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The influence of futsal players‘ initial physical condition on the occurrence of injuries

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Abstract:
Although there are some studies that have linked fitness parameters and sports injuries, the literature remains controversial. The aim of the study was to prospectively analyze the influence of initial physical condition parameters on the development of injury in the first three months of the sports season in futsal players. A total of 68 players (24.26 ± 4.63 years old) were assessed before the start of the sport season in relation to certain physical condition parameters, such as body composition (bioimpedance), lower limb power (countermovement jump, CMJ) and muscle strength (isokinetic dynamometer). The injured players showed significantly worse initial performance in the CMJ compared to the uninjured players ($p < 0.001$). There were no significant differences between groups in body composition and muscle strength. Lower power values were associated with a higher risk of injury in the first few months of the sport season (OR = 0.92; 95% CI = 0.88 - 0.99). Muscle power was an independent predictor of injury in the first few months of the sports season in futsal players, indicating that improving players‘ physical condition could help reduce the number of injuries.

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Abstract

Although there are some studies that have linked fitness parameters and sports injuries, the literature remains controversial. The aim of the study was to prospectively analyze the influence of initial physical condition parameters on the development of injury in the first three months of the sports season in futsal players. A total of 68 players (24.26 ± 4.63 years old) were assessed before the start of the sport season in relation to certain physical condition parameters, such as body composition (bioimpedance), lower limb power (countermovement jump, CMJ) and muscle strength (isokinetic dynamometer). The injured players showed significantly worse initial performance in the CMJ compared to the uninjured players ($p < 0.001$). There were no significant differences between groups in body composition and muscle strength. Lower power values were associated with a higher risk of injury in the first few months of the sport season (OR = 0.92; 95% CI = 0.88 - 0.99). Muscle power was an independent predictor of injury in the first few months of the sports season in futsal players, indicating that improving players' physical condition could help reduce the number of injuries.

Keywords:

Body Composition; Lower Limb Power; Muscle Strength; Futsal; Injury.

Introduction

Futsal is a team sport that has more than 12 million players worldwide and is officially recognized by the Fédération International de Football Association (FIFA) [1]. During the game of futsal, players are exposed to physical contact with their opponents and to high-intensity physical demands, such as accelerations and decelerations, rapid changes of direction, tackles and kicks [2,3]. A high level of physical condition is essential for players, particularly in terms of body composition, power and muscle strength, in order to match the various actions of the game [4]. All these factors put futsal players at substantial risk of injury and, in fact, it has been indicated that futsal is among the ten most injury-prone sports [5]. Currently, prospective epidemiological studies in futsal indicate injury incidence rates ranging from 2.22 to 6.7 injuries per 1000 hours of exposure [6–8], with the majority of injuries occurring in the lower limbs [7,9], mainly affecting the groin, thigh, knee and ankle, and non-contact injuries being the most commonly referred to mechanism [6].

In order to develop effective prevention programs, it is imperative that injury risk factors are clearly identified and recognized and the literature, although controversial, suggests that the physical condition of players can influence and predict the occurrence of sports injuries [10–15]. In this sense, body composition, namely muscle mass, fat mass and body mass index (BMI), are important determinants of physical condition and all these parameters are related to the risk of injury and the health of players [16,17]. On the other hand, power and muscle strength are essential physical attributes in futsal and, as a general rule, stronger and more powerful players tend to be faster and more agile [18–20]. The indirect assessment of lower limb power through the Countermovement Jump (CMJ) is commonly referred to in the literature, as it reflects the effectiveness of the neuromuscular system in producing maximum force in the shortest possible time. With regard to muscle strength, although the importance and effectiveness of assessing it using the isokinetic dynamometer is recognized, the literature lacks research into futsal. However, de Lira et al. [21] showed that futsal players have lower extensor strength compared to soccer and beach soccer players, although they all showed strength imbalances in the hamstring/ quadriceps ratio (H/Q ratio).

Additionally, it is during the preseason period that sports and health professionals focus on developing players' physical condition in order to prepare them for the various demands of the competitive period [22]. It is also at this stage, especially at the beginning of the sport season, that the clinical department of each club should provide a detailed and rigorous assessment of the players' physical condition, including the evaluation of body composition, lower limb power and muscle strength, with the aim of characterizing the general state of health as well as identifying the players' individual needs in terms of potentially modifiable injury risk factors [23–26]. In this way, it is possible to anticipate the probability of injury during the competitive season, implementing preventive and individualized training programs [24] aimed above all at optimizing performance and minimizing the risk of injury [11,23,27].

Nevertheless, the relationship between physical condition at the start of the preseason and the occurrence of injury in futsal seems to us to be a clear limitation of the literature, in this sense, and as far as we know, there are no previous studies that have investigated the relationship between body composition, power, strength and the appearance of injury in the first few months of the sport season. For this reason, the main aim of our study was to prospectively analyze the influence of initial physical condition parameters (body composition, lower limb power and isokinetic muscle strength) on the development of injury in the first three months of the sports season in futsal players. Based on the literature, our hypothesis is that low initial physical condition levels were associated with a higher likelihood of sports injury in the first few months of the season [28,29].

Materials and Methods

Participants

This is a prospective study and the participants were recruited intentionally and for convenience. Sixty-eight senior male futsal players (24.26 ± 4.63 years), selected from five Portuguese teams, took part in this study. Data was collected from the first day of pre-season until the end of the following 3 months (beginning of August until November 2023), after this period they were divided into two groups, with injury (24.71 ± 3.63 years) and without injury (24.06 ± 5.04 years).

To select the sample, the inclusion criteria were all senior male players from the respective teams duly registered at the club; all players who remained at the club during the investigation; and the exclusion criteria were the existence of an injury that prevented the assessment of physical condition on the first day of the season.

Procedures and instruments

Initially, a formal and institutional contact was made with the clubs, presenting the objectives and asking for their cooperation, after which the participants were given a questionnaire and a term of informed consent. Next, all the players who met the defined inclusion criteria, the evaluation procedures and purposes of the study were explained, which respected and preserved all the ethical principles, international norms and standards relating to the Declaration of Helsinki and the Convention on Human Rights and Biomedicine, having been approved by the institutional review board.

Injuries were recorded daily by each club's physiotherapist during the research period (from the first day of the sports season until the end of 3 months), on a grid drawn up for the purpose, and categorized according to the part of the body that suffered structural and/or functional changes, the anatomical region, the type of injury, the contact mechanism (resulting from a specific, identifiable event) or non-contact mechanism (resulting from repeated microtraumas without a single, identifiable event) and the severity (minimal (1-3 days), mild (4-7 days), moderate (8-28 days) and severe (more than 28 days)) [30].

The initial physical condition of each player was assessed on day 1 of each club's sports season using three laboratory instruments. First, we used a bioimpedance scale to assess body composition (InBody 270, Biospace, California, USA) with a tetrapolar electrode system with 8 electrodes and frequencies of 20 and 100 kHz. Height was recorded with a portable stadiometer. During the assessment, the players stood barefoot, in contact with the scale's sensors and with their arms about 45º away from their torso. Beforehand, the participants were informed of some precautions such as: fasting for 4 hours before the test; abstaining from intense physical activity 24 hours before the test; emptying the bladder and bowels before the test [31]. The variables considered for analysis were BMI, muscle mass (Kg) and fat mass (Kg).

Second, the players warmed up for 5 minutes on a cycle ergometer and then had their lower limb muscle power assessed using the maximum height reached in the CMJ jump as this is one of the most reliable measures for assessing muscle power [28,32–35] and we used a force platform (ChronoJump Boscosystem) to apply the protocol. The players were asked to adopt a vertical position, with their feet shoulder-width apart and their hands on their waist, in order to minimize the influence of the upper limbs during the execution of the jump. They were then encouraged to jump as high as possible with their lower limbs in extension, as indicated by Bosco et al. [36] Three attempts were made at the CMJ with a short recovery interval between repetitions (10 to 20 seconds), until they were ready to perform the next jump, and the highest jump (cm) was recorded.

Third, we used concentric isokinetic tests using a dynamometer (System 4, Biodex Medical Systems, Shirley, New York, USA) to assess the muscle strength of the quadriceps and hamstrings, as indicated in other studies [37]. The players were correctly positioned on the dynamometer with the knee and hip at 90°, the knee flexion angle was set at 110° and 0° in extension and the weight of the limb was used to correct for the effects of gravity. To prevent undesirable movements, three straps were used to secure the thoracic region, the hip and the knee. For familiarization, the players received verbal instructions on the procedures and performed a few submaximal practice attempts, then performed five repetitions of knee extension and flexion at a speed of 60°/s, as this is the recommended angular velocity to recruit a greater number of muscle fibers [38]. The players were verbally encouraged throughout the test to perform their maximum strength. We recorded the peak concentric torque of the quadriceps and hamstrings for the dominant and non-dominant limb. The H/Q ratio used for analysis was calculated by dividing the peak concentric torque of the hamstrings by the peak concentric torque of the quadriceps at the same contraction speed. We determined this variable in the strength assessment because it plays a fundamental role in knee joint stability and has been used to investigate functional capacity, joint stability and muscle balance between knee flexors and extensors [39]. Furthermore, studies indicate that an imbalance in the

H/Q ratio correlates with a higher incidence of lower limb injuries [40]. According to some authors, values below 60% increase the likelihood of injury [26,41].

Statistical Analysis

The data was analyzed using SPSS statistical software (v.23.0) and Shapiro-Wilk tests were used to verify the normality of the data. The non-parametric Kruskal Wallis test was used to compare two groups: players who developed injuries and players who did not. In another analysis, we used binary logistic regression to see if the physical condition variables assessed at the start of preseason could predict the occurrence of injuries in the first three months of the sports season.

Results

Of the total sample, 21 players developed injuries in the first three months of the sporting season, with the majority occurring in the lower limbs (26.5%), the ankle (10.3%), thigh (10.3%) and knee (5.9%) were the most frequently injured anatomical regions and the most common type of injury was muscle and ligament, both with 13.2%. With regard to the mechanism of injury, non-contact was the most common and, in terms of severity, the majority of injuries were moderate (16.2%).

Table 1 shows that the players who developed an injury in the first few months of the sport season performed less well in the CMJ compared to the players without an injury, with significant differences observed in both groups ($p < 0.001$). As for the variables of body composition (muscle mass, fat mass and BMI) and muscle strength (H/Q ratio), we found no statistically significant differences between groups ($p > 0.05$), however, when analyzing the averages of each group, it can be seen that the injured group showed worse results for all variables.

Table 2 shows that, in general terms, the model including all the independent variables was not significant [X^2 (8) = 7.946; $p > 0.05$; R^2 Negelkerke = 0.147]. In line with the results presented above, the players who developed an injury during the first three months of the sport season had, on average, a worse initial physical condition with regard to the variables studied, however, only the power of the lower limbs expressed by the height of the CMJ was a significant predictor (OR = 0.92; 95% CI = 0.88 - 0.99), which indicates that a lower jump height was associated with a greater risk of injury (table 2). For every one-unit increase in the height of the CMJ, the probability of injury decreases by around 8% ($p = 0.04$), showing a negative association between these variables.

Discussion

The main objective of this study was to verify whether the physical condition parameters of futsal players assessed at the start of the pre-season would be predictors of the occurrence of injury in the first few months of the sport season. Previous studies have highlighted the importance of physical condition variables as determinant predictors of the likelihood of injury occurring in soccer players [42,43], however, in futsal there is a notable lack of research at this level [10].

In the present study, we found no significant differences in body composition (muscle mass, fat mass and BMI) between the groups, and none of the variables analyzed were directly related to the occurrence of injuries in female futsal players, and this result is in line with previous studies which also found no relationship between body composition and the development of injuries [10,44]. On the other hand, in contrast to our study, other authors have indicated that high BMI values were associated with lower limb injuries in elite female soccer players [45]; just as Grant et al. [46] showed that BMI was a predictor of injuries in female ice hockey players. Interestingly, in the Watson et al. study, muscle mass was related to injuries at the start of the season (first four weeks) in female college soccer players, but was not related to injuries during the season, which is somewhat in line with our study. Since the population differs from study to study and different methods are used to assess body composition, it is very difficult to compare our results. According to the literature, there seems to be a specific relationship between each sport, body composition and the risk of injury, since, for example, higher body mass can protect against contact injuries in Australian soccer [47]; and in the case of American soccer, a substantial part of the players are categorized as overweight or obese [48]. Still, this hypothesis needs to be confirmed with more prospective studies [10].

With regard to lower limb muscle power, this is one of the most crucial skills in the success of the game of futsal, allowing players to perform numerous explosive tasks such as jumping, running, shooting and changing direction [49,50]. In our study, we found that players without injuries performed significantly better in the CMJ at the start of the sports season compared to the group of players who developed injuries ($p < 0.001$), and we also found that power was found to be an independent predictor of an 8% decrease in the likelihood of sports injuries. This result showed a clear relationship between power and sports injuries, i.e. the lower the height of the CMJ jump, the greater the likelihood of injury, as had already been seen in a study similar to ours by Angoorani et al [10].

According to the literature, muscle strength can be a potential risk factor for sports injuries [21]. However, like other studies, in general terms we didn't find any relationship between the H/Q ratio, the peak torque of the quadriceps and hamstrings and the occurrence of injuries in futsal players [10]. In the present study, the average peak torque values for the extensors and flexors were higher than those found in the study by Lira et al. [21] on futsal players, but for the flexors they were lower than those found by Nunes et al. [51]. However, as had already been seen in the Lira et al. [21] study, when analyzing lower limb asymmetry based on the sample studied, most of the players didn't show differences greater than the recommended 10%; specifically, only 33.8% showed bilateral deficits for the flexor muscles and 17.6% showed bilateral deficits for the extensor muscles. However, these results do not rule out the need for individual assessments to identify this possible risk factor for injury. From another perspective and corroborating our study, Östenberg & Roos [52] indicated that isokinetic muscle strength was also not considered a risk factor for sports injuries at any of the speeds assessed (60°/s and 180°/s.). On the other hand, in a study of soccer players, Soderman et al. [53] concluded that a lower H/Q ratio increased the risk of lower limb injuries. Furthermore, surprisingly, both groups (with injury and without injury) had H/Q ratio values lower than the 60% recommended in the literature, as was the case in other studies [24,26], indicating that these players were at greater risk of injury. Therefore, the results highlight the need to introduce strength programs for the hamstrings in both groups studied.

Despite the promising line of research that led to this study, it is necessary to point out some limitations. Firstly, the low number of injured players included in the study compared to the number of non-injured players; and secondly, we could have assessed other dimensions of physical fitness, such as balance, agility, speed and lung capacity, in order to obtain more robust results that were closer to reality.

Conclusions

Although there have been a few studies relating physical fitness parameters to sports injuries, the literature remains controversial. We concluded in this study that there were no significant differences in body composition and muscle strength between futsal players who were injured in the first three months of the season and players who were not injured, but there were differences in lower limb power, with players without injuries showing better results at the start of the season. Finally, we concluded that lower limb power was a predictor of an 8% reduction in the likelihood of injury in the first few months of the season. We draw attention to the need for more studies to determine the risk factors for injury in the context of futsal, with the aim of developing prevention programs suited to the sport.

Practical implications

- Lower limb muscle power has been shown to be an independent predictor of injury in the first few months of the sports season in futsal players, which is why physical trainers and physiotherapists should work in symbiosis to improve players' physical condition in general, and specifically muscle power, in order to reduce the number of injuries.

References

[1] Beato M, Coratella G, Schena F. Brief review of the state of art in futsal. J Sports Med Phys Fitness 2016; 56: 428–432

[2] Castagna C, D'Ottavio S, Vera JG, et al. Match demands of professional Futsal: A case study. J Sci Med Sport 2009; 12: 490–494. doi:10.1016/j.jsams.2008.02.001

[3] Doğramacı NS, Watsford LM. A comparison of two different methods for time-motion analysis in team sports. Int J Perform Anal Sport 2006; 6: 73–83. doi:10.1080/24748668.2006.11868356

[4] Gorostiaga EM, Llodio I, Ibáñez J, et al. Differences in physical fitness among indoor and outdoor elite male soccer players. Eur J Appl Physiol 2009; 106: 483–491. doi:10.1007/s00421-009-1040-7

[5] Junge A, Dvorak J. Injury risk of playing football in Futsal World Cups. Br J Sports Med 2010; 44: 1089–1092. doi:10.1136/bjsm.2010.076752

[6] Lopes M, Martins F, Brito J, et al. Epidemiology of Injuries in Elite Male Futsal Players. Clin J Sport Med 2023; 33: 527–532. doi:10.1097/JSM.0000000000001142

[7] Angoorani H, Haratian Z, Mazaherinzhad A, et al. Injuries in Iran Futsal National Teams: A Comparative Study of Incidence and Characteristics. Asian J Sports Med 2014; 5. doi:10.5812/asjsm.23070

[8] Ruiz-Pérez I, López-Valenciano A, Jiménez-Loaisa A, et al. Injury incidence, characteristics and burden among female sub-elite futsal players: a prospective study with three-year follow-up. PeerJ 2019; 7: e7989. doi:10.7717/peerj.7989

[9] Hamid MSA, Jaafar Z, Mohd Ali AS. Incidence and characteristics of injuries during the 2010 FELDA/FAM National Futsal League in Malaysia. PLoS One 2014; 9: e95158. doi:10.1371/journal.pone.0095158

[10] Angoorani H, Haratian Z, Farmanara H, et al. Lower Physical Fitness Is Associated with Injuries in Iranian National Futsal Teams: A Prospective Study. Asian J Sports Med 2021; 12. doi:10.5812/asjsm.110778

[11] Dauty M, Menu P, Fouasson-Chailloux A, et al. Prediction of hamstring injury in professional soccer players by isokinetic measurements. Muscles Ligaments Tendons J 2016; 6: 116–123. doi:10.11138/mltj/2016.6.1.116

[12] Lago-Fuentes C, Jiménez-Loaisa A, Padrón-Cabo A, et al. Perceptions of the technical staff of professional teams regarding injury prevention in Spanish national futsal leagues: a cross-sectional study. PeerJ 2020; 8: 1–15. doi:10.7717/peerj.8817

[13] Liporaci RF, Saad M, Grossi DB, et al. Clinical Features and isokinetic Parameters in Assessing Injury Risk in elite Football Players. Int J Sports Med 2019; 40: 903–908. doi:10.1055/a-1014-2911

[14] Nikolaidis P. Association between body mass index, body fat per cent and muscle power output in soccer players. Cent Eur J Med 2012; 7: 783–789. doi:10.2478/s11536-012-0057-1

[15] Ruiz-Pérez I, Raya-González J, López-Valenciano A, et al. Physical Differences between Injured and Non-Injured Elite Male and Female Futsal Players. Applied Sciences 2023; 13: 6503. doi:10.3390/app13116503

[16] Silva AM. Structural and functional body components in athletic health and performance phenotypes. Eur J Clin Nutr 2019; 73: 215–224. doi:10.1038/s41430-018-0321-9

[17] Stubbs-Gutierrez A, Medina-Porqueres I. Anthropometric characteristics and physical fitness in elite futsal male players. A systematic review. Movement & Sport Sciences - Science & Motricité 2021; 19–28. doi:10.1051/sm/2020011

[18] Freitas TT, Pereira LA, Alcaraz PE, et al. Influence of Strength and Power Capacity on Change of Direction Speed and Deficit in Elite Team-Sport Athletes. J Hum Kinet 2019; 68: 167–176. doi:10.2478/hukin-2019-0069

[19] Newton RU, Rogers RA, Volek JS, et al. Four Weeks of Optimal Load Ballistic Resistance Training at the end of Season Attenuates Declining Jump Performance of Women Volleyball Players. J Strength Cond Res 2006; 20: 955–961. Doi:10.1519/00124278-200611000-00037

[20] Wilson GJ, Newton RU, Murphy AJ, et al. The optimal training load for the development of dynamic athletic performance. Med Sci Sports Exerc 1993; 25: 1279–1286. doi:10.1249/00005768-199311000-00013

[21] De Lira CAB, Mascarin NC, Vargas VZ, et al. Isokinetic Knee Muscle Strength Profile in Brazilian Male Soccer, Futsal, and Beach Soccer Players: A Cross-Sectional Study. Int J Sports Phys Ther 2017; 12: 1103–1110. Doi:10.26603/Ijspt20171103

[22] Parpa K, Michaelides M. Relationship of Pre-Season Strength Asymmetries, Flexibility and Aerobic Capacity with In-Season Lower Body Injuries in Soccer Players. Sport Mont 2022; 20: 69–74. doi:10.26773/smj.220611

[23] Ardern CL, Pizzari T, Wollin MR, et al. Hamstrings Strength Imbalance in Professional Football (Soccer) Players in Australia. J Strength Cond Res 2015; 29: 997–1002. doi:10.1519/JSC.0000000000000747

[24] Croisier J-L, Ganteaume S, Binet J, et al. Strength imbalances and prevention of hamstring injury in professional soccer players: a prospective study. Am J Sports Med 2008; 36: 1469–1475. doi:10.1177/0363546508316764

[25] Kennedy MD, Fischer R, Fairbanks K, et al. Can pre-season fitness measures predict time to injury in varsity athletes?: a retrospective case control study. Sports Med Arthrosc Rehabil Ther Technol 2012; 4: 26. doi:10.1186/1758-2555-4-26

[26] Ferreira R, Araújo JP, Barreira P, et al. Preseason Evaluation. In: Injuries and Health Problems in Football. Berlin, Heidelberg: Springer Berlin Heidelberg; 2017: 493–514

[27] Veeck F, Ruas C V., Pinto MD, et al. Low Pre-Season Hamstring-to-Quadriceps Strength Ratio Identified in Players Who Further Sustained In-Season Hamstring Strain Injuries: A Retrospective Study from a Brazilian Serie A Team. Sports 2023; 11: 89. doi:10.3390/sports11040089

[28] Eliakim E, Doron O, Meckel Y, et al. Pre-season Fitness Level and Injury Rate in Professional Soccer – A Prospective Study. Sports Med Int Open 2018; 02: E84–E90. doi:10.1055/a-0631-9346

[29] Šiupšinskas L, Garbenytė-Apolinskienė T, Salatkaitė S, et al. Association of pre-season musculoskeletal screening and functional testing with sports injuries in elite female basketball players. Sci Rep 2019; 9: 9286. doi:10.1038/s41598-019-45773-0

[30] Fuller CW, Ekstrand J, Junge A, et al. Consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries. Br J Sports Med 2006; 40: 193–201. doi:10.1136/bjsm.2005.025270

[31] Heyward VH. Avaliação da Composição Corporal Aplicada. Manole. 2000

[32] Cuadrado-Peñafiel V, Párraga-Montilla J, Ortega-Becerra M, et al. Repeated sprint ability in professional soccer vs. professional futsal players. E-balonmano.com: Revista de Ciencias del Deporte 2014; 10: 89–98

[33] Buchheit M, Spencer M, Ahmaidi S. Reliability, usefulness, and validity of a repeated sprint and jump ability test. Int J Sports Physiol Perform 2010; 5: 3–17

[34] Naser N, Ali A, Macadam P. Physical and physiological demands of futsal. J Exerc Sci Fit 2017; 15: 76–80. doi:10.1016/j.jesf.2017.09.001

[35] Pueo B, Penichet-Tomas A, Jimenez-Olmedo J. Reliability and validity of the Chronojump open-source jump mat system. Biol Sport 2020; 37: 255–259. doi:10.5114/biolsport.2020.95636

[36] Bosco C, Mognoni P, Luhtanen P. Relationship between isokinetic performance and ballistic movement. Eur J Appl Physiol Occup Physiol 1983; 51: 357–364. doi:10.1007/BF00429072

[37] Kyritsis P, Bahr R, Landreau P, et al. Likelihood of ACL graft rupture: not meeting six clinical discharge criteria before return to sport is associated with a four times greater risk of rupture. Br J Sports Med 2016; 50: 946–951. doi:10.1136/bjsports-2015-095908

[38] Baltzopoulos V, Brodie DA. Isokinetic dynamometry. Applications and limitations. Sports Med 1989; 8: 101–116. doi:10.2165/00007256-198908020-00003

[39] Andrade MDS, De Lira CAB, Koffes FDC, et al. Isokinetic hamstrings-to-quadriceps peak torque ratio: the influence of sport modality, gender, and angular velocity. J Sports Sci 2012; 30: 547–553. doi:10.1080/02640414.2011.644249

[40] Knapik JJ, Bauman CL, Jones BH, et al. Preseason strength and flexibility imbalances associated with athletic injuries in female collegiate athletes. Am J Sports Med 1991; 19: 76–81. doi:10.1177/036354659101900113

[41] Aagaard P, Simonsen EB, Magnusson SP, et al. A New Concept for Isokinetic Hamstring: Quadriceps Muscle Strength Ratio. Am J Sports Med 1998; 26: 231–237. doi:10.1177/03635465980260021201

[42] Martins F, Przednowek K, França C, et al. Predictive Modeling of Injury Risk Based on Body Composition and Selected Physical Fitness Tests for Elite Football Players. J Clin Med 2022; 11: 4923. doi:10.3390/jcm11164923

[43] Soheil H, Hassan D, Saeid B. A Prospective Study on the Relationship between Sports Injuries and some of the Physical Fitness Factors in Soccer Players. International Journal of Health and Rehabilitation Sciences (IJHRS) 2018; 7: 92. doi:10.5455/ijhrs.0000000149

[44] Watson A, Brickson S, Brooks MA, et al. Preseason Aerobic Fitness Predicts In-Season Injury and Illness in Female Youth Athletes. Orthop J Sports Med 2017; 5: 232596711772697. doi:10.1177/2325967117726976

[45] Nilstad A, Andersen TE, Bahr R, et al. Risk Factors for Lower Extremity Injuries in Elite Female Soccer Players. Am J Sports Med 2014; 42: 940–948. doi:10.1177/0363546513518741

[36] Grant JA, Bedi A, Kurz J, et al. Ability of Preseason Body Composition and Physical Fitness to Predict the Risk of Injury in Male Collegiate Hockey Players. Sports Health: A Multidisciplinary Approach 2015; 7: 45–51. doi:10.1177/1941738114540445

[37] Henderson B, Cook J, Kidgell DJ, et al. Game and Training Load Differences in Elite Junior Australian Football. J Sports Sci Med 2015; 14: 494–500

[38] Bosch TA, Carbuhn AF, Stanforth PR, et al. Body Composition and Bone Mineral Density of Division 1 Collegiate Football Players: A Consortium of College Athlete Research Study. J Strength Cond Res 2019; 33: 1339–1346. doi:10.1519/JSC.0000000000001888

[39] Caetano FG, de Oliveira MJ, Marche AL, et al. Characterization of the Sprint and Repeated-Sprint Sequences Performed by Professional Futsal Players, According to Playing Position, During Official Matches. J Appl Biomech 2015; 31: 423–429. doi:10.1123/jab.2014-0159

[40] Ribeiro JN, Gonçalves B, Coutinho D, et al. Activity Profile and Physical Performance of Match Play in Elite Futsal Players. Front Psychol 2020; 11. doi:10.3389/fpsyg.2020.01709

[41] Nunes RFH, Dellagrana RA, Nakamura FY, et al. Isokinetic Assessment of Muscular Strength and Balance in Brazilian Elite Futsal Players. Int J Sports Phys Ther 2018; 13: 94–103

[42] Östenberg A, Roos H. Injury risk factors in female European football. A prospective study of 123 players during one season. Scand J Med Sci Sports 2000; 10: 279–285. doi:10.1034/j.1600-0838.2000.010005279.x

[43] Söderman K, Alfredson H, Pietilä T, et al. Risk factors for leg injuries in female soccer players: a prospective investigation during one out-door season. Knee Surgery, Sports Traumatology, Arthroscopy 2001; 9: 313–321. doi:10.1007/s001670100228

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Table 1 Comparison of the injured and uninjured groups in terms of body composition, power and muscle strength variables

Table 2 Summary of the results of the binary logistic regression analysis: Comparison between the groups of injured and non-injured futsal players with potential injury predictor parameters.

Table 1 Comparison of the injured and uninjured groups in terms of body composition, power and muscle strength variables

Variables	Injured group (n=21) M ± SD	Non-injured group (n=47) M ± SD	*p*
Muscle mass, Kg	34.79 ± 3.84	35.15 ± 4.35	0.87
Fat mass, Kg	13.40 ± 6.48	10.07 ± 3.09	0.10
BMI	24.09 ± 3.32	23.38 ± 2.22	0.59
CMJ, cm	24.39 ± 5.73	**29.52 ± 4.38**	**0.001***
Peak Torque Q, D	234.43 ± 37.10	236.84 ± 42.61	0.83
Peak Torque Q, ND	234.79 ± 31.52	238.09 ± 45.09	0.92
Peak Torque H, D	132.32 ± 21.20	133.84 ± 26.37	0.85
Peak Torque H, ND	125.97 ± 19.64	128.46 ± 26.07	0.75
H/Q ratio	55.60 ± 6.62	55.65 ± 7.11	0.62

* $p \leq 0.05$ used in Kruskal Wallis; significant values and their associated effects are shown in bold; N: Number of Subjects; M: Mean; SD: Standard Deviation; BMI: Body Mass Index; CMJ: Countermovement Jump; D, dominant; ND, non-dominant.

Table 2 Summary of the results of the binary logistic regression analysis: Comparison between the groups of injured and non-injured futsal players with potential injury predictor parameters.

Variables	Injured group (n=21) M ± DP	Non-injured group (n=47) M ± DP	Total (n=68) M ± DP	OR	CI 95% for OR		*p*
					Lower	Upper	
Muscle mass, Kg	34.79 ± 3.84	35.15 ± 4.35	34.91 ± 3.98	0.99	0.82	1.21	0.96
Fat mass, Kg	13.40 ± 6.48	10.07 ± 3.09	11.73 ± 5.73	0.84	0.65	1.08	0.18
BMI	24.09 ± 3.32	23.38 ± 2.22	23.87 ± 3.03	1.16	0.71	1.90	0.55
CMJ, cm	24.39 ± 5.73	**29.52 ± 4.38**	26.95 ± 5.91	0.92	0.88	0.99	**0.04***
Peak Torque Q, D	234.43 ± 37.10	236.84 ± 42.61	235.64 ± 40.72	1.01	0.98	1.02	0.55
Peak Torque Q, ND	234.79 ± 31.52	238.09 ± 45.09	236.44 ± 41.20	0.99	0.97	1.01	0.48
Peak Torque H, D	132.32 ± 21.20	133.84 ± 26.37	133.08 ± 24.73	1.01	0.97	1.05	0.62
Peak Torque H, ND	125.97 ± 19.64	128.46 ± 26.07	127.21 ± 24.15	1.02	0.97	1.07	0.29
H/Q ratio	55.60 ± 6.62	55.65 ± 7.11	55.61 ± 6.72	1.01	0.92	1.09	0.93

Abbreviations: BMI, body mass index (weight in kilograms divided by height in meters squared); CMJ, counter movement jump (jump height in centimeters); H/Q ratio (strength ratio between flexors divided by extensors); Q, quadriceps; H, hamstrings; D, dominant; ND, non-dominant; N, number of subjects; M, mean; SD, standard deviation; OR, odds ratio; CI, confidence interval; * Significant p-values ≤ 0.05 are shown in bold.