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Physical Differences between Injured and Non-Injured Elite Male and Female Futsal Players

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Abstract: Futsal is one of the most harmful sports due to its great physical demands. The asymmetries have been proposed as one of the most important risk factors of suffering an injury. However, no study has analysed the relationship between neuromuscular assessment and its implication on the likelihood of suffering injuries comparing male and female players. The purpose of the study was to analyse the physical fitness differences between elite futsal players (both male and female) who suffered an injury in the following four months after being evaluated with those who did not suffer the injuries. Twenty-six and twenty-two male and female elite futsal players were recruited from four different teams and underwent an evaluation of different neuromuscular assessments (isometric hip abduction and adduction peak torque, flexion-rotation trunk test, hop test, countermovement jump (CMJ), drop vertical jump (DVJ), leg stiffness, 15 m sprint, Y-balance test, and Illinois test) that have been considered potential sport-related injury risk factors during the pre-season. Statistical analysis only showed differences between injured and non-injured players in isometric hip adduction strength and unilateral ratio for the non-dominant leg ($p < 0.05$). Neuromuscular performance scores showed significant differences ($p < 0.001$) between male and female futsal players in several variables (hip abduction non-dominant leg, hops, CMJ, DVJ, leg stiffness, sprint, and Illinois test) but not in ratio or asymmetry. Isometric hip adduction and abduction–adduction unilateral ratio deficits for the non-dominant leg might be an important factor toward suffering an injury. Male and female futsal players showed different neuromuscular performances and consequently different training programs should be implemented for them.

Keywords: injury risk; neuromuscular performance; balance; prevention; sex differences; indoor football

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Citation: Ruiz-Pérez, I.; Raya-González, J.; López-Valenciano, A.; Robles-Palazón, F.J.; Ayala, F. Physical Differences between Injured and Non-Injured Elite Male and Female Futsal Players. *Appl. Sci.* **2023**, *13*, 6503. https://doi.org/10.3390/app13116503

Academic Editor: Mark King

Received: 7 May 2023
Revised: 23 May 2023
Accepted: 24 May 2023
Published: 26 May 2023

1. Introduction

Futsal, sanctioned by soccer's international governing body, Fédération Internationale de Football Association (FIFA), is an intermittent team sport played worldwide with more than 12 million players all over the world [1,2]. Elite futsal competition requires players to perform repeated high-intensity physical demands, such as sudden accelerations and decelerations, tackling, kicking, rapid changes in direction and to face situations that place them at high risk of suffering collisions with other players [3,4]. Moreover, the characteristics of this sport (i.e., unlimited substitutions, small play space, etc.) mean that the rhythm and intensity of futsal play do not decline as matches progress, significantly increasing the physical demands on these players compared to other team sports athletes [5]. These physical demands alongside the congested training and competitive calendar place futsal players at high risk of injury. In fact, futsal has been suggested among the top ten injury-prone sports [6] reporting injury rates of 44.9 and 10.3 injuries per 1000 match hours for male and female players, respectively. The majority of these injuries are soft-tissue injuries by non-contact mechanisms, and they take place in the lower limbs [7]. In the short term, these high injury rates affect the futsal players and therefore their team success [8–10], while in the long term, injuries could have significant consequences for both the individual and sport organisations (e.g., physical, psychological, financial) [11–13]. Therefore, one of the main purposes of futsal practitioners is to develop specific training programmes to reduce the risk of suffering an injury or its severity, and thus improve the success of their teams.

Several studies have related different neuromuscular variables to the likelihood of suffering an injury, such as dynamic postural control, isometric hip strength, coordination or jump performance, among others [14–17]. Additionally, previous studies have associated the presence of asymmetries, which are highly expected in futsal due to its unilateral nature, with athletes at high risk of suffering an injury [18–20]. The presence of inter- or intra-limb asymmetries is expected in elite futsal, given that the majority of high-intensity actions occur unilaterally. However, the well-known physical and physiological differences between men and women might affect the variables that pre-dispose futsal players to an increased risk of suffering an injury [21–24]. To date, and to the authors' knowledge, no study has analysed yet the relationship between neuromuscular assessment and its implication on the likelihood of suffering injuries comparing male and female futsal players. Furthermore, sometimes it is quite difficult to carry out laboratory tests to perform players' physical evaluation, due to their lack of specificity, high economic cost, displacements, time, and organisation. Therefore, evaluating through a cost-effective, non-time-demanding field test seems to be an interesting alternative.

Therefore, the purpose of this study was to analyse the physical fitness differences among elite futsal players who suffered an injury in the following four months after being evaluated with those who did not suffer injuries. Additionally, physical fitness differences between male and female elite futsal players divided by overall, injured players and non-injured players were analysed.

2. Materials and Methods

Forty-eight elite futsal players were recruited from two different male teams engaged in first and second divisions (n = 26 (age: 19.08 ± 2.79 years, stature: 1.78 ± 0.06 m, body mass: 72.30 ± 6.92 kg)) and from two different female teams engaged in first and second divisions, respectively (n = 22 (age: 21.45 ± 4.97 years, stature: 1.63 ± 0.07 m, body mass: 58.75 ± 6.93 kg)). To be included in the study, players had to fulfil the following criteria: (a) be free of any orthopaedic problem that could prevent the proper execution of one or more of the different tests; (b) not to be transferred to a different team, which would prevent a proper follow-up before the Christmas break after testing. The study was conducted during the pre-season for two consecutive seasons. The Institutional Research Ethics Committee of Miguel Hernández University of Elche approved the protocol (DPS.FAR.01.14, date of approval: 14 January 2014) and all the participants were verbal and written informed of the experimental procedure and the potential risk. Signed consent was obtained from all the players according to the Declaration of Helsinki.

2.1. Study Design

For the purposes of this study, a prospective cohort design was used. After a standardised dynamic warm-up [25], futsal players underwent an evaluation of different neuromuscular assessments that have been mostly considered potential sport-related injury risk factors during the pre-season (mid-August–mid-September). Lower leg soft-tissue and non-contact injuries, accounted before Christmas break, were prospectively collected for all players. The club's medical staff of each team recorded the injuries on an injury form that was sent to the study group each week. The consensus document for football injury surveillance studies [26] and the collection procedures for studies of injuries by the UEFA were followed [27]. For each injury, the medical staff provided date of injury, moment (training or competition), player position (goalkeeper or field player (lastman, wing, or pivot)), injury mechanism (traumatic (contact or non-contact) or overuse), injury location, type of injury (the specific injury diagnosis was also recorded), extremity of the injury (dominant/non-dominant), injury severity based on layoff time (0 days (when a player could not participate fully on the day of an injury but was available for full participation the next day), minimal (1–3 days), mild (4–7 days), moderate (8–28 days), severe (>28 days), and career-ending injury), whether it was a recurrence or new injury and total time taken to resume full training and competition. Illnesses and any physical or mental complaint that did not result from a futsal match or training were excluded.

2.2. Testing Procedure

Isometric hip abduction and adduction peak torque was assessed according to the methodology described by Thorborg et al. [28]. For that, players were placed on a bench lying in a supine position with the leg extended (Figure 1f) and a portable handle dynamometer was used (Nicholas Manual Muscle Tester; Lafayette Instrument Company, Lafayette, Indiana). Participants performed two specific warm-up trials at 50 and 80% of the self-perceived isometric maximal voluntary contraction (MVC) and then three 5 s isometric MVC trials for each leg and hip movement. When the difference between trials was higher than 5%, another trial was assessed. The best trial (i.e., higher value in N) was normalised by the body weight of the players and used for the subsequent statistical analysis.

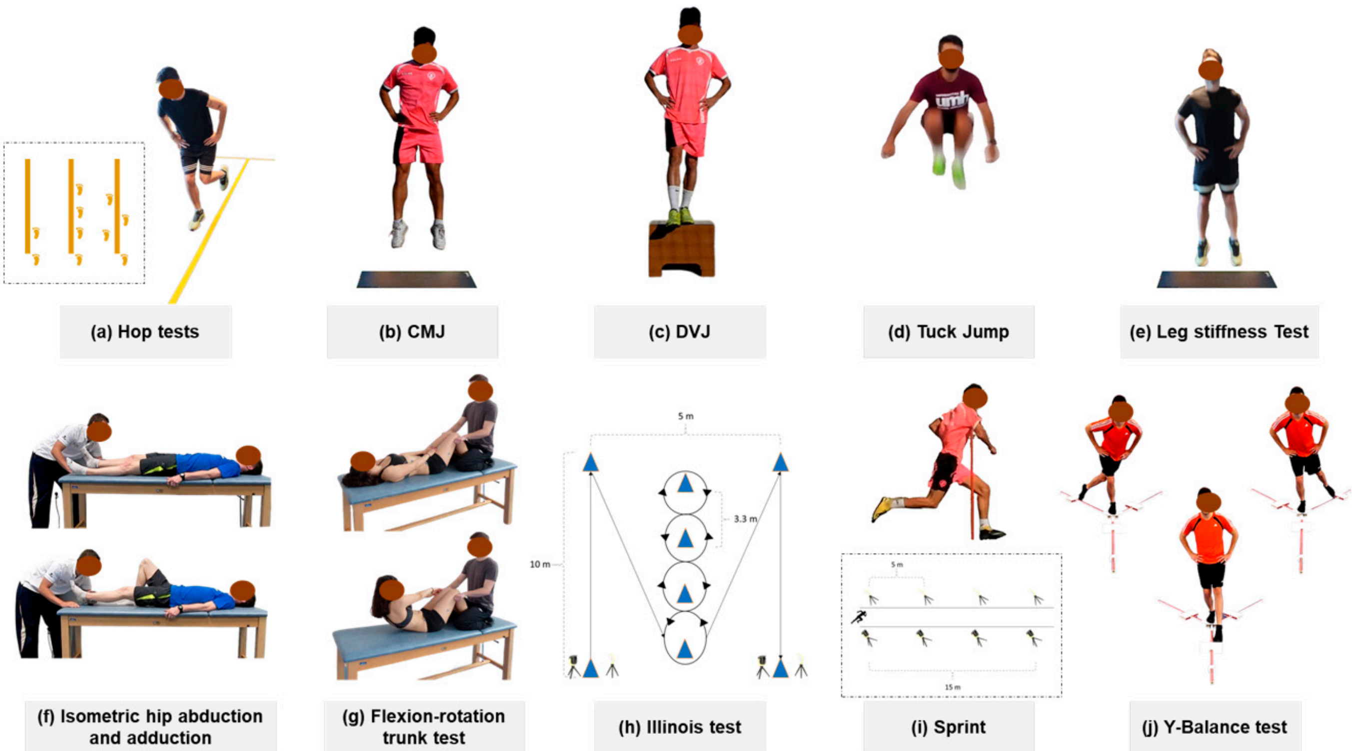

Figure 1. (**a**) Hop test; (**b**) countermovement jump; (**c**) drop jump; (**d**) tuck jump; (**e**) leg stiffness test; (**f**) isometric hip abduction and adduction; (**g**) flexion–rotation trunk test; (**h**) Illinois test; (**i**) 15 m sprint test; (**j**) Y-balance test.

Trunk flexion–rotation endurance was evaluated through the Flexion Rotation Trunk Test (FRT). Following the methodology described by Brotons et al. [29], futsal players, lying on a mat in a supine position with legs together and 90° knee flexion, had to perform the maximum number of trunk flexion and rotation movements possible in 90 s (Figure 1g).

The single-leg horizontal hop test [30] was assessed with the participants placing their hands on their hips and a measuring tape of 15 cm width and 8 m long glued to the floor. Three different measures were registered for each leg: single hop for distance, triple hop for distance, and crossover hop for distance (Figure 1a). For the single hop for distance, the players had to stand on one leg and then hop forward as far as possible on the same leg. For the triple hop for distance, players had to stand on one leg and hop forward three consecutive times. For the crossover hop for distance, players had to stand on one leg and the hop forward and over the 15 cm width line in zig-zag three consecutive times as far as possible landing on the same leg. In the case that the player was unable to keep the balance in a hop, the trial was not registered. Players were allowed to practice the different hops until they felt comfortable enough to perform them. The best trial (i.e., higher value in cm) was normalised by the leg length of the player and used for the subsequent statistical analysis.

Countermovement jump (CMJ) and drop vertical jump (DVJ) [31,32] were measured with a contact platform (Chronojump Boscosystem; Barcelona, Spain). For the CMJ (Figure 1b), participants were instructed to rapidly squat down and then jump as high as possible. Five repetitions for bipodal CMJ and five for each leg were recorded. For the DVJ (Figure 1c), assessment futsal players were indicated to lean forward on a 40 cm high box and drop from it as vertically as possible and after contacting the platform, jumping immediately, performing a maximal vertical jump, and landing again on the same platform. As in the CMJ, five trials were registered for bipodal, dominant leg (defined as the participants' kicking leg), and non-dominant leg, respectively. The trials with the highest jump (in m) were used for the statistical analysis.

For the repeated tuck jump test (Figure 1d), players were instructed to start with a countermovement jump followed by repeated vertical jumps, for 10 s, as high as possible while pulling their knees to their chest. The test was recorded with two commercial video cameras (Panasonic Lumix DMC-FZ 200; Panasonic; Osaka, Japan) for the posterior landings analysis [33].

Leg stiffness (Figure 1e) was calculated following the methodology described by Dalleau et al. [34]. With the help of an electronic metronome to help players to maintain the frequency (0.2 Hz), they performed 10 maximal hops on a contact platform (Chronojump Boscosystem; Barcelona, Spain) keeping the legs as straight as possible and with their hands on the hips.

The Y-balance test (Y-Balance Test, Move2—Perform; Evansville, IN, USA) was used to assess the dynamic postural control following the methodology proposed by Shaffer et al. [35]. After at least 2 min practices, futsal players performed a maximum of five trials to obtain three successful trials for each one of the three directions (anterior, posteromedial, and posterolateral) and each leg (Figure 1j). The highest distance in each direction was normalised by the player leg length and the composite balance score was calculated (summatory of the three directions divided by three and normalised by the leg length).

Time during a 15 m sprint test in straight line (Figure 1i) was measured using Witty photocells (Microgate; Bolzano, Italy). Four different photocell doors were used to register time for each 5 m [36]. Participants performed the test twice with three-minute recovery between trials. The fastest time was used for the statistical analysis.

The Illinois changes in direction test [37] was timed with the same photocells as the previous test (Figure 1h). Participants were instructed concerning the path they had to follow, and they performed two trials walking and two trials jogging to familiarise themselves with the test. The path consisted in a 10 m sprint, turning around, return to the starting line, swerving in and out of four markers, and finishing with another 10 m sprint. Afterward, participants completed the test at maximum speed two times with a three-minute rest between trials. As in the previous test, the fastest time was used for the analysis.

2.3. Statistical Analysis

Data are presented as mean ± standard deviation (SD). Bilateral ratios and unilateral ratios were calculated with the bilateral strength asymmetry equation [38] and inter-limb asymmetries. The latter were calculated by using the following formula [39,40]:

$$Limb\ Asymmetry = \frac{limb\ with\ better\ performance\ score - limb\ with\ lower\ performance\ score}{limb\ with\ better\ performance\ score} \times 100$$

Student's *t*-test was used to analyse whether there were differences between groups (injured players vs. non-injured players; male vs. female players; injured male vs. injured female players; non-injured male vs. non-injured female players; injured male vs. non-injured male players; injured female vs. non-injured female players) on each measure with statistical significance set at $p < 0.05$. All statistical analyses were performed using the JASP computer software version 0.16.3 (Amsterdam, The Netherlands). Furthermore, Cohen's d was calculated for those variables that showed differences. The standardised effect size was classified as trivial (<0.2), small (0.2–0.6), moderate (0.6–1.2), large (1.2–2.0), and very large (2.0–4.0) [41].

3. Results

The descriptive data and the physical fitness differences between groups are presented in Tables 1–3. During the follow-up period, six players suffered an injury, three of them suffered by male players and three by female players. Statistical analysis showed differences between all men and all women in isometric hip abduction and adduction strength in the non-dominant leg. In the same sense, non-injured women and non-injured men revealed differences in hip abduction (δ = 2.136 (very large), δ = 1.295 (large)) and adduction in the non-dominant leg (δ = 0.922 (moderate), δ = 1.138 (moderate)), and in the hip adduction and abduction bilateral ratios (δ = 1.422 (large), δ = 0.575 (small), δ = 1.553 (large), δ = 0.089 (moderate)). Injured men revealed significant differences from their non-injured counterparts for the hip adduction in both limbs (δ = 1.369 (large), δ = 1.683 (large)). When analysed together (men and women), injured futsal players showed differences from non-injured players in hip adduction peak torque for the non-dominant leg (δ = 1.277 (large)) and in the unilateral ratio between adduction and abduction in the non-dominant leg (δ = 1.287 (large)). Regarding the FRT performance, only differences between all men and all women were found (δ = 0.757 (moderate)).

For the functional hops test, differences between women and men were found for the single hop (δ = 1.153 (moderate), δ = 1.103 (moderate)); triple hop (δ = 1.194 (moderate), δ = 1.084 (large)), and triple crossover hop in both legs (δ = 0.381 (small), δ = 0.395 (small)). Differences between all male and female futsal players, and non-injured male and female players were found for all the analysed variables in the CMJs and DVJs, except the asymmetries, and for the leg stiffness test.

Regarding the dynamic postural control, women showed differences from men for the anterior direction with the dominant (δ = 0.771 (moderate) and non-dominant leg δ = 0.930 (moderate)), and for the posterolateral direction of the non-dominant leg (δ = 0.670 (moderate)). Significant differences between injured female players and injured male players were also observed for the composite value in the non-dominant leg (δ = 2.872 (very large)). Women showed differences in the time needed for the 5 m (δ = 1.907 (large), δ = 1.429 (large), δ = 2.191 (very large)); 10 m (δ = 2.951 (very large), δ = 3.200 (very large), δ = 3.169 (very large)); and 15 m (δ = 3.087 (very large), δ = 3.110 (very large), δ = 3.309 (very large)) sprint and in the Illinois agility test (δ = 3.555 (very large), δ = 2.696 (very large), δ = 3.910 (very large)) with their counterpart men.

Table 1. Hip adduction and abduction and flexion rotation trunk test scores (mean ± SD).

	All Participants			Men			Women		
	All Participants	**Non-Injured**	**Injured**	**All Men**	**Non-Injured**	**Injured**	**All Women**	**Non-Injured**	**Injured**
HABD_DL (N·kg^{-1})	2.77 ± 0.33	2.77 ± 0.35	2.75 ± 0.30	2.75 ± 0.29	2.77 ± 0.30	2.55 ± 0.20.	2.82 ± 0.46	2.77 ± 0.53	2.94 ± 0.26
HABD_NDL (N·kg^{-1})	2.85 ± 0.46	2.90 ± 0.47	2.60 ± 0.36	2.97 ± 0.46	3.02 ± 0.44	2.58 ± 0.48	2.53 ± 0.31 [d]	2.49 ± 0.32 [c]	2.62 ± 0.31
HADD_DL (N·kg^{-1})	2.76 ± 0.35	2.79 ± 0.33	2.59 ± 0.45	2.70 ± 0.33	2.74 ± 0.30	2.32 ± 0.41 [b]	2.92 ± 0.38	2.94 ± 0.42	2.85 ± 0.35
HADD_NDL (N·kg^{-1})	2.91 ± 0.54	2.10 ± 0.49	2.36 ± 0.56 [a]	3.03 ± 0.51	3.12 ± 0.42	2.35 ± 0.79 [b]	2.56 ± 0.48 [D]	2.61 ± 0.54 [c]	2.39 ± 0.09
HABD bilateral ratio	0.99 ± 0.15	0.97 ± 0.14	1.07 ± 0.17	0.94 ± 0.13	0.93 ± 0.11	1.02 ± 0.24	1.12 ± 0.13 [D]	1.11 ± 0.16 [c]	1.13 ± 0.05
HADD bilateral ratio	0.97 ± 0.18	0.95 ± 0.17	1.10 ± 0.22	0.91 ± 0.15	0.89 ± 0.14	1.04 ± 0.23	1.15 ± 0.13 [D]	1.14 ± 0.10 [C]	1.19 ± 0.25
UR_DL	1.00 ± 0.11	1.01 ± 0.11	0.94 ± 0.12	0.98 ± 0.10	0.99 ± 0.09	0.91 ± 0.17	1.05 ± 0.14	1.08 ± 0.15	0.97 ± 0.05
UR_NDL	1.02 ± 0.12	1.04 ± 0.11	0.89 ± 0.14 [a]	1.02 ± 0.12	1.04 ± 0.11	0.89 ± 0.17 [b]	1.01 ± 0.14	1.05 ± 0.13	0.89 ± 0.16
HABD Asymmetry	11.18 ± 7.81	10.89 ± 7.84	12.62 ± 8.16	10.55 ± 8.30	10.09 ± 7.95	14.07 ± 12.10	12.79 ± 6.43	13.48 ± 7.46	11.18 ± 3.73
HADD Asymmetry	13.54 ± 9.39	13.49 ± 9.30	13.89 ± 11.02	13.65 ± 9.96	13.64 ± 10.26	13.71 ± 8.97	13.24 ± 8.03	12.98 ± 5.62	14.16 ± 18.02
FRT test	81.84 ± 14.09	81.11 ± 13.95	86.33 ± 15.46	77.85 ± 11.72	77.91 ± 12.25	77.33 ± 8.08	87.94 ± 15.53 [d]	86.36 ± 15.40	95.33 ± 17.01

HABD: hip abduction; HADD: hip adduction; DL: dominant leg; NDL: non-dominant leg: UR: unilateral ratio; FRT: flexion rotation trunk test. a: Significant difference ($p < 0.05$) between injured players and non-injured players; b: Significant difference ($p < 0.05$) between injured and non-injured male players; c: Significant difference ($p < 0.005$) between non-injured male and non-injured female players; C: Significant difference ($p < 0.001$) between non-injured male and non-injured female players; d: Significant difference ($p < 0.05$) between male and female players; D: Significant difference ($p < 0.001$) between male and female players.

Table 2. Functional hops, countermovement jumps, drop vertical jumps, repeated tuck jump, and leg stiffness scores (mean ± SD).

	All Participants			Men			Women		
	All Participants	**Non-Injured**	**Injured**	**All Men**	**Non-Injured**	**Injured**	**All Women**	**Non-Injured**	**Injured**
Single_Hop_DL (m)	1.55 ± 0.16	1.54 ± 0.17	1.57 ± 0.14	1.62 ± 0.14	1.62 ± 0.14	1.61 ± 0.17	1.46 ± 0.15 [D]	1.44 ± 0.15 [C]	1.54 ± 0.13
Single_Hop_NDL (m)	1.59 ± 0.17	1.59 ± 0.18	1.58 ± 0.15	1.67 ± 0.16	1.67 ± 0.17	1.69 ± 0.08	1.50 ± 0.15 [D]	1.50 ± 0.16 [c]	1.49 ± 0.13
Triple_Hop_DL (m)	5.18 ± 0.52	5.18 ± 0.54	5.12 ± 0.41	5.42 ± 0.39	5.42 ± 0.40	5.42 ± 0.41	4.89 ± 0.50 [D]	4.88 ± 0.54 [C]	4.91 ± 0.28
Triple_Hop_NDL (m)	5.18 ± 0.50	5.17 ± 0.52	5.22 ± 0.43	5.40 ± 0.44	5.37 ± 0.45	5.61 ± 0.22	4.91 ± 0.45 [D]	4.91 ± 0.49 [c]	4.93 ± 0.27 [e]
Triple_Cross_Hop_DL (m)	4.54 ± 0.74	4.53 ± 0.78	4.60 ± 0.40	4.67 ± 0.51	4.66 ± 0.53	4.76 ± 0.28	4.39 ± 0.93 [d]	4.37 ± 1.01 [c]	4.47 ± 0.46
Triple_Cross_Hop_NDL (m)	4.59 ± 0.70	4.57 ± 0.72	4.73 ± 0.55	4.72 ± 0.51	4.68 ± 0.53	5.02 ± 0.27	4.45 ± 0.85	4.43 ± 0.91 [c]	4.51 ± 0.63
Single_Hop bilateral ratio	0.98 ± 0.07	0.97 ± 0.07	1.00 ± 0.07	0.97 ± 0.07	0.98 ± 0.07	0.94 ± 0.05	0.98 ± 0.07	0.97 ± 0.06	1.04 ± 0.05
Triple_Hop bilateral ratio	1.00 ± 0.05	1.00 ± 0.05	0.98 ± 0.04	1.00 ± 0.05	1.01 ± 0.05	0.95 ± 0.04	1.00 ± 0.03	1.00 ± 0.04	1.00 ± 0.03
TripleCross_Hop bilateral ratio	1.00 ± 0.19	1.00 ± 0.20	0.98 ± 0.08	0.99 ± 0.07	0.99 ± 0.06	0.94 ± 0.10	1.02 ± 0.27	1.02 ± 0.30	1.00 ± 0.06

Table 2. *Cont.*

	All Participants			Men			Women		
	All Participants	Non-Injured	Injured	All Men	Non-Injured	Injured	All Women	Non-Injured	Injured
Single_Hop Asymmetry	5.02 ± 4.77	5.00 ± 4.95	5.17 ± 3.91	4.97 ± 5.08	4.86 ± 5.20	5.87 ± 4.84	5.08 ± 4.50	5.18 ± 4.74	4.65 ± 3.76
Triple_Hop Asymmetry	3.41 ± 2.60	3.44 ± 2.59	3.24 ± 2.92	4.07 ± 2.94	4.00 ± 2.88	4.64 ± 4.10	2.63 ± 1.92	2.73 ± 2.02	2.19 ± 1.54
Triple_Cross_Hop Asymmetry	6.93 ± 10.30	7.12 ± 10.99	5.84 ± 4.91	4.86 ± 4.65	4.39 ± 4.35	8.47 ± 6.28	9.39 ± 14.15	10.61 ± 15.39	3.86 ± 3.11
CMJ (m)	0.35 ± 0.06	0.35 ± 0.06	0.34 ± 0.07	0.37 ± 0.04	0.37 ± 0.05	0.39 ± 0.04	0.28 ± 0.03 [D]	0.27 ± 0.03 [C]	0.29 ± 0.04
CMJ_DL (m)	0.19 ± 0.03	0.19 ± 0.03	0.19 ± 0.04	0.20 ± 0.03	0.20 ± 0.03	0.22 ± 0.02	0.15 ± 0.03 [D]	0.15 ± 0.03 [C]	0.16 ± 0.03
CMJ_NDL (m)	0.19 ± 0.03	0.19 ± 0.03	0.19 ± 0.04	0.20 ± 0.03	0.20 ± 0.03	0.23 ± 0.01	0.16 ± 0.02 [D]	0.16 ± 0.03 [C]	0.16 ± 0.01 [e]
CMJ Asymmetry	10.05 ± 7.88	10.47 ± 8.03	7.93 ± 7.36	11.26 ± 8.41	12.03 ± 8.53	5.37 ± 5.06	6.89 ± 5.44	5.34 ± 2.24	10.49 ± 9.49
DVJ (m)	0.34 ± 0.07	0.34 ± 0.07	0.34 ± 0.06	0.36 ± 0.06	0.36 ± 0.06	0.37 ± 0.07	0.28 ± 0.05 [D]	0.27 ± 0.06 [c]	0.31 ± 0.03
DVJ_DL (m)	0.21 ± 0.04	0.20 ± 0.04	0.22 ± 0.03	0.22 ± 0.04	0.22 ± 0.04	0.23 ± 0.01	0.18 ± 0.04 [d]	0.16 ± 0.03 [c]	0.21 ± 0.04
DVJ_NDL (m)	0.21 ± 0.04	0.21 ± 0.04	0.22 ± 0.04	0.22 ± 0.04	0.22 ± 0.04	0.24 ± 0.06	0.18 ± 0.02 [d]	0.17 ± 0.01 [c]	0.20 ± 0.03
DVJ Asymmetry	10.10 ± 9.03	9.97 ± 8.97	10.73 ± 10.17	11.17 ± 9.02	10.37 ± 8.76	17.29 ± 10.45	7.32 ± 8.90	8.67 ± 10.24	4.17 ± 4.50
Repeat Tuck Jump	2.68 ± 1.36	2.73 ± 1.39	2.43 ± 1.27	2.68 ± 1.41	2.59 ± 1.47	3.33 ± 0.58	2.68 ± 1.34	2.93 ± 1.28	1.75 ± 1.26
Leg Stiffness ($N \cdot m^{-1}$)	21.28 ± 8.38	20.91 ± 8.68	23.71 ± 6.10	24.71 ± 7.47	24.62 ± 7.50	25.47 ± 8.85	16.59 ± 7.33 [D]	15.58 ± 7.54 [C]	21.96 ± 2.35

DL: dominant leg; NDL: non-dominant leg; CMJ: countermovement jump; DVJ: drop vertical jump. c: Significant difference ($p < 0.005$) between non-injured male and non-injured female players; C: Significant difference ($p < 0.001$) between non-injured male and non-injured female players; d: Significant difference ($p < 0.05$) between male and female players; D: Significant difference ($p < 0.001$) between male and female players; e: Significant difference ($p < 0.05$) between injured male and injured female players.

Table 3. Y-balance test, sprint, and Illinois test scores (mean ± SD).

	All Participants			Men			Women		
	All Participants	No Injured	Injured	All Men	No Injured	Injured	All Women	No Injured	Injured
YB Anterior DL (cm)	62.88 ± 5.33	62.81 ± 5.04	63.32 ± 7.48	61.24 ± 4.95	61.60 ± 5.02	58.53 ± 4.08	65.11 ± 5.11 [d]	64.55 ± 4.68	68.11 ± 7.38
YB Anterior NDL (cm)	63.42 ± 5.27	63.23 ± 5.28	64.68 ± 5.55	61.53 ± 4.88	61.45 ± 5.08	62.08 ± 3.59	66.01 ± 4.76 [d]	65.78 ± 4.57 [c]	67.27 ± 6.62
YB PosteroMedial DL (cm)	103.43 ± 8.39	103.34 ± 8.78	104.01 ± 5.75	103.74 ± 7.32	103.88 ± 7.44	102.71 ± 7.62	102.99 ± 9.86	102.56 ± 10.62	105.32 ± 4.42
YB Posteromedial NDL (cm)	105.48 ± 6.44	105.37 ± 6.79	106.17 ± 3.62	105.48 ± 6.11	105.68 ± 6.36	103.97 ± 4.13	105.48 ± 7.03	104.93 ± 7.57	108.36 ± 1.13
YB PosteroLateral DL (cm)	101.41 ± 9.00	102.11 ± 9.37	96.87 ± 4.11	100.78 ± 7.78	101.37 ± 7.97	96.19 ± 4.76	102.28 ± 10.61	103.17 ± 11.28	97.54 ± 4.27
YB Posterolateral NDL (cm)	101.13 ± 7.35	101.33 ± 7.75	99.77 ± 4.13	99.13 ± 6.31	99.32 ± 6.58	97.67 ± 4.21	103.85 ± 7.95 [d]	104.22 ± 8.57	101.88 ± 3.40
YB Anterior bilateral ratio	0.99 ± 0.05	0.99 ± 0.05	0.98 ± 0.08	0.99 ± 0.06	1.00 ± 0.05	0.94 ± 0.09	0.99 ± 0.05	0.99 ± 0.05	1.02 ± 0.04
YB PosterioMedial bilateral ratio	0.98 ± 0.05	0.98 ± 0.05	0.98 ± 0.06	0.98 ± 0.04	0.98 ± 0.04	0.98 ± 0.08	0.98 ± 0.06	0.98 ± 0.06	0.98 ± 0.05

Table 3. *Cont.*

	All Participants			Men			Women		
	All Participants	**No Injured**	**Injured**	**All Men**	**No Injured**	**Injured**	**All Women**	**No Injured**	**Injured**
YB PosteroLateral bilateral ratio (cm)	1.00 ± 0.05	1.01 ± 0.04	0.97 ± 0.06	1.01 ± 0.04	1.02 ± 0.04	0.98 ± 0.07	0.99 ± 0.05	0.99 ± 0.05	0.96 ± 0.08
YB Composite DL (cm)	89.24 ± 6.13	89.42 ± 6.31	88.07 ± 5.12	88.59 ± 5.59	88.95 ± 5.67	85.81 ± 4.98	90.13 ± 6.86	90.09 ± 7.28	90.32 ± 5.04
YB Composite NDL (cm)	90.01 ± 5.20	89.98 ± 5.50	90.21 ± 2.90	88.71 ± 4.87	88.82 ± 5.15	87.91 ± 2.04	91.78 ± 5.23	91.65 ± 5.71	92.50 ± 0.99 [e]
YB Anterior Asymmetry	4.22 ± 2.71	4.04 ± 2.36	5.42 ± 4.54	4.45 ± 3.04	4.06 ± 2.47	7.44 ± 5.76	3.91 ± 2.23	4.00 ± 2.26	3.39 ± 2.45
YB PosteroMedial Assymetry	3.71 ± 3.49	3.54 ± 3.59	4.75 ± 2.85	3.28 ± 3.04	3.05 ± 2.94	5.05 ± 3.92	4.28 ± 4.04	4.25 ± 4.36	4.46 ± 2.15
YB PosteroLateral Asymmetry	3.33 ± 3.19	3.12 ± 2.99	4.67 ± 4.38	3.28 ± 2.33	3.17 ± 2.19	4.11 ± 3.69	3.40 ± 4.17	3.06 ± 3.95	5.23 ± 5.77
YB Composite Asymmetry	2.57 ± 2.50	2.35 ± 2.24	4.02 ± 3.75	2.26 ± 2.47	1.96 ± 1.96	4.48 ± 5.04	3.01 ± 2.55	2.91 ± 2.56	3.55 ± 3.02
Sprint 5 m (s)	1.04 ± 0.15	1.05 ± 0.16	0.98 ± 0.09	0.94 ± 0.05	0.95 ± 0.05	0.92 ± 0.01	1.15 ± 0.15 [D]	1.18 ± 0.15 [C]	1.03 ± 0.10 [e]
Sprint 10 m (s)	1.81 ± 0.19	1.82 ± 0.20	1.78 ± 0.15	1.67 ± 0.07	1.67 ± 0.07	1.64 ± 0.04	1.99 ± 0.14 [D]	2.01 ± 0.14 [C]	1.88 ± 0.09 [e]
Sprint 15 m (s)	2.49 ± 0.24	2.50 ± 0.24	2.44 ± 0.21	2.31 ± 0.08	2.32 ± 0.09	2.25 ± 0.03	2.71 ± 0.17 [D]	2.73 ± 0.17 [C]	2.59 ± 0.14 [e]
Illinois test (s)	15.96 ± 0.98	15.96 ± 0.96	15.98 ± 1.15	15.26 ± 0.38	15.31 ± 0.38	14.94 ± 0.20	16.97 ± 0.60 [D]	17.04 ± 0.53 [C]	16.76 ± 0.86 [e]

YB: Y-balance test; DL: dominant leg; NDL: non-dominant leg. c: Significant difference ($p < 0.005$) between non-injured male and non-injured female players; C: Significant difference ($p < 0.001$) between non-injured male and non-injured female players; d: Significant difference ($p < 0.05$) between male and female players; D: Significant difference ($p < 0.001$) between male and female players; e: Significant difference ($p < 0.05$) between injured male and injured female players.

4. Discussion

The purpose of this study was to analyse the differences among injured (players that suffered an injury during the following four months after they were evaluated) and non-injured futsal players in different neuromuscular parameters (e.g., performance scores, bilateral ratios, unilateral ratios, and asymmetries). Moreover, differences between male and female futsal players were also analysed. This is the first study to the authors' knowledge that compares physical fitness differences between injured and non-injured futsal players of both sexes. Results showed that, except in the isometric hip adduction strength for the non-dominant leg and in the unilateral ratio of the same leg, there are no differences in any variable between those futsal players that suffered an injury and those that did not suffer injuries. However, neuromuscular performance scores showed statistically significant differences between male and female futsal players in several variables but not in ratio or asymmetry.

Strength levels have been considered as a key variable in the likelihood of suffering an injury, but its relevance might vary regarding different muscle groups [18–20,42]. In this sense, strength levels in hip and trunk muscles may have a great impact in the risk of suffering an injury in similar sports players [43–46]. Regarding these variables, injured players reported lower strength levels in the adductor muscles of the non-dominant leg, which was reflected in a lower UR for the group. This weakness might increase the likelihood of suffering an injury not just in that muscle but, also, in other related structures such as low back muscles [47], knee joints [44], and ankle joints [45]. When analysing the male group individually, the same results can be observed; however, injured male players also presented lower strength levels for the adductors in the dominant leg. Otherwise, for the female injured players, no differences in any variable were reported, suggesting lower relevance of the strength level when determining the risk of suffering an injury in female futsal players. This could be due to the difference between male and female futsal characteristics, contributing to the higher number of high intensity phases observed in elite male players during the course of futsal play [48,49] that might contribute to generating different adaptations. Comparing male and female futsal players, results confirm the differences showing how female players either analysed globally (non-injured + injured) or only considering the non-injured players, showed reduced strength values in abduction, adduction, and trunk flexion–rotation when comparing to their male counterparts. These findings provide valuable information to design and implement injury prevention programmes specific to each sex in futsal.

For the evaluation of the strength functional levels of the lower limbs in futsal players, it could be interesting to apply a jump battery that includes bilateral and unilateral tests and in multiple or several jumps [30,32,50]. In this sense, no differences were observed when considering players either globally or in male or female players. This could be due to the learning and coordinating process that requires this kind of a test [51]. When comparing male and female players, it should be noted that the global group of male and the non-injured male players showed higher scores in the single hop, triple hop, triple cross hop, CMJ, DVJ, and leg stiffness test than their female counterpart. These results are in accordance with the differences in conditional levels between male and female athletes presented in the literature [52–56]. Nevertheless, it might be interesting whether or not the increase in the scores of the female futsal players would have a positive influence on their performance in the field. Therefore, future studies should analyse it. However, the differences between injured male and injured female players were presented just for the triple hop and the CMJ for the non-dominant leg in both cases, but this could be explained by the low number of injured players in both groups.

A holistic analysis of the physical condition of male and female futsal players requires the combination of strength tests with evaluation of physical qualities and other assessments that measure different qualities related to the injury risk, such as the balance, the speed, or the agility. Similar to the strength test, no differences were observed between injured and non-injured players when comparing males and females in the same group or in isolated groups. This might suggest the low capacity of the test to predict athletes at high risk of suffering an injury on their own, as suggested previously [57], but the results could be also explained by the low sample of injured players. Regarding the stability scores of the participants, only a few variables show differences and always in the female players' favour. The growing knowledge concerning the effect of that Q angle and the influence of balance on it, created a change in the injury prevention paradigm that could explain these results. Conversely, male players showed higher performance in the speed and agility test than female players, agreeing with the previous literature and due to the genetic component and its influence on the muscle mass of the male players [55,56]. These findings confirm the necessity of performing tailored training programs for the sex and population that the program is aimed at.

Despite the promising line of research that opens through this work, and as is inherent in any work, it is needed to indicate that this study does not lack limitations. First of all, the low number of injured players included in the study, so we cannot assess differences between tactical positions. However, the number of elite futsal players included in the study allows for representing with certain accuracy the reality of the sport. In addition, the constant evaluation of the professional futsal players is not possible due to daily professional competition. Therefore, the time frame after the evaluation was set within the next 4 months due to the fact that the injuries suffered afterward might be related to the registered values. Even though the tests that were used in this study are related to the likelihood of suffering an injury, it might be adequate to combine these field tests with the laboratory tests, in order to provide more robust results such as isokinetic strength ratio, thermography analysis, or even motion analysis through 3D capture systems. Although the results of the study enlighten the relationship of individual neuromuscular assessment scores and the likelihood of suffering an injury in futsal players, this was achieved through a traditional methodology that has not been specifically designed to manage class imbalance problems such as injuries (number of non-injured players is much higher than injured players). Future studies should deepen the knowledge through more robust and modern techniques such as machine learning or data mining environments, in which variables can be analysed together with their relationship to the injuries.

5. Conclusions

Isometric hip adduction strength for the non-dominant leg weakness and in the unilateral ratio for the same leg might be an important factor toward suffering an injury. There are differences in neuromuscular performance values for male and female futsal players. Medical, fitness trainers, or any futsal practitioner should focus their attention on designing, programming, and implementing training programs that are tailored to the population that they aim at. Male and female futsal players have different physical demands and consequently different training programs should be implemented for them.

Author Contributions: Conceptualisation, I.R.-P. and F.A.; data curation, I.R.-P.; formal analysis, F.A.; investigation, I.R.-P. and A.L.-V.; methodology, A.L.-V., F.J.R.-P. and F.A.; resources, F.J.R.-P.; supervision, A.L.-V. and F.A.; writing—original draft, I.R.-P. and J.R.-G.; writing—review and editing, J.R.-G., A.L.-V., F.J.R.-P. and F.A. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and the Research Ethics Committee of Miguel Hernández University of Elche approved the protocol (DPS.FAR.01.14, date of approval 14 January 2014).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Acknowledgments: Javier Raya-González was supported by a Ramón y Cajal postdoctoral fellowship (RYC2021-031072-I) given by the Spanish Ministry of Science and Innovation, the State Research Agency (AEI), and the European Union (NextGenerationEU/PRTR). Francisco Javier Robles-Palazón was supported by a Margarita Salas postdoctoral fellowship (UMU/R-1500/2021) given by the Spanish Ministry of Universities and funded by the European Union-NextGenerationEU. Francisco Ayala was supported by a Ramón y Cajal postdoctoral fellowship (RYC2019-028383-I) given by the Spanish Ministry of Science and Innovation, the State Research Agency (AEI), and the European Regional Development Fund (ERDF). This study is part of the project entitled "El fútbol femenino importa: identificación del riesgo de lesión a través de la inteligencia artificial [Women's football matters: identification of injury risk through artificial intelligence]" (I+D+I/PID2020-111886RB-100) funded by MCIN/AEI/10. 13039/501100011033).

Conflicts of Interest: The authors declare no conflict of interest.

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