applied sciences

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# Reliability of a Field-Based Test for Hamstrings and Quadriceps Strength Assessment in Football Players

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**Featured Application: Knee injuries, such as an anterior cruciate ligament tear, may occur when there are deficits in the hamstring and quadriceps strength as the force production of these muscles is key to maintaining dynamic knee stability during athletic manoeuvres. The current study presents a field-based test with acceptable day-to-day reliability for the assessment of hamstring and quadriceps isometric strength. This tool allows simple field assessments of hamstring and quadriceps strength on a custom-built bench which can be employed to detect muscle deficits during injury prevention and management processes of football teams.**

**Abstract:** Background: Field-based tests using portable devices are extremely helpful to assist physicians and coaches in the assessment of athletes' muscle strength and for injury risk screening. The aim of this study was to investigate the reliability of a field-based test to assess unilateral hamstring and quadriceps isometric muscle strength in a nearly extended position (30° knee flexion) in football players. Methods: Nineteen male football players completed the field-based test on two separate occasions, one week apart, to produce a test–retest design. To complete the test, participants performed maximal isometric efforts on a custom-built bench with 30° of knee flexion and 90° of hip flexion while the force applied was measured with a portable load cell at 80 Hz. On each occasion, participants performed two 2 s maximal isometric repetitions intending to flex and extend the knee to assess hamstring and quadriceps strength, respectively. In each repetition, the force developed during the maximum voluntary isometric contraction (MVIC) and rate of force development (RFD) metrics for hamstring (H) and quadriceps (Q) were collected, and the H:Q ratio was calculated afterwards. Results: MVIC showed the highest reliability for the measurement of both hamstring and quadriceps strength (ICC > 0.80, [95% CI: 0.55, 0.96]; CV < 14%, [95% CI: 6.6, 20]) and for H:Q (ICC > 0.75, [95% CI: 0.48, 0.95]; CV < 15%, [95% CI: 8.9, 22.4]). $RFD_{0–150}$ and $RFD_{0–250}$ yielded moderate reliability values for hamstring strength (ICC = 0.78–0.86, [95% CI: 0.52, 0.94]; CV = 20–27%, [95% CI: 15, 39.7]). $RFD_{0–50}$ presented the largest variability (ICC < 0.80, [95% CI: 0.62, 0.95]; CV > 25%, [95% CI: 19.2, 45.3]). Conclusions: The field-based test presented here provided reliable results for the measurement of maximal isometric hamstring and quadriceps strength and for the calculation of the H:Q ratio. However, the measurement of RFD with this test is less reliable. This test allows reliable field-based assessments of hamstring and quadriceps maximal isometric strength which can be helpful to identify muscle strength deficits and imbalances during injury prevention and management processes in football players.

**Keywords:** risk factors; athletic injury; muscle strength; isometric contraction; anterior cruciate ligament



**Citation:** Miralles-Iborra, A.; Moreno-Pérez, V.; Del Coso, J.; Courel-Ibáñez, J.; Elvira, J.L.L. Reliability of a Field-Based Test for Hamstrings and Quadriceps Strength Assessment in Football Players. *Appl. Sci.* **2023**, *13*, 4918. https://doi.org/10.3390/app13084918

Academic Editors: Matej Supej and René Schwesig

Received: 10 March 2023
Revised: 7 April 2023
Accepted: 12 April 2023
Published: 14 April 2023

## 1. Introduction

Strength assessment is of critical importance in sports medicine during the injury management and return-to-play process. Identifying inadequate strength levels or muscle imbalance may assist in reducing the injury risk [1,2]. In addition, strength measurements are widely advocated for assessing injury severity and prognosis, and as an effective assessment for controlling injury rehabilitation success [3,4]. Specifically, strength imbalance between knee flexor (hamstring) and extensor (quadriceps) muscles has been suggested as a risk factor marker for an acute hamstring injury and re-injury [5–7]. Furthermore, a recent review pointed out that lower limb injuries, such as anterior cruciate ligament tears, can occur when hamstrings are limited to produce force enough for the slow rotation or high shear of the anterior tibia in the extended movements of the knee, which are induced by the maximum strength of the quadriceps [8].

It is well-known that isokinetic dynamometers are the gold standard for strength assessments in clinical settings; however, they are expensive and difficult to transport, which limits their use in the field. On the other hand, at present, one can easily and automatically collect force metrics while providing real-time visual feedback using force plates or portable force sensors attached to a bench, a post or a table [9–11]. This opens a window to provide physicians and coaches with more practical and user-friendly tools for strength assessment and injury risk screening.

Muscle strength in the lower limb is commonly tested through the maximum voluntary isometric contraction (MVIC) as the highest force the individual can produce during an isometric test [12,13]. MVIC is a reliable variable during isometric knee flexion and extension tests using hand-held dynamometers [14,15] and fixed force sensors [16–18]. However, whereas MVIC can be useful to determine the force production in the late phase of the muscle contraction (300 ms after the contraction onset), it seems limited to check the players' ability to produce force immediately after the contraction onset (0 to 200 ms) [12,19].

An alternative to the MVIC, the rate of force development (RFD) emerged as a more accurate measure to screen the force production at rapid events, which may describe better players' performance during football match-specific movements [20]. Importantly, RFD measurements taken with the knee near full extension (~30° of knee flexion) can provide important information about the recruitment of the posterior chain muscles [21] which is related to the anterior cruciate ligament and hamstring strain injury mechanism [22,23]. RFD has an important neural component, as it requires the player to perform ballistic actions as fast and strongly as possible; therefore, robust procedures need to be employed to achieve sufficient reliability [20,24]. Previous studies have examined RFD metrics with different equipment during isometric knee extension [16,25] and flexion [26]. However, there is still no data available about RFD reliability at nearly extended knee positions. This is important given the aforementioned potential relationship with the injury mechanism. Another metric of interest to monitor muscle imbalances and knee joint stability [8] is the hamstring-to-quadriceps muscle strength ratio (H:Q). Previous findings suggested that deficits in the H:Q strength ratio may increase the risk of hamstring strain injury in football players [27]. The H:Q ratio has shown high reliability for RFD and MVIC in elite football players using sophisticated equipment such as an isokinetic dynamometer [28]. However, to the best of our knowledge, no study has analysed hamstring and quadriceps force production and H:Q ratio in a near-extended knee position with a field-based test. The existence of a reliable field test to measure these variables may be key to avoiding the cost and limitations of laboratory-based measurements (e.g., isokinetic dynamometer). For this reason, the aim of this study was to determine the reliability of a field-based test to assess unilateral hamstring and quadriceps muscle isometric strength in a nearly extended position (30° knee flexion) in football players. The neuromuscular parameters analysed in each muscle group were MVIC and RFD at different time intervals, while the H:Q ratio was calculated afterwards. We hypothesised that the field-based test presented here would produce reliable measures of strength during maximal isometric contraction of the hamstring and quadriceps muscle.

## 2. Materials and Methods

### 2.1. Participants

Nineteen male football players from the 1st Spanish juvenile division (M ± SD; age: 19 ± 1 years; body mass: 72 ± 7.4 kg; height: 175.3 ± 0.1 cm; 12 ± 2 years of experience) agreed to voluntarily participate in this study. The sample size was calculated through G*Power v.3.1.9.6. (Düsseldorf, Germany), and results indicated that a total sample of 19 participants would be required to detect acceptable day-to-day correlations assuming $r = 0.6$, power = 0.8 and $\alpha = 0.05$. The inclusion criteria used were (a) no pain or disability at the time of testing, (b) no lower limb muscle or joint injury in the prior 6 months, (c) no use of medicaments, pain relieving strategies or dietary supplements for the duration of this study and (d) participation in the usual routines of the football team. Players trained ~4.5 h per week plus one match/week and continued with their regular training practices during this study. However, participants were encouraged to avoid vigorous exercise in the 24 h before the evaluations. Before the start of this investigation, all players were fully informed about the testing procedures and provided a signed informed consent form. All procedures were conducted following the Declaration of Helsinki and were approved by the Ethics Committee of the University (code: DCD.JLE.01.20).

### 2.2. Procedures

Evaluations were performed independently on two separate occasions one week apart, at the same time to produce a test–retest experimental design. On each occasion, participants performed 2 s maximal isometric efforts on a custom-built bench with 30° of knee flexion and 90° of hip flexion while the force was measured with a portable load cell. Participants performed two maximal isometric repetitions intending to flex and extend the knee in each lower limb to assess isometric hamstring and quadriceps strength, respectively. Leg dominance was determined in a self-reported manner by asking for the leg used to kick a ball toward a target [29]. Before the onset of the testing, football players performed a standardized and specific warm-up consisting of 2 sets of 6 s of three rapid response neuromuscular activation exercises (base rotations, side to side over a line and 2-inch run in place) [30] and 2 submaximal contractions for each movement (flexion and extension) in both legs (dominant and non-dominant). After the warm-up, the test was performed on a custom-built bench (75 cm high) while participants were in a seated position at 30° of knee flexion and 90° of hip flexion with stabilization straps around the thighs (Figure 1). A portable S-Type Stainless Steel Load Cell (Model 620 Tedea-Huntleigh, Vishay Precision Group Inc., Holon, Israel) was attached to a rigid bar anchored, and the rigid bar was linked to the ankle by using a strap placed above the malleolus. The length of the bar was adjusted to maintain the 30° of the knee flexion and to be perpendicular to the shank, allowing the strain gauge to collect linear force generated by the hamstrings and quadriceps. The bench and the bar were reinforced to guarantee mechanical rigidity and minimize joint movement. The load cell was connected to an A/D converter to obtain force data at 80 Hz, and the software Chronojump (Chronojump Bosco System, Barcelona, Spain) was used to filter and smooth the signal using the settings recommended by the manufacturer.

Data for MVIC and RFD metrics at different time phases from the onset of contraction ($RFD_{max}$, $RFD_{0–50}$, $RFD_{0–150}$ and $RFD_{0–250}$) were automatically collected during each repetition. All players were familiarized with the procedures one week before evaluations to avoid the influence of the learning effect [16]. Participants first performed two executions to assess hamstring strength with a 20 s rest period between repetitions. Then, after a 30 s rest, participants consecutively performed two executions to assess quadriceps strength with the same leg used to assess hamstring strength. After 5 min of recovery, the other leg was evaluated following the same process. Participants were instructed to contract knee muscles “as fast and hard as you can while keeping your torso upright” with the emphasis on the explosive/ballistic phase of contraction for 2 s. There was a standardized verbal encouragement to produce maximal efforts [16]. Quadriceps strength was evaluated with a traction isometric effort and hamstring strength with an isometric compression effort. The starting leg (dominant or non-dominant) was counterbalanced. Attempts in which the participant flexed or extended his trunk or hips were considered invalid. Two researchers were present for the assessment and determined the validity of each repetition visually. The mean value from both attempts was used for the analysis. The strain gauge was calibrated before each session using a 5 kg weight, according to the manufacturer's specifications.

**Figure 1.** Image of the custom-built bench, placement of the portable strain gauge and participant's position for the measurement of hamstring and quadriceps strength using a field-based test.

*2.3. Statistical Analysis*

Reliability and level of agreement of the force variables between sessions (test–retest) were determined by the intraclass correlation coefficient (ICC), typical error (TE), coefficient of variation (CV%) and minimum detectable change (MDC). The intraclass coefficient correlation (ICC) was calculated using the two-way mixed-effects ICC. ICC values were interpreted as poor (<0.50), moderate (0.50–0.75), good (0.76–0.90) and excellent (>0.90) [31]. The CV was calculated relative to the TE as a percentage (CV% = 100 TE/mean of the test–retest). A combination of ICC > 0.75 and CV < 15% was used as key statistical parameters to categorize measurements with good reliability [32]. In addition, MDC was calculated through TE to represent the error expected from a given measurement [33], using the following formula: $MDC = TE \cdot \sqrt{2} \cdot 1.96$ [32]. The ICC, TE and MDC were calculated with their corresponding 95% confidence interval (CI). Bland–Altman plots were used to assess and display the agreement along the entire spectrum of loads. Systematic difference (bias) and its 95% limits of agreement (LoA = bias ± 1.96 SD) were calculated [34]. Calculations were performed using a specific spreadsheet for consecutive pairs of trials (http://www.sportsci.org/resource/stats/xrely.xls (accessed on 15 December 2020)) and the GraphPad Prism 6.0 (GraphPad Software Inc., San Diego, CA, USA).

## 3. Results

Results from reliability analyses are detailed in Table 1. Overall, results show both isometric hamstring (ICC 95% CI: 0.72 to 0.96) and quadriceps muscle strength (ICC 95% CI: 0.55 to 0.96). MVIC values range from moderate to excellent reliability. In addition, hamstring (ICC 95% CI: 0.19 to 0.89) and quadriceps (ICC 95% CI: 0.30 to 0.97). RFD-max values present the largest variability (Table 1). Isometric hamstring and quadriceps RFD metrics at different time phase ($RFD_{0–50}$, $RFD_{0–150}$ and $RFD_{0–250}$) values range from moderate to excellent (ICC 95% CI: 0.52 to 0.95) and from poor to excellent reliability (ICC 95% CI: 0.22 to 0.91), respectively. Bias and LoA are presented in Bland–Altman plots (Figures 2A–E and 3A–E), and residuals were equally distributed with no presence of heteroscedasticity according to the visual inspection of the plots. Results from the H:Q reliability were good for the MVIC in both dominant (M ± SD: 1.5 ± 0.4 vs. 1.5 ± 0.5, ICC = 0.86, [95% CI: 0.66, 0.95]; TE = 0.17 N, [95% CI: 0.13, 0.26]; CV = 11.8%, [95% CI: 8.9, 17.7]) and non-dominant legs (M ± SD: 1.5 ± 0.4 vs. 1.4 ± 0.4, ICC = 0.76, [95% CI: 0.48, 0.90]; TE = 0.22 N, [95% CI: 0.17, 0.32]; CV = 14.8%, [95% CI: 11.7, 22.4]). In contrast, RFD metrics showed a large variability with insufficient reliability to compute the index (ICC = 0.08 to 0.75; CV% = 27 to 85%).

**Table 1.** Reliability of isometric hamstring and quadriceps strength measured through a field-based test in football players.

| | Test | Retest | ICC (95% CI) | TE (95% CI) | CV% (95% CI) | MDC (95% CI) |
|---|---|---|---|---|---|---|
| Hamstring strength | | | | | | |
| **MVIC (N)** | | | | | | |
| Dominant leg | 344 ± 93 | 362 ± 93 | 0.88 (0.72, 0.95) | 34 (25, 50) | 9.6 (7.1, 14.1) | 94 (69, 139) |
| Non-dominant leg | 334 ± 94 | 331 ± 91 | 0.90 (0.77, 0.96) | 30 (22, 44) | 9.1 (6.6, 13.2) | 83 (61, 122) |
| **$RFD_{max}$ ($N \cdot s^{-1}$)** | | | | | | |
| Dominant leg | 1435 ± 696 | 1340 ± 695 | 0.75 (0.45, 0.89) | 366 (276, 541) | 26.3 (19.9, 39) | 1014 (765, 1500) |
| Non-dominant leg | 1415 ± 753 | 1201 ± 629 | 0.59 (0.19, 0.82) | 459 (347, 680) | 35.1 (26.5, 52) | 1274 (962, 1885) |
| **$RFD_{0–50}$ ($N \cdot s^{-1}$)** | | | | | | |
| Dominant leg | 1313 ± 963 | 1139 ± 791 | 0.84 (0.62, 0.93) | 375 (283, 555) | 30.6 (23.1, 45.3) | 1041 (784, 1538) |
| Non-dominant leg | 1285 ± 940 | 1465 ± 910 | 0.87 (0.70, 0.95) | 350 (264, 517) | 25.4 (19.2, 37.6) | 970 (732, 1433) |
| **$RFD_{0–150}$ ($N \cdot s^{-1}$)** | | | | | | |
| Dominant leg | 1017 ± 608 | 902 ± 493 | 0.80 (0.56, 0.92) | 257 (194, 381) | 26.8 (20.2, 39.7) | 714 (538, 1056) |
| Non-dominant leg | 965 ± 584 | 1088 ± 551 | 0.86 (0.68, 0.94) | 222 (168, 329) | 21.6 (16.4, 32.1) | 616 (466, 912) |
| **$RFD_{0–250}$ ($N \cdot s^{-1}$)** | | | | | | |
| Dominant leg | 746 ± 338 | 824 ± 421 | 0.78 (0.52, 0.91) | 185 (140, 274) | 23.6 (17.8, 34.9) | 515 (388, 759) |
| Non-dominant leg | 857 ± 376 | 769 ± 401 | 0.84 (0.64, 0.94) | 162 (122, 240) | 19.9 (15.0, 29.5) | 450 (338, 665) |
| Quadriceps strength | | | | | | |
| **MVIC (N)** | | | | | | |
| Dominant leg | 252 ± 76 | 245 ± 62 | 0.90 (0.76, 0.96) | 23 (18, 34) | 9.3 (11.3, 13.7) | 64 (50,94) |
| Non-dominant leg | 239 ±73 | 250 ± 69 | 0.80 (0.55, 0.92) | 33 (25, 49) | 13.5 (10.2, 20) | 92 (69, 136) |
| **$RFD_{max}$ ($N \cdot s^{-1}$)** | | | | | | |
| Dominant leg | 1919 ± 755 | 2081 ± 796 | 0.66 (0.30, 0.85) | 470 (355, 695) | 23.5 (17.8, 34.8) | 1304 (984, 1926) |
| Non-dominant leg | 2013 ± 886 | 1926 ± 792 | 0.92 (0.80, 0.97) | 256 (193, 378) | 13.0 (9.8, 19.2) | 710 (535, 1048) |
| **$RFD_{0–50}$ ($N \cdot s^{-1}$)** | | | | | | |
| Dominant leg | 1707 ± 844 | 1529 ± 747 | 0.62 (0.25, 0.84) | 505 (381, 746) | 31.1 (23.5, 46.1) | 1399 (1056, 2068) |
| Non-dominant leg | 1739 ± 1020 | 1427 ± 853 | 0.73 (0.43, 0.89) | 505 (382, 747) | 31.9 (24.1, 47.2) | 1400 (1059, 2071) |
| **$RFD_{0–150}$ ($N \cdot s^{-1}$)** | | | | | | |
| Dominant leg | 985 ± 335 | 1089 ± 450 | 0.72 (0.41, 0.88) | 217 (164, 321) | 20.9 (15.8, 31.0) | 603 (455, 890) |
| Non-dominant leg | 891 ± 312 | 1034 ± 467 | 0.61 (0.22, 0.83) | 257 (194, 380) | 26.9 (20.2, 39.5) | 712 (538, 1053) |
| **$RFD_{0–250}$ ($N \cdot s^{-1}$)** | | | | | | |
| Dominant leg | 794 ± 303 | 730 ± 213 | 0.78 (0.51, 0.91) | 129 (98, 191) | 17.0 (13, 25.1) | 359 (272, 529) |
| Non-dominant leg | 739 ± 300 | 676 ± 213 | 0.70 (0.37, 0.87) | 147 (111, 218) | 20.9 (15.7, 30.8) | 410 (308, 604) |

MVIC: Maximal voluntary isometric contraction; RFD: Rate of force development; ICC: Intraclass correlation coefficient; TE: Typical error; CV: Coefficient of variation; MDC: Minimum detectable change; 95% CI: 95% confidence interval.

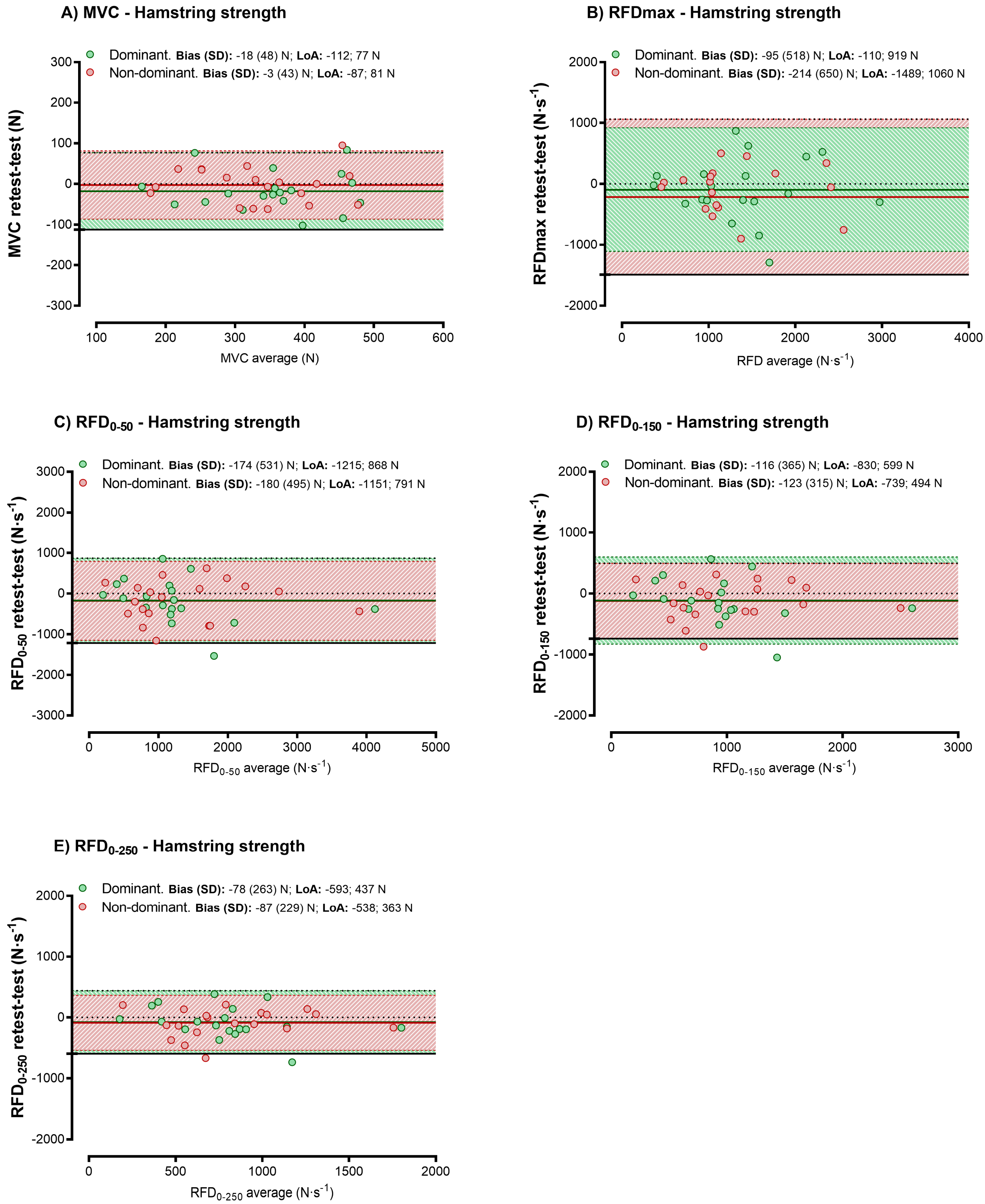


**Figure 2.** (**A**–**E**) Bland–Altman plots show the bias (test-retest differences) for the isometric hamstring strength test. Shadows are limits of agreement (LoA) for dominant (green, clear) and non-dominant (red, dark) legs.

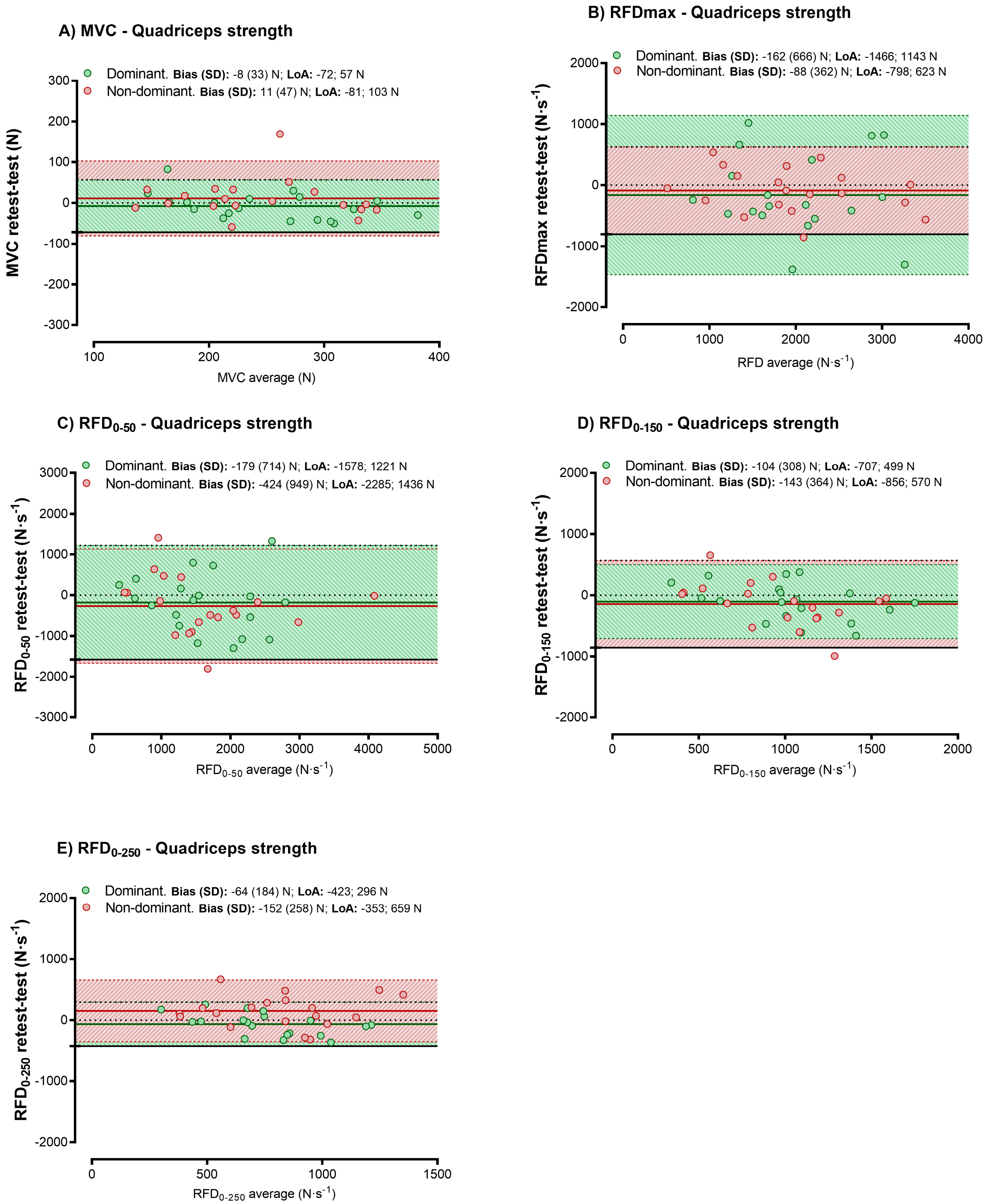


**Figure 3.** (**A**–**E**) Bland–Altman plots show the bias (test-retest differences) for the isometric quadriceps strength test. Shadows are limits of agreement (LoA) for dominant (green, clear) and non-dominant (red, dark) legs.

## 4. Discussion

This study examines the reliability of a field-based test to assess isometric hamstring and quadriceps strength at 30° of knee flexion and 90° of hip flexion in football players. Results suggested an acceptable level of reliability for testing MVIC strength of both isometric hamstring and quadriceps muscles and for the calculation of the H:Q muscle strength ratio. However, although some RFD metrics yielded reliable results, especially for larger phases (>150 ms after contraction onset), caution is needed when interpreting these values due to the large errors of measurement. These findings contribute to the existing knowledge on field-based tests to examine lower limb strength in football by providing results from a new tool to easily assess isometric hamstring and quadriceps strength. Another important contribution of the present field-based protocol using a strain gauge is the allowance for testing consecutively the strength of both flexor and extensor muscles from the same position, which may save time during evaluations. Information about errors of measurement for each metric may have practical implications to assist physicians and coaches in a more accurate description of players' strength status and their evolution during the injury management and return-to-play processes.

In line with our results, MVIC has been suggested as the more reliable measurement during isometric extension [15,17,25] and flexion tests [15,26] at angulations close to full extension (0–45°). However, because changes in the knee angle may lead to different mechanical outputs, the reliability of the MVIC can be compromised if conducting tests at different knee and hip positions [35]. It is important to note that hamstring strain injuries are the most common injury in several sprint team sports such as football [36]. It is well recognized that most (83%) of hamstring strain injury occurs to the biceps femoris [22] during a terminal swing. Several studies have suggested that inadequate levels of hamstring strength and imbalances between the hamstring and quadriceps strength are potential risks factors for acute hamstring strain injury and re-injury [5–7]. Furthermore, the anterior cruciate ligament is often injured in a position where athletes have a relatively straight knee [23]. A recent review highlighted the importance of monitoring hamstring strength and its relationship with the quadriceps assisting in the function of the anterior cruciate ligament [8]. Thus, MVIC measurements of the isometric hamstring and quadriceps muscles strength at 30° of knee flexion and 90° of hip flexion could provide reliable knowledge of the functional status of the knee and assist in the prevention of hamstring strain and anterior cruciate ligament injuries, as they are in a key position during the injury [22,23].

The RFD metrics can provide significantly different information than MVIC assessment on neuromuscular determinants [20], being more sensitive to fatigue [37]. However, the present results show a high variability of the outcomes which may limit its reliability in the practice. Although previous studies have evaluated the RFD reliability of knee extension [16,25] and flexion [26], it is difficult to make comparisons as there are no reports about the reliability of isometric hamstring and quadriceps muscle strength tests at 30° of knee flexion and 90° of hip flexion. The observed variability in RFD measurements may be due to some methodological considerations made to adapt to the context of a team. The test–retest was carried out in 7 days, despite the recommendations to perform it in an interval close to 48 h [20]. In addition, it was only possible to leave 24 h without vigorous exercise because the athletes were in a competitive period. RFD has been suggested as a more sensitive measure for acute and chronic changes in neuromuscular function than MVIC [20]. The demand of a competitive week itself may be sufficient to alter muscle activation, mediated by the motor neuron discharge rate and the recruitment threshold [38,39] influencing the greater variability of RFD measurements during the early stages. On the other hand, although stabilization straps were used for the knee during the execution of the tests, the athlete's torso was not stabilized. The participant was instructed to keep his torso upright, and repetitions that were not maintained during the whole effort were discarded. However, there is still the possibility of hip and pelvic compensations, as they were not totally controlled. This may have modified the degree of muscle–tendon stiffness and have had a major influence on the time to reach a given force [40].

One last finding of this study was the calculation of the H:Q muscle strength ratio to check whether MVIC and RFD metrics can yield reliable values using a field-based protocol. Previous studies demonstrated that a reduced H:Q muscle strength ratio could increase four to five times the risk of sustaining hamstring injuries [27]. This is explained by the fact that weaknesses of hamstring muscles are associated with an imbalance in the propulsive quadriceps maximal torque during extended knee movements, and that hamstring muscles are responsible for deceleration actions that frequently occur before an injury situation [8]. According to our results, MVIC records can be used to calculate the H:Q ration with sufficient reliability (ICC > 0.75, [95% CI: 0.48, 0.95]; CV < 15%, [95% CI: 8.9, 22.4]), using a portable force sensor at 80 Hz. This seems important because coaches are now provided with a tool to easily screen the H:Q ratio, well-documented to be related to the risk of injuries in football [27,41].

In contrast to our expectations, the current protocol and equipment were not good enough to provide reliable RFD ratio metrics. Given the increasing interest in these outcomes, future studies are encouraged to further investigate RFD measures with field-based devices to obtain additional information on neuromuscular determinants which can be critical in the injury management and return-to-play process.

The current experiment and the field-based test presented here possess some limitations that should be discussed. First, the custom-built bench used for this study does not have a backrest to fix the torso to ultimately avoid trunk flexion and extension during the isometric effort. This is a difference from the more traditional hamstring and quadriceps strength measurements, such as the isokinetic dynamometer. Although we acknowledge the importance of trunk control when applying lower extremity strength, we designed the bench without a backseat to facilitate the adoption of 90° hip flexion in participants with different body characteristics. However, it is important to note that researchers interested in this field test have to observe each repetition and discard those in which the participant flexes/extends his/her trunk visibly. The second limitation is that this test–retest study was developed with juvenile football players, and its reliability should be tested in other football populations such as professional football players and female football players before its application as a field test. The strengths of the work include the simplicity and cost of the load cell-based devices, which improve the applicability of the test over the use of laboratory-based equipment. In addition, our device features a rigid bar that allows the evaluation of the hamstring and quadriceps muscles sequentially, ensuring the mechanical rigidity needed for a correct isometric strength evaluation.

## 5. Conclusions

The current field-based tool provided consistent results for consecutively testing maximal strength during an isometric contraction of the hamstring and quadriceps muscle at 30° of knee flexion and 90° of hip flexion. This means that the test is reliable for assessing the hamstring and quadriceps maximal isometric strength, which can be helpful to identify muscle strength deficits and imbalances in football players. The use of this test may be key during injury prevention and management processes, as its easy application allows repeated measurements along the season. However, the use of this test to assess the RFD metrics is not recommended considering particular errors of measurement. Finally, the MVIC outcomes can be used to calculate metrics of interest such as the H:Q ratio. Because of the affordable, portable and easy-to-use procedure employed, it seems advisable to incorporate it in sports clubs to monitor players' performance and assist in the injury management and return-to-play process.

**Author Contributions:** Conceptualization, V.M.-P. and J.L.L.E.; methodology, A.M.-I., V.M.-P. and J.L.L.E.; formal analysis, A.M.-I., J.D.C. and J.C.-I.; investigation, A.M.-I., V.M.-P., J.D.C., J.C.-I. and J.L.L.E.; data curation, A.M.-I.; writing—original draft preparation, A.M.-I. and V.M.-P.; writing—review and editing, J.D.C., J.C.-I. and J.L.L.E.; supervision, V.M.-P. and J.L.L.E. All authors have read and agreed to the published version of the manuscript.

**Funding:** AM-I contribution was financed by a grant from the Ministry of Universities of Spain (grant number: FPU21/04536).

**Institutional Review Board Statement:** This study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Ethics Committee of Miguel Hernandez University of Elche (code: DCD.JLE.01.20).

**Informed Consent Statement:** Participants were fully informed about the testing procedures and provided a signed informed consent form.

**Data Availability Statement:** Supporting data and results not included in the publication are available upon reasonable request from the authors of this study.

**Acknowledgments:** The authors would like to thank the football players who participated in this study.

**Conflicts of Interest:** The authors declare no conflict of interest in this study.

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