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Correlation Between Quadriceps-Hamstring Muscle Strength Ratio and Knee Joint Stability in Female Futsal Athletes

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Abstract

Knee joint stability is an important component in supporting performance and injury prevention in female futsal athletes, especially because futsal requires explosive movements, acceleration, deceleration, change of direction, and repetitive body control. One of the factors that is thought to be related to knee stability is the balance of quadriceps and hamstring muscle strength expressed through the Q:H Ratio. The study used an analytical observational design with a cross-sectional approach. The research subjects amounted to 25 female futsal athletes who were selected based on inclusion and exclusion criteria. The strength of the quadriceps and hamstring muscles was measured to obtain a Q:H Ratio value, while the dynamic stability of the knee was measured using the Y-Balance Test through the YBT Composite Score value. Data analysis began with descriptive statistics and normality tests using Kolmogorov-Smirnov and Shapiro-Wilk. The results of the normality test showed that the Q:H Ratio and YBT Composite Score data were not normally distributed, so the relationship analysis was carried out using Spearman Rank Correlation. The results showed that there was a positive relationship between the Q:H Ratio and YBT Composite Score with a correlation coefficient $\rho = 0.304$ and a significance value $p = 0.140$. These results show that the relationships formed are in the weak to moderate category, but not statistically significant. Thus, the hypothesis that there is a significant relationship between the Q:H Ratio and the dynamic stability of the knee joint in female futsal athletes is not proven. This study concludes that the Q:H ratio cannot be used as a single indicator of knee stability, as dynamic stability is likely influenced by neuromuscular factors, proprioception, hip muscle strength, core stability, movement coordination, and ability to change direction.

Keywords: women futsal athletes, Q:H Ratio, Knee Stability, Y-Balance Test, Biomechanics.

INTRODUCTION

Futsal is a high-intensity team sport that requires players to accelerate, decelerate, change of direction, short sprints, duels, and explosive movements repeatedly in a relatively narrow playing space. These characteristics make futsal athletes, especially female athletes, need good neuromuscular capacity to maintain performance while reducing the risk of lower extremity injuries. Recent studies show that women's futsal has the typical physiological, neuromuscular, technical, and characteristic demands of players, so monitoring physical profiles and injury risk is an important need in the development of achievement and injury prevention (Barreira et al., 2025; Marques et al., 2026; Pérez Armendáriz et al., 2024). In the context of performance, the ability to change direction, accelerate, land, and stabilize the body is closely related to leg muscle strength, postural control, and neuromuscular coordination (Baena-Raya et al., 2021; Ferrández-Laliena et al., 2023; Vasquez-Bonilla et al., 2025).

One of the important aspects of knee joint stability is the balance of strength between the quadriceps muscle as a knee extensor and the hamstring as a knee flexor. The quadriceps-hamstring strength ratio or Q:H Ratio is often used as an indicator of thigh muscle balance, motion control capacity, and potential knee injury risk. In sports that demand explosive movements, the dominance of the quadriceps that is not optimally balanced by hamstring activation can increase the anterior load

on the tibia and increase pressure on the stabilizing structures of the knee, including the anterior cruciate ligament. The biomechanics literature suggests that fatigue factors, valgus motion patterns, changes in direction, and low neuromuscular control can increase pressure on the knee joint, especially in female athletes (Jian et al., 2025; Ferrández-Laliena et al., 2025). Therefore, the evaluation of the relationship between Q:H Ratio and knee dynamic stability is important in women's futsal.

The main problem in this study is the unclear extent to which the quadriceps-hamstring muscle strength ratio correlates with knee joint stability in professional women's futsal athletes. The initial article file shows that this study is focused on the analysis of the relationship between Q:H Ratio as an independent variable and knee joint stability as a bound variable, with an observational design of cross-sectional analysis in professional women's futsal athletes. Dynamic stability is assessed through the Y-Balance Test or Star Excursion Balance Test, while muscle strength is measured using an isokinetic dynamometer or a validated hand-held dynamometer. This problem is relevant because women's futsal has an activity pattern that puts the knee in complex mechanical situations, such as cutting movements, sharp changes of direction, and landing after explosive movements. In addition, several studies show that female futsal athletes are still relatively underrepresented in injury and performance research compared to football or other team sports (Sanmiguel-Rodríguez et al., 2021; Gómez-Campos et al., 2023; Barreira et al., 2025).

Various solutions have been offered in the literature to lower the risk of knee injuries and improve joint stability, including neuromuscular exercises, balance exercises, proprioperception exercises, hamstring strengthening, direction-change exercises, as well as FIFA 11+-based injury prevention programs. The FIFA 11+ program has been shown to be widely used to improve athletes' performance, biomechanical parameters, and physiological responses, while the FIFA 11+ Referees adaptation can reportedly improve knee proprioception and dynamic balance in female futsal referees (Asgari et al., 2023; Khosravi Rad et al., 2025). In addition, exercises that stimulate hamstring activation are considered beneficial in injury prevention and rehabilitation programs because the hamstring plays a role in helping stabilize the knee during high-risk sports activities (Bencke et al., 2023). A high-load strengthening approach is also considered to improve muscle capacity, neural drive, and tendon stiffness related to the active stability of the knee joint (Liaghat et al., 2024).

However, there is still a research gap. Most studies have focused on intervention programs, physiological profiles, match demands, or injury patterns in general, while the specific relationship between Q:H Ratio and knee dynamic stability in professional women's futsal athletes has not been studied directly. Several studies have examined the asymmetry of leg strength, ACL injury risk, biomechanical patterns during changes of direction, and neuromuscular characteristics of female futsal or football athletes (Parpa et al., 2022; Ferrández-Laliena et al., 2023; Ferrández-Laliena et al., 2025; Marques et al., 2026), but has not fully answered whether the quadriceps-hamstring power imbalance has a strong relationship with the results of dynamic stability tests such as the Y-Balance Test in professional women's futsal athletes. Thus, this study places the Q:H Ratio not only as an indicator of muscle strength, but also as a biomechanical variable that needs to be tested for its association with functional postural control.

This study aims to analyze the relationship between quadriceps-hamstring muscle strength ratio and knee joint stability in professional women's futsal athletes. The novelty of this study lies in its focus on professional women's futsal athletes, the use of Q:H Ratio as an indicator of thigh muscle strength balance and testing its relationship with knee dynamic stability through the Y-Balance Test

or SEBT. The scope of the study was limited to cross-sectional correlational analysis without training intervention, so the results of the study are expected to serve as a starting basis for coaches, sports physiotherapists, and strength and conditioning practitioners in developing injury prevention programs, hamstring strengthening, neuromuscular control improvement, and more specific evaluation of knee stability in female futsal athletes.

METHODS

Research Design

This study uses an analytical observational design with a cross-sectional approach; i.e. variable measurements are carried out at one time without the provision of exercise interventions. This design was chosen because the purpose of the study was to analyze the relationship between the quadriceps-hamstring muscle strength ratio (Q:H ratio) as an independent variable and the dynamic stability of the knee joint as a bound variable. The relevant cross-sectional approach is used in sports studies that aim to describe the relationship between the physical, neuromuscular, and functional variables of athletes in the actual conditions of training or competition. In the context of women's futsal, this approach is appropriate because performance and injury risk are influenced by a combination of muscle strength, neuromuscular control, balance, proprioception, and the ability to perform explosive movements such as acceleration, deceleration, and change of direction (Barreira et al., 2025; Marques et al., 2026; Ferrández-Laliena et al., 2023).

Research Subject

The subjects of the study were 25 female futsal athletes who actively participated in training and competitions. The sampling technique uses purposive sampling, which is the selection of subjects based on certain criteria that are in accordance with the research objectives. The inclusion criteria in this study include active female futsal athletes, in good health at the time of data collection, not experiencing acute lower extremity injuries, and willing to follow all measurement procedures. Exclusion criteria include having a history of severe knee injury soon, undergoing rehabilitation after lower extremity surgery, experiencing pain during the test, or not completing the entire series of measurements. The selection of female futsal athletes as subjects is based on the characteristics of futsal that demand high knee control during short sprints, cutting movements, landings, as well as repeated changes of direction that have the potential to increase the risk of knee stability disorders (Khosravi Rad et al., 2025; Villarejo-García et al., 2026).

Research Variables

This study consists of two main variables. The independent variable is the Q:H Ratio, which is the ratio of the strength of the hamstring muscle to the quadriceps. This ratio is used as an indicator of the balance of the strength of the thigh muscles which play a role in the stabilization of the knee joint. The quadriceps muscle serves as a knee extensor, while the hamstring acts as a knee flexor while helping to control the anterior translation of the tibia during dynamic activity. An imbalance in the strength of the two muscle groups can affect the mechanics of movement and knee stability, especially in sports activities that involve changes of direction and landing (Bencke et al., 2023; Jian et al., 2025). The bound variable is the dynamic stability of the knee joint, which is measured through the Y-Balance Test Composite Score. This score describes the athlete's ability to maintain postural control and lower extremity stability while performing dynamic range in multiple directions.

Research Instruments

Measurements of quadriceps and hamstring muscle strength are performed using muscle

strength measuring devices, such as isokinetic dynamometers or other validated muscle strength measuring devices. The values used in the study were the strength of the quadriceps and hamstring muscles in the dominant leg, then calculated as the Q:H Ratio. Dynamic stability measurements were carried out using the Y-Balance Test (YBT), which is a functional test that is widely used to assess dynamic balance, neuromuscular control, and lower extremity stability. YBT is relevant to use in the context of futsal because movements in this sport require the ability to maintain body balance when changing direction, deceleration, and controlling the position of the knee joint. Previous studies have shown that dynamic balance and knee proprioception have an important role in injury prevention and movement performance of female futsal athletes (Khosravi Rad et al., 2025; Asgari et al., 2023).

Data Collection Procedure

Before data collection, all subjects were explained the objectives, benefits, and procedures of the research. Subjects who meet the criteria are asked to fill out a participation agreement. Measurements began with recording basic identity and anthropometric characteristics, followed by standard warm-ups to prepare the neuromuscular system and reduce the risk of injury during testing. After that, the strength of the quadriceps and hamstring muscles in the dominant leg was measured. The value of hamstring strength was then compared to the value of quadriceps strength to obtain the Q:H Ratio. Measurements are carried out with the same instructions for all subjects so that the data collection procedure is consistent.

Data Analysis Techniques

The data is analyzed using statistical software. The first stage is a descriptive analysis to describe the characteristics of the subjects and research variables, including minimum, maximum, average, and standard deviation values. Next, normality tests were carried out using Kolmogorov-Smirnov and Shapiro-Wilk to determine the distribution of data. The results of the normality test showed that the Q:H Ratio and YBT Composite Score data were not normally distributed, so the relationship analysis was carried out using Spearman Rank Correlation. The Spearman test is used because it is suitable for data that do not meet the assumption of normality and aims to assess the direction and strength of the relationship between variables in a nonparametric manner. The significance level is set at $\alpha = 0.05$. The value of the correlation coefficient is interpreted based on the direction of the positive or negative relationship and the strength of the relationship, while the significance decision is based on the p-value.

RESULTS

This study involved professional female futsal athletes who actively participated in competitions. Based on descriptive data, the age of the subjects was in the range of 21–26 years with an average age of 23.25 ± 1.48 years. These data show that the study subjects were in the young adult age group who were physiologically in the productive phase for competitive sports performance. This characteristic is relevant to the study of women's futsal which shows that performance demands in female athletes are closely related to neuromuscular capacity, balance, leg strength, and the ability to change direction explosively (Barreira et al., 2025; Marques et al., 2026; Villarejo-García et al., 2026).

Table 1. Decriptive statistic

	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
Age	24	5.00	21.00	26.00	23.2500	1.48177	2.196
BMI	25	220	22	242	202.80	68.126	4641.167
PT Quadriceps	25	1949	205	2154	371.16	536.606	287945.473

PT Hamstring	25	1210	135	1345	1129.80	305.258	93182.167
Ratio Q:H	25	53	6	59	50.32	16.782	281.643
YBT Composite Score	25	863	92	955	819.24	274.174	75171.523
Valid N (listwise)	24						

Based on Table 1, the average Q:H Ratio value of 50.32 ± 16.78 shows a variation in the balance of strength between the hamstring and quadriceps muscles in female futsal athletes. Meanwhile, the average YBT Composite Score of 819.24 ± 274.17 shows a variation in dynamic stability abilities between athletes. In the context of sports biomechanics, this variation is important because futsal demands the ability to stabilize the knee when performing short sprints, changes of direction, deceleration, and repetitive explosive movements. Knee stability is not only affected by the strength of the thigh muscles, but also by proprioception, neuromuscular control, movement coordination, exercise experience, and the functional condition of the lower extremities (Khosravi Rad et al., 2025; Ferrández-Laliena et al., 2023; Bencke et al., 2023).

Table 2. Normality test result

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Ratio Q:H	.427	25	<.001	.469	25	<.001
YBT Composite Score	.459	25	<.001	.451	25	<.001

a. Lilliefors Significance Correction

The results of the Shapiro-Wilk test showed that the Q:H Ratio and YBT Composite Score data had a significance value of $p < 0.001$. Because the significance value is less than 0.05, the two variables are declared not to be normally distributed. Thus, methodologically, the analysis of the relationship between variables is more recommended using the nonparametric Spearman Rank Correlation test.

Table 4. Spearman Rank Correlation test result

			Rasto Q:H	YBT Composite score
Spearman's rho	Ratio Q:H	Correlation Coefficient	1.000	.304
		Sig. (2-tailed)	.	.140
		N	25	25
	YBT Composite Score	Correlation Coefficient	.304	1.000
		Sig. (2-tailed)	.140	.
		N	25	25

Based on the results of the Spearman Rank Correlation test, the value of the correlation coefficient between the Q:H Ratio and YBT Composite Score was obtained of $\rho = 0.304$ with a significance value of $p = 0.140$ at $N = 25$, which indicates a positive relationship in the weak to medium category, but not statistically significant because $p > 0.05$. These findings indicate that an increase in the ratio of hamstring strength to quadriceps is likely to be followed by an increase in knee dynamic stability, but the association is not strong enough to be meaningful in female futsal athletes. Thus, the Q:H ratio cannot be used as a single predictor of knee joint stability, because dynamic stability in futsal sports may be influenced by other factors such as proprioception, neuromuscular control, hip muscle strength, core stability, movement coordination, fatigue, and the ability to accelerate, decelerate, and change direction. This interpretation is in line with studies that confirm that performance and injury risk in women's futsal are multifactorial, involving neuromuscular

demands, movement biomechanics, and complex postural control (Barreira et al., 2025; Marques et al., 2026; Ferrández-Laliena et al., 2023; Khosravi Rad et al., 2025; Bencke et al., 2023).

Based on the results of the analysis, the Q:H Ratio and YBT Composite Score data were not distributed normally, so the relationship test was carried out using Spearman Rank Correlation. The test results showed a correlation coefficient value of $\rho = 0.304$ with a significance value of $p = 0.140$ at $N = 25$, which means that there was a tendency for a weak to moderate positive relationship between the quadriceps-hamstring muscle strength ratio and knee dynamic stability, but the relationship was not statistically significant. These findings suggest that athletes with better Q:H ratios tend to have higher knee stability scores, but these trends are not strong enough to conclude a meaningful relationship. Thus, the Q:H Ratio cannot be used as a single indicator of knee joint stability in female futsal athletes, because dynamic stability may be influenced by other factors such as proprioception, neuromuscular control, hip muscle strength, core stability, movement coordination, fatigue, and the ability to accelerate, decelerate, and change of direction.

DISCUSSION

The empirical findings of this study show that the quadriceps-hamstring muscle strength ratio has a positive relationship direction with the dynamic stability of the knee joint in female futsal athletes, but the relationship is not statistically significant. Rationally, these results indicate that athletes with a better balance of hamstring and quadriceps strength tend to have better knee stability abilities, but these tendencies are not strong enough to make the Q:H Ratio the only indicator of knee stability. This condition can be understood because futsal is a sport with complex demands of movement, involving short sprints, acceleration, deceleration, change of direction, cutting movement, body contact, and quick response to game situations. Knee stability in such a context depends not only on thigh muscle strength, but also on neuromuscular coordination, proprioception, postural control, hip muscle strength, core stability, quality of landing techniques, and ability to control fatigue. Studies on women's futsal also show that the physiological, biomechanical, and neuromuscular characteristics of female athletes are multidimensional, so performance and risk of injury cannot be explained through just one muscle strength variable (Barreira et al., 2025; Marques et al., 2026; Pérez Armendáriz et al., 2024; Villarejo-García et al., 2026).

The results of this study are supported by several previous findings that place knee stability as the result of the interaction of various neuromuscular and biomechanical factors. Khosravi Rad et al. (2025) showed that the FIFA 11+ Referees program can improve knee proprioception in female futsal referees, but the improvement in dynamic balance does not always occur significantly. This corroborates that proprioception, muscle strength, and dynamic stability have functional relationships, but they do not always move in a linear manner. Asgari et al. (2023) also reported that the FIFA 11+ program influenced performance, biomechanical parameters, and physiological responses, but its effectiveness was highly dependent on the training components and the characteristics of the subjects.

On the other hand, Bencke et al. (2023) explain that the activation of the thigh muscles differs between standing and landing tasks, so the contribution of the quadriceps and hamstrings to knee stability is highly dependent on the context of movement. These findings are in line with current research results that suggest that quadriceps-hamstring balance is indeed relevant, but not yet sufficient to explain the overall variation in knee stability. Parpa et al.'s (2022) research on lower body strength asymmetry in football, basketball, futsal, and volleyball athletes also confirms the

importance of evaluating leg strength, but force asymmetry is not the only factor determining movement control.

Meanwhile, Ferrández-Laliena et al. (2023) showed that biomechanical patterns on the directional change test were related to the risk of knee injury, while Ferrández-Laliena et al. (2025) emphasized the existence of differences in kinematics and muscle activity between players at risk of ACL injuries and healthy players. Some other studies have even highlighted that fatigue, genu valgum, and tissue pathologies around the knee can increase stress on the structure of the ACL, so that knee stability is not only affected by muscle strength ratio, but also by morphological conditions, motion mechanics, and functional status of the joint (Jian et al., 2025; Kawashima et al., 2024; Amirouche et al., 2026).

Theoretically, the results of this study reinforce the view that the stability of the knee joint is the result of integration between active stability and sensorimotor stability. Active stability is primarily affected by the strength and activation of the muscles around the joints, specifically the quadriceps, hamstrings, gastrocnemius, gluteus, and core muscles. The hamstring plays an important role in controlling the anterior translation of the tibia and helps to reduce the load on the ligament structure, while the quadriceps plays a role in knee extension and force production during acceleration, landing, and change of direction. However, if the hamstring function is not dominant enough to compensate for the quadriceps extension force, then knee control can become less than optimal, especially in explosive movements.

However, the results of this study show that the quadriceps-hamstring balance is not strong enough as a single determinant of dynamic stability. It can be explained through neuromuscular control theory that functional stability requires the interaction between sensory inputs, central nervous system processing, and proper motor output. Therefore, the Y-Balance Test not only reflects the strength of the thigh muscles, but also the ability to maintain the center of body mass, control the position of the knees and hips, maintain the balance of one leg, and regulate the movement strategy of the lower extremities. In women's futsal, this ability is increasingly complex because athletes have to change direction at a high tempo, often in conditions of fatigue and game pressure. The study of Baena-Raya et al. (2021) showed that the mechanical properties of sprints affect the ability to change direction in female futsal players, while Vasquez-Bonilla et al. (2025) highlighted the relationship between cutting movements and muscle work responses in women's futsal. Thus, the findings of this study develop the understanding that the Q:H Ratio is more appropriately positioned as one of the components of neuromuscular evaluation, rather than as a single indicator of knee stability.

The practical implication of this study is that coaches, sports physiotherapists, and strength and conditioning practitioners need to use a more comprehensive approach to evaluation and exercise in improving knee stability in women's futsal athletes. The evaluation of the Q:H Ratio remains important for identifying the balance of forces between the hamstrings and quadriceps, but the results need to be combined with other measurements such as the Y-Balance Test, proprioperception test, directional change analysis, hamstring eccentric strength test, hip and core stability assessment, and observation of landing and deceleration techniques.

The training program should also not only emphasize strengthening the quadriceps and hamstrings, but also includes neuromuscular exercises, balance, proprioception, eccentric hamstring exercises, gluteal strengthening, core stability, plyometric landing control, and cutting movement exercises that resemble futsal game situations. This recommendation is in line with studies showing that women's futsal performance and injury prevention require the integration of strength, balance,

coordination, sprint capacity, and biomechanical control of movement (Asgari et al., 2023; Khosravi Rad et al., 2025; Baena-Raya et al., 2021; Marques et al., 2026; Villarejo-García et al., 2026). Thus, the results of this study provide the basis that improving knee stability in female futsal athletes should be done through multidimensional strategies, not just through increasing the Q:H Ratio.

CONCLUSION

Based on the results of the study, it can be concluded that there is a tendency for a positive relationship between the Q:H Ratio and YBT Composite Score in female futsal athletes. That is, the better the balance of the strength of the hamstring muscle against the quadriceps, the more the dynamic stability of the knee joint tends to increase. However, the relationship is not statistically significant, so the Q:H Ratio cannot be stated as a factor that has a meaningful relationship with the dynamic stability of the knee in this study sample. These findings show that knee joint stability in female futsal athletes is not only determined by the balance of quadriceps and hamstring muscle strength, but is also influenced by other factors such as proprioception, neuromuscular control, hip muscle strength, core stability, movement coordination, fatigue, and the ability to accelerate, decelerate, and change of direction. Therefore, the Q:H Ratio should not be used as a single indicator in assessing knee stability or injury risk in female futsal athletes. Practically, the results of this study provide recommendations that trainers, sports physiotherapists, and strength and conditioning practitioners need to apply a more comprehensive evaluation approach. Measurement of the Q:H Ratio remains important as an indicator of thigh muscle strength balance, but it needs to be combined with dynamic stability tests, proprioception, movement quality analysis, hip muscle strength, and neuromuscular control. Injury prevention training programs also need to include hamstring strengthening, balance exercises, proprioperception exercises, core stability, landing control, and directional change exercises that are in accordance with the characteristics of the futsal game.

RECOMMENDATION

Based on the results of the study, coaches, sports physiotherapists, and strength and conditioning practitioners are advised not only to use the Q:H Ratio as a single indicator in assessing the stability of the knee joint of female futsal athletes. Measurement of the quadriceps-hamstring muscle strength ratio remains important, but it needs to be combined with other evaluations such as the Y-Balance Test, proprioperception test, analysis of movement during acceleration and deceleration, agility test, hip muscle strength, core stability, and a history of lower extremity injuries. Injury prevention training programs should be comprehensively designed to include hamstring strengthening exercises, especially eccentric exercises, balanced quadriceps strengthening, core stability exercises, one-leg balance exercises, proprioception exercises, landing control, and change of direction exercises that resemble futsal game situations. The training needs to be done progressively, programmatically, and adjusted to the physical condition and level of competition of the athlete. For subsequent researchers, it is recommended to involve a larger number of samples, comparing groups of athletes based on playing position or injury history, as well as adding other variables such as hip muscle strength, leg symmetry index, hamstring eccentric strength, fatigue level, and biomechanics analysis of motion. Further research may also use longitudinal design or exercise interventions to determine the effect of neuromuscular programs on improving the Q:H Ratio and dynamic stability of the knee more deeply.

REFERENCES

Ahluwalia, A. A., & Ramteke, S. U. (2025). Effect of modified progressive Copenhagen exercise versus sliding hip exercise in adjunct to conventional physiotherapy on strength, core stability and agility in futsal athletes: A study protocol for randomised controlled trial. BMJ Open Sport & Exercise Medicine, 11(3). https://doi.org/10.1136/bmjsem-2025-002726

Ahmadi, M., Hoorang, N., & Imanian, B. (2024). Boosting recovery: Omega-3 and whey protein enhance strength and ease muscle soreness in female futsal players. Nutrients, 16(24). https://doi.org/10.3390/nu16244263

Amirouche, F., Elbert, K., & Madraswala, M. (2026). Biomechanical impact of lateral meniscus pathology on anterior cruciate ligament stress: A finite element analysis. Journal of Orthopaedic Surgery and Research, 21(1). https://doi.org/10.1186/s13018-025-06583-5

Asgari, M., Nazari, B., & Bizzini, M. (2023). Effects of the FIFA 11+ program on performance, biomechanical measures, and physiological responses: A systematic review. Journal of Sport and Health Science, 12(2), 226–235. https://doi.org/10.1016/j.jshs.2022.05.001

Baena-Raya, A., García-Ortega, D., & Sánchez-López, S. (2021). The influence of sprint mechanical properties on change of direction in female futsal players. Journal of Human Kinetics, 79(1), 221–228. https://doi.org/10.2478/hukin-2021-0075

Barreira, J., Wunderlich, K., & Batista, A. B. C. V. (2025). Physiological demands and player characteristics in women's futsal: A systematic review. Frontiers in Physiology, 16. https://doi.org/10.3389/fphys.2025.1642594

Bencke, J., Strøm, M., & Curtis, D. J. (2023). Differences in thigh muscle activation between standing and landing exercises for knee injury prevention and rehabilitation. International Journal of Sports Physical Therapy, 18(1), 102–112. https://doi.org/10.26603/001c.67829

Carrera-Quintanar, L., Funes, L., & Herranz-López, M. (2023). Modulation of oxidative stress and antioxidant response by different polyphenol supplements in five-a-side football players. Nutrients, 15(1). https://doi.org/10.3390/nu15010177

Castillo, M., Lozano-Casanova, M., & Sospedra, I. (2022). Energy and macronutrients intake in indoor sport team athletes: Systematic review. Nutrients, 14(22). https://doi.org/10.3390/nu14224755

Chaudhari, D., & Ramteke, S. U. (2026). Effect of accentuated eccentric loading countermovement jumps and drop jump training with ladder training versus ladder training alone on sprint performance and change of direction ability in futsal players: A randomized controlled trial protocol. PLOS ONE, 21(3). https://doi.org/10.1371/journal.pone.0343869

Chen, Y.-S., Clemente, F. M., & Pagaduan, J. C. (2022). Relationships between perceived measures of internal load and wellness status during overseas futsal training camps. PLOS ONE, 17(4). https://doi.org/10.1371/journal.pone.0267227

da Costa, J. L. T., Spineli, H., Júnior, P. B., Prado, E. S., & de Araujo, G. G. (2021). Physiological and technical demands of the small-sided and generic games in female futsal players. Motriz: Revista de Educação Física, 27. https://doi.org/10.1590/S1980-65742021018120

Farhani, F., Arazi, H., & Mirzaei, M. (2022). Associations between bio-motor ability, endocrine markers and hand-specific anthropometrics in elite female futsal players: A pilot study. BMC Sports Science, Medicine and Rehabilitation, 14(1). https://doi.org/10.1186/s13102-022-00453-x

Ferrández-Laliena, L., Vicente-Pina, L., Sánchez-Rodríguez, R., Orantes-González, E., & Heredia-Jimenez, J. (2023). Diagnostics using the change-of-direction and acceleration test (CODAT) of the biomechanical patterns associated with knee injury in female futsal players: A cross-sectional analytical study. Diagnostics, 13(5). https://doi.org/10.3390/diagnostics13050928

Ferrández-Laliena, L., Vicente-Pina, L., & Sánchez-Rodríguez, R. (2025). Differences in kinematic and muscle activity between ACL injury risk and healthy players in female football: Influence

of change of direction amplitude in a cross-sectional case–control study. Medicina, 61(7). https://doi.org/10.3390/medicina61071259

Filgueiras, A., Stults-Kolehmainen, M., & Melo, G. (2023). Cognition in soccer and futsal: Evidence of validity of a 4-instrument protocol to assess executive functioning among women athletes. BMC Psychology, 11(1). https://doi.org/10.1186/s40359-023-01464-0

Gómez-Campos, R., Vidal-Espinoza, R., & Muñoz-Muñoz, F. (2023). Systematic review of the anthropometric profile of female futsal players 2010–2020. European Journal of Translational Myology, 33(1). https://doi.org/10.4081/ejtm.2023.10986

Gontara, S. Y., Doewes, R. I., & Adirahma, A. S. (2023). Correlation between momentum and ball speed in shooting movements of female futsal players. Sport TK, 12. https://doi.org/10.6018/SPORTK.587521

Irawan, A., Fitranto, N., & Hasibuan, M. H. (2024). Impact of plyometric training on sprint and agility performance in college-level futsal athletes: A comparative study using hurdle jumps and box jumps. Fizjoterapia Polska, 2024(5), 50–55. https://doi.org/10.56984/8ZG020C68QJ

Jian, X., Sun, D., & Xu, Y. (2025). Running-induced fatigue exacerbates anteromedial ACL bundle stress in females with genu valgum: A biomechanical comparison with healthy controls. Sensors, 25(15). https://doi.org/10.3390/s25154814

Katanic, B., Bjelica, D., & Sebic, L. (2023). Comparative analysis of anthropometric characteristics and body composition among elite female futsal players in Montenegro, North Macedonia and Croatia. Sport Mont, 21(3), 77–81. https://doi.org/10.26773/smj.231012

Kawashima, T., Mutsuzaki, H., & Watanabe, A. (2024). Impact of surgical timing on functional outcomes after anterior cruciate ligament reconstruction. Journal of Clinical Medicine, 13(10). https://doi.org/10.3390/jcm13102994

Khosravi rad, F., Zarei, M., & Hosseini, S. M. (2025). The FIFA 11+ Referees program improves knee proprioception in female futsal referees. Scientific Reports, 15(1). https://doi.org/10.1038/s41598-025-20054-1

Koźlenia, D., & Kochan-Jacheć, K. (2024). The impact of interaction between body posture and movement pattern quality on injuries in amateur athletes. Journal of Clinical Medicine, 13(5). https://doi.org/10.3390/jcm13051456

Li, S., Qin, Y., & Wang, H. (2023). Repair of ramp lesions of the medial meniscus with ACL reconstruction can better restore knee stability: A cadaveric study. Orthopaedic Journal of Sports Medicine, 11(4). https://doi.org/10.1177/23259671221140120

Liaghat, B., Bojsen-Møller, J., & Juul-Kristensen, B. (2024). High-load strength training compared with standard care treatment in young adults with joint hypermobility and knee pain: Study protocol for a randomised controlled trial (the HIPEr-Knee study). BMJ Open, 14(10). https://doi.org/10.1136/bmjopen-2024-090812

Marques, C., Rebelo, M., & Serrano, J. (2026). Neuromuscular characteristics of female futsal players: A systematic review. Sports, 14(3). https://doi.org/10.3390/sports14030098

Mechó, S., Lisbona Ortega, R., Pruna, R., Nescolarde Selva, L., & Morillas Pérez, J. (2023). Measuring direct and indirect tendon parameters to characterize the proximal tendinous complex of the rectus femoris in football and futsal players. Frontiers in Physiology, 14. https://doi.org/10.3389/fphys.2023.986872

Ohji, S., Aizawa, J., Hirohata, K., Ohmi, T., & Mitomo, S. (2021). Injury-related fear in athletes returning to sports after anterior cruciate ligament reconstruction: A quantitative content analysis of an open-ended questionnaire. Asia-Pacific Journal of Sports Medicine, Arthroscopy, Rehabilitation and Technology, 25, 1–7. https://doi.org/10.1016/j.asmart.2021.03.001

Parpa, K., & Michaelides, M. (2022). Anterior-posterior and inter-limb lower body strength asymmetry in soccer, basketball, futsal, and volleyball players. Medicina, 58(8). https://doi.org/10.3390/medicina58081080

Pérez Armendáriz, M. L., Spyrou, K., & Alcaraz, P. E. (2024). Match demands of female team sports: A scoping review. Biology of Sport, 41(1), 175–199. https://doi.org/10.5114/biolsport.2024.129476

Ramos-Pastrana, L. M., Gil-Caselles, L., & Ruiz-Barquín, R. (2026). Beyond the injury: A case report on psychological intervention during ACL rehabilitation in a professional futsal player. International Journal of Environmental Research and Public Health, 23(1). https://doi.org/10.3390/ijerph23010026

Rico-Lara, T., Mateo-Orcajada, A., & Abenza-Cano, L. (2023). Differences in psychological variables and the performance of female futsal players according to playing position, match result and menstruation. International Journal of Environmental Research and Public Health, 20(8). https://doi.org/10.3390/ijerph20085429

Rodrigues, M. A. A., de Oliveira, V., Ribeiro, L. C., Bortolan, K. W., & Clemente, F. M. (2023). No relative age effect among Brazilian elite female futsal athletes: An analysis based on tactical individual performance and team's final position in the national championship. Kinesiology, 55(1), 138–145. https://doi.org/10.26582/k.55.1.14

Sanmiguel-Rodríguez, A. (2021). Presence of women in futsal: A systematic review. Archivos de Medicina del Deporte, 38(3), 245–252. https://doi.org/10.18176/archmeddeporte.00048

Santos, I. A., Lemos, M. P., Puggina, E. F., & Mota, G. R. (2024). Innovative integration: Optimizing performance through warm-up and photobiomodulation in high-intensity test. Frontiers in Sports and Active Living, 6. https://doi.org/10.3389/fspor.2024.1341106

Söğüt, M., Yapici, H., Luz, L. G. O., Giudicelli, B., & Clemente, F. M. (2022). Maturity-associated variations in anthropometry, physical fitness, and sport-specific skills among young male and female futsal players. Human Movement, 23(4), 70–76. https://doi.org/10.5114/hm.2022.108321

Tamashiro, L., Marques, R. F. R., & Oliveira, F. V. C. (2022). Women's futsal at a Brazilian university: Does the academic social environment influence prejudices against the players? Motriz: Revista de Educação Física, 28. https://doi.org/10.1590/S1980-657420220003921

Vasquez-Bonilla, A. A., Cruz-Fuentes, I., & Ugalde-Ramírez, J. A. (2025). Muscle oxygen saturation and cutting movements in women's futsal. Apunts Sports Medicine. https://doi.org/10.1016/j.apunsm.2025.100505

Villarejo-García, D. H., Navarro-Martínez, C., & Pino-Ortega, J. (2026). Beyond PlayerLoad: Detection of critical moments and injury risk in elite women's futsal. Sports, 14(1). https://doi.org/10.3390/sports14010008

Weber, V. M. R., Dantas, D. B., & da Silva, D. F. (2024). Trends in anthropometric and somatotype profiles of Brazilian female futsal players: A 20 year study. European Journal of Translational Myology, 34(1). https://doi.org/10.4081/ejtm.2024.11887

Zhao, W.-C., Chen, H., & Li, Y.-X. (2024). The application of proximal tibial anterior closing wedge osteotomy in anterior cruciate ligament reconstruction. Asia-Pacific Journal of Sports Medicine, Arthroscopy, Rehabilitation and Technology, 38, 1–8. https://doi.org/10.1016/j.asmart.2024.06.001