ± 2.70	.86 [.68 - .96]	8.56*
		ND	11.16 ± 2.51	.70 [.39 - .90]	12.35
	Max	D	13.94 ± 2.89	.88 [.70 - .96]	6.72*
		ND	12.61 ± 2.81	.71 [.39 - .90]	10.67

Notes: Force and descriptive statistics are displayed in kilograms as means ± standard deviations; ICC: Intraclass correlation coefficient; CV: Coefficient of variance in per cent; *: Coefficient of variances being within acceptable limits (<10%); D = Dominant leg; ND = Non-dominant leg; Overall: Reports the overall ICC, with k = 12; Day 1-4: Distinction of the testing day-specific ICC's, with k = 3

Results

A summary of the results, including all values for ICC and CV for hip extension max force for dominant and non-dominant limbs can be found in table 1.

Discussion

The primary finding of this study was that the isometric hip extension test shows good repeatability after familiarization. It was also demonstrated that hip extension force was affected by limb dominance. This is, to the best of authors' knowledge, the first study examining the reliability of isometric hip extension testing in a standing position.

Overall repeatability was observed to be good. Nevertheless, this studies' results indicated slightly lower ICC's, and slightly higher CV's, compared to methodologies measuring isometric hip extension with force plates (5), handheld dynamometers or isokinetic dynamometers (11). This studies' methodology was chosen to allow for a lot of variation, purposed to challenge the ICC, and mimic variation that may be present in field testing of strength measures in professional teams. Previous methodologies only tested across two days to establish test-retest reliability one week apart and controlled for fatigue up to three days prior to testing and at the same time on the respective testing day (11, 5). Therefore, limiting factors like training before measurements and fatigue (12), the time between measurement days and the time of measurement (13), makes the lower reliability coefficients of the novel test not only unsurprising, it shows that the test is relatively robust to these constraints. This leads to the assumption, that if the current test were used in a more controlled environment similarly to the abovementioned methodologies, its reliability coefficients would improve remarkably.

Compared to previous testing methodologies, this test possesses several strengths. It is portable, and more feasible than isokinetic dynamometers, it can be used in athlete groups without being dependent on the practitioners' strength like in handheld dynamometers, and it is done in a more ecologically valid position, standing not laying or seated. In terms of data applicability, the current results suggest that the application of max force values provide a more reliable measurement; however, further research is needed to confirm this finding.

Practical applications

Early results demonstrate the novel methodology could be a promising monitoring tool in team-sports environments to identify fatigue; ideally providing coaches and practitioners information that could support tactical decisions to prevent non-contact injuries and reduce time loss, based on data from a more ecologically valid method. It should be noted that this is a pilot study and further development is required. Consequently, future research should focus on the tests' reliability in a more controlled environment, validity, and sensitivity to fatigue.

Limitations

- There is a need for assessment of this test to ascertain which muscles are contributing and their level of activation to the development of peak force during this test should be undertaken.
- There is a need for assessment of this test to show sensitivity to changes in performance following field-based locomotion activities to examine fatigue and monitor both acute and chronic changes in strength should be undertaken.

Disclosure Statement

The authors report no conflict of interest.

Accompanying dataset

Data available on request.

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