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Reliability of externally fixed dynamometry hamstring strength testing in elite youth football players

Martin Wollin[a,*], Craig Purdam[a,b], Michael K. Drew[a,b]

[a] *Department of Physical Therapies, Australian Institute of Sport, Australia*
[b] *University of Canberra, Australia*

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ABSTRACT

Objectives: To investigate inter and intra-tester reliability of an externally fixed dynamometry unilateral hamstring strength test, in the elite sports setting.
Design: Reliability study.
Methods: Sixteen, injury-free, elite male youth football players (age = 16.81 ± 0.54 years, height = 180.22 ± 5.29 cm, weight 73.88 ± 6.54 kg, BMI = 22.57 ± 1.42) gave written informed consent. Unilateral maximum isometric peak hamstring force was evaluated by externally fixed dynamometry for inter-tester, intra-day and intra-tester, inter-week reliability. The test position was standardised to correlate with the terminal swing phase of the gait running cycle.
Results: Inter and intra-tester values demonstrated good to high levels of reliability. The intra-class coefficient (ICC) for inter-tester, intra-day reliability was 0.87 (95% CI = 0.75–0.93) with standard error of measure percentage (SEM%) 4.7 and minimal detectable change percentage (MDC%) 12.9. Intra-tester, inter-week reliability results were ICC 0.86 (95% CI, 0.74–0.93), SEM% 5.0 and MDC% 14.0.
Conclusions: This study demonstrates good to high inter and intra-tester reliability of isometric externally fixed dynamometry unilateral hamstring strength testing in the regular elite sport setting involving elite male youth football players. The intra-class coefficient in association with the low standard error of measure and minimal detectable change percentages suggest that this procedure is appropriate for clinical and academic use as well as monitoring hamstring strength in the elite sport setting.

1. Introduction

Football is a popular sport played worldwide by men, women and children of all ages. Playing football is associated with both health benefits and injury risk.[1,2] Hamstring injuries (HI) are the most common injury in male professional players, responsible for significant time loss and high recurrence rates.[3–5] The long head of biceps femoris (LHBF) muscle demonstrates the highest incidence and recurrence rate of HI in football.[6] Increasing age, past injury, match play and weekly match frequency are established risk factors for HI.[1,3,4] Of the intrinsic, modifiable risk factors, strength deficits and imbalances are easy to quantify. Athletes with a previously injured hamstring can present with significant strength deficits compared to the non-injured side after returning to sport.[7,8]

Bilateral hamstring strength asymmetry has been identified as a potential risk factor for HI in football.[9,10] Corrective strength training and re-testing of strength deficits and imbalances measured at pre-season in football players demonstrated reduced HI rates compared to players that did not correct strength imbalances.[9] Statistically selected cut-offs included a bilateral hamstring strength asymmetry greater than 15%.[9]

The hamstrings are sensitive to football induced fatigue demonstrated by decreased isometric, concentric and eccentric strength after match play and repeated sprint efforts.[11–13] Hamstring injuries frequently occur during fast speed running towards the late or terminal swing phase of the running gait cycle.[14] The terminal swing phase involves hip flexion and approximately 30–45° knee flexion.[15] During this phase of fast running the hamstring biomechanical loads appear to increase resulting in peak knee flexion torque and muscle lengths.[15–17] In vivo measurements of the human LHBF propose that it primarily works on the plateau and descending arm of the length-tension curve, which involves 45–90° of hip flexion and 0–90° of knee flexion.[18] The incorporation of 45°

* Corresponding author.
E-mail address: martin.wollin@ausport.gov.au (M. Wollin).

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of hip flexion has been suggested as a method to utilise a larger range of the muscle length–tension relationship during hamstring exercise.[18]

An objective physical measure of fatigue in the absence of injury to measure strength reductions is needed. The frequency of football actions during match play has been correlated with muscle damage and fatigue up to 72 h post-match.[11,19] Typically, football training and occasionally match play resumes within 72 h post-match, which suggests that player fatigue is still prevalent in this period. A valid and reliable hamstring test that can be integrated efficiently and safely in the regular training environment may assist staff in the clinical reasoning and decision making process around HI and football induced fatigue. The majority of hamstring strength testing is performed seated, which is a non-functional position in relation to terminal swing of the running gait cycle. Acceptable inter-tester reliability of externally fixated dynamometry knee flexion strength has previously been demonstrated[7,20,21]; however, these studies were performed seated, prone or kneeling.

Isokinetic dynamometry remains the gold standard for strength testing. However, the use of hand held dynamometers for strength testing is increasing in popularity in elite sport programmes. Several reasons exist for the increased popularity of using hand held dynamometers such as time efficiency, cost of the device and results being available immediately. Prior to implementing dynamometry into the regular elite sport setting, the intra and inter-tester reliability as well as the standard error measure (SEM) and minimal detectable change (MDC) need to be established to make an informed decision on the best method for use in the clinic, player monitoring programmes and research.

The objectives of this study were (i) to investigate inter and intra-tester reliability of a hamstring strength test in a position associated with terminal swing in the elite sport setting of which it is to be applied (ii) to determine the SEM and (iii) to determine MDC.

2. Methods

Twenty-one male youth football players from a centralised national elite player development programme gave written informed consent to participate in the study. All players had one familiarisation session prior to data collection. For inclusion in the study players had to be free of any lower limb injury and involved in regular football training. This study was approved by the Australian Institute of Sport Ethics Committee.

Testing was performed in the clinical area of the Department of Physical Therapies, Australian Institute of Sport. The testing was conducted by a senior sports physiotherapist with 13 years of sport specific experience and a junior physiotherapist with 6 years of clinical experience. The testers were blinded from each other and performed the test procedure separately.

The setup and equipment included a calibrated load cell secured to the floor, an electronic examination table, a seatbelt and a portable 45° wedge (Fig. 1). Maximum voluntary isometric peak force was recorded on an electronic display (Omni Instruments AMLTR-150+RS232, product number TR150, United Kingdom) connected to a load cell (XTRAN S1W-9KN, Australia). Forces were converted to torque in accordance with published reports.[22]

Inter-tester, intra-day data was collected 10 min apart. Intra-tester, inter-week results were collected on the same day and time one week apart. Between testing sessions all participants were in the competitive season following their normal training and match cycle. The testing procedure was standardised and participants instructed to stabilise themselves on the inclined wedge, in prone, and holding on to its corners. The wedge design ensured that hip flexion was standardised to 45°. A fixed goniometer was used to set knee flexion at 30°. Axis of movement was taken on the lateral side of the knee with goniometer arms pointing towards the greater trochanter proximally and lateral malleolus distally. The seat belt was placed across the lower leg five centimetres (cm) proximal to the distal point of the lateral malleolus. Lever length was measured from the lateral joint line at the knee to 5 cm proximal to the lateral malleolus. The testing procedure involved two practice repetitions and one maximal test effort of each leg separately. Each repetition was 5 s in duration followed by 10 s rest between practices and 20 s rest between the final practice and the maximal test effort. Instructions of “go ahead, pull, pull, pull, pull and relax” were given and vigorous verbal encouragement was provided during the maximal test. Less than 5 min was required to administer the test per player. Tester sequence was randomised for the inter-tester sessions. Leg testing order was randomised for both the intra and inter-tester sessions.

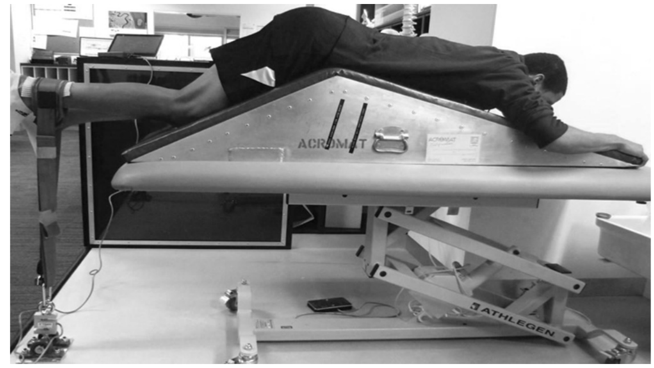

Fig. 1. Testing set-up.

To assess the relative reliability intra-class correlation coefficients ($ICC_{2,1}$) absolute agreement, single measure with corresponding 95% confidence intervals (95% CI) were utilised. The absolute reliability was examined and the SEM ($SD \times \sqrt{1-ICC}$) and MDC ($SEM \times 1.96 \times \sqrt{2}$) were calculated utilising the same methodology as previous dynamometry studies[23,24] and based on Weir.[25] SEM% and MDC% were calculated by dividing their respective value with the related average of the test and retest values. The relative reliability was evaluated in accordance with previously defined criteria (poor = 0.60–0.69, fair = 0.70–0.79, good = 0.80–0.89, high = 0.90–0.99).[26] Post hoc power calculations indicated that this study is adequately powered ($\alpha = 0.05$, $\beta = 0.999$). To compare left and right as well as dominant and non-dominant legs a two-sample t-test with unequal variances was utilised. All calculations were performed using SPSS version 19 (SPSS Inc., Chicago, IL, USA). Statistical significance was set at $p < 0.05$ for all calculations.

3. Results

Five players were excluded from the study, two due to a current lower limb injury and three due to incomplete data. In total, 16 players completed the study involving 32 lower limbs, age = 16.81 ± 0.54 years, height = 180.22 ± 5.29 cm, weight = 73.38 ± 6.54 kg, and BMI = 22.57 ± 1.42. The reliability of the hamstring strength results is presented in Tables 1 and 2. Inter and intra-tester values demonstrated good to high levels of reliability. ICC for combined inter-tester, intra-day reliability was 0.87 (95% CI = 0.75–0.93), SEM% 4.7 and MDC% 12.9 (Table 1). Combined intra-tester, inter-week reliability results were ICC 0.86 (95% CI = 0.74–0.93), SEM% 5.0 and MDC% 14.0 (Table 2). The distribution of player’s preferred kicking leg, defined as the dominant leg, was right, $n = 11$ and left, $n = 5$. The dominant limbs were significantly