ORIGINAL ARTICLE

# Isokinetic performance of knee muscles in futsal athletes during pre-season and middle-season

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## ABSTRACT

Futsal is a multiple sprint that require constant changes in direction, speed, kicks and tackles, therefore the lower limbs, and specifically the knee muscles, play a crucial role during these futsal's actions, as the intense demands put on athletes during a futsal regular season can result in muscle imbalances between the lower limbs and between the extensor and flexor muscles of the knee, thereby, decreasing the muscular performance and increasing the risk of knee injuries. **Objective:** The aims of this study were to analyze the lower limbs differences after the demands of a regular season on the knee's muscles' strength, and the relations between the extensor and flexor muscles. **Method:** Data on 15 professional futsal players at pre-season and middle-season, provided by a database were analyzed. The database provided data from isokinetic dynamometer evaluations in a concentric-concentric mode for the knee extensor and flexor muscles at angular velocities of 60°/s, 120°/s, 180°/s and 240°/s. **Results:** No significant differences in peak torque (PT) of the extensor and flexor muscles, and of the flexor/extensor ratios were found between the limbs when compared at the same angular velocity and at the same time, either pre-season or middle-season. However, the PT values for the middle-season were almost always significantly higher when compared to the pre-season. **Conclusion:** These findings indicate that the training prescribed during the season was adequate and allowed to increase the muscle strength and also prevented imbalances.

**Keywords:** Muscle Strength, Knee, Athletes

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## INTRODUCTION

In 1930, a physical education teacher from Uruguay invented an indoor football game.[1,2] Nowadays, this game is known as futsal and it is played by 5 players in each team.[3] Futsal can be considered a new sport type and it is one of the most popular sports in the world in all its categories (amateur, semiprofessional and professional).[2,4,5] Even though it is similar to football (soccer), it is more consistent, intermittent and intense, and it requires greater physical demands.[4,6-11] Futsal is a multiple sprint sport that requires constant changes in direction and speed[7,8,12] as well as kicks.[12] Consequently, the lower limbs, specially the knee muscles, have crucial relevance along the practice of this sport.[11,13]

Disorders in these muscles may lead to musculoskeletal injuries of the lower limbs. Junge and Dvorak,[14] regarding injury prevalence along three Futsal World Championships (2000, 2004, and 2008), have shown that throughout 136 matches, there were 165 injuries, most of them in the lower limbs (70%), being 15.8% in the knees, 13.9% in the thighs, and 12.1% in the ankles and legs. Other studies reporting regular seasons have shown that knees (37.3%) and ankles (13.5%);[15] ankles (40.7%), knees (22.2%), and groins (12%);[16] and ankles (39%) and knees (33%) are the most common regions injured during futsal matches.

Moreover, the physical demands that is imposed on the athletes along a regular season may result in muscle imbalances between both limbs and between the extensor and flexor muscles, consequently diminishing muscle performance and increasing the chances for injuries. Given this issue, individual muscle assessment before and along the competition season may help in defining goals for minimizing muscle injuries. Also, assessments during mid-season may also be required for identifying whether the physical treatment is effective or whether it needs to be changed.

To fulfill this need, isokinetic dynamometry is a commonly used and validated tool for assessing the muscle strength and imbalances of athlete knee muscles,[18,19] what can be applied to avoid injuries during futsal games. However, there are no studies that investigate muscle strength changes of professional futsal athletes during a regular season, and there are few studies evidencing knee muscle asymmetries in these athletes.

## OBJECTIVES

The objectives of this study were: 1) analyze the bilateral differences between knees and the relationship between flexor and extensor knee muscles, based on retrospective data on pre and mid-season of futsal competition; and 2) based on the same dataset, analyze the impact of a regular season on the knee muscle strength and the relationship between flexor and extensor muscles of the knee.

## METHODS

This is a retrospective quantitative study that was carried out in the *Instituto de Medicina do Esporte e Ciências Aplicadas ao Movimento Humano da Universidade de Caxias do Sul (IME-UCS), Rio Grande do Sul*, Brazil. This study was approved by the Independent Ethics Committee (IEC) of the *Faculdade Cenecista Bento Gonçalves,* (*Rio Grande do Sul*, Brazil). It received approval number 947.527, and was conducted in accordance with the Brazilian National Health Council resolution 466/2012, that regulates clinical trials.

The IME-UCS dataset contains concentric/concentric isokinetic assessments of knee extensors and knee flexors of 15 professional futsal male athletes of a top rank national futsal team. The evaluations were carried out pre and mid-season, a gap of 5 months from each other. The sample size was convenient and, therefore, it was intentionally and not probabilistically determined, given the available data in the IME-UCS dataset. Data on athletes that underwent lower limbs injuries or acute pathologies that could hinder the analysis, and data on athletes who did not sign the Informed Consent Form were excluded from the analysis. The mean age was 23 (±4.73) years the mean height was 1.77 (±0.57) meters and the mean body mass was 75.06 (±7.24) kilograms. The mean BMI was 23.99 (±1.99)kg/m², what is considered normal.20

The evaluations were carried out with an isokinetic dynamometer (Biodex System 4®, Biodex Medical Systems, Shieley, New York, USA). For both evaluations, the athletes undertook an 8-minute warmup protocol in a cycle ergometer at 70-80RPM without load. Then the athletes were instructed on the isokinetic proper evaluation. Then, they placed in the dynamometer in sitting position with the trunk at 85° and strapped at the hips and thigh (1/3 distal) for stabilization and for avoiding compensatory movements, and the motor axis was aligned to the knee joint axis. Firstly, the evaluation was performed on the dominant limb (DL), then it was performed in the non-dominant limb (NDL). The athletes performed three submaximal repetitions (50% of maximal contraction) and one repetition at maximal contraction in each of the tests of four speeds for familiarization and warmup. The test protocol was 5, 10, 15, and 20 maximal repetitions of knee extension and flexion in the concentric/concentric mode, at the angular speeds of 60°/s, 120°/s, 180°/s, and 240°/s, respectively. A rest break of 1 minute was allowed in between one speed and another, and a 3-minute break was allowed in between both limbs tests. The tests were accompanied by verbal commands for stimulating the athletes towards their maximum strength.

The isokinetic variables, peak torque (PT, N/m) and the ratio flexors/extensors (%), were collected for the analysis. The mean PT of flexor and extensor knee muscles and the ratio flexors/extensors were statistically analyzed by the statistical pack SPSS 17.0 (*Statistical Package to Social Science for Windows*). The data normality was assessed by the Shapiro-Wilk test. The data was considered normal and non-parametric, and the Student t-test was used for comparing DL and NDL in each evaluation. Similarly, the mean values of the evaluations of pre-season were compared to those of the mid-season. Significance was set as $<0.05$.

## RESUTS

Data on assessments of 15 athletes was analyzed. The mean values and standard deviation (±SD) of the concentric isokinetic PT evaluations of pre and mid-season are presented in Table 1. No significant differences were found between DL and NDL in the mean values of PT of the knee extensor and flexor muscles and angular speed in each moment (pre or mid-season). However, statistically significantly difference was found between both moments. The angular speeds of 180°/s and 240°/s of extensors and flexors were significantly higher in the mid-season, when compared to the pre-season in both legs, either dominant or non-dominant. Moreover, the PT of the flexor muscles in the mid-season was significantly higher in the DL in all angular speeds tested, whereas NDL achieved higher PT only in the 180°/s speed.

Table 2 presents the mean and standard deviation (±SD) of the ratio flexors/extensors of the knee muscles. The results did not evidence significant differences between both limbs at the same evaluation time regarding angular speed. Moreover, the mean flexors/extensors ratio of the NDL, at angular speed of 240°/s of the pre-season was significant higher when compared to the findings at the mid-season evaluations.

## DISCUSSION

Futsal is a developing sport with growing demands and needs for a better understanding of its characteristics.[2] The knee muscles are crucial for futsal athletes, once they are essential for decisive movements during a match,[11] whereas isokinetic dynamometry is the gold standard for evaluating and analyzing muscle performance due to its constant angular speed along all range of motion.[21,22] Despite its popularity and competitive status of futsal, few studies dared to examine the muscle characteristics of futsal athlete. Therefore, the purpose of this study was to examine the bilateral differences of knee muscle strength and the relation between flexors/extensors, and consequently determine the impact of a regular season in both variables, the knee muscle strength and the flexors/extensors relation.

Our results did not evidence statistically significant differences in peak torque (PT), i.e. muscle strength, of both the extensors and flexors muscles of the knee, neither in the dominant limb (DL), nor in the non-dominant limb (NDL), at any angular speed, regardless the evaluation moment, pre-season or mid-season. We considered the PT because it is the most common parameter to assess muscle strength at isokinetic dynamometry,[23] even though there are limited studies that analyzed PT differences in futsal athletes.[24,26] Two studies assessed angular speed of 60°/s only: Andrade[24] evaluated 92 athletes, whereas Vidmar et al.[26] evaluated 9 athletes during pre-season, but neither of both found significant differences between DL and NDL in the PT of extensor muscles. However, Ferreira et al.[25] reported significant differences between both limbs at 60º/s, (n=23), nonetheless no difference was found at 120°/s, 180°/s, or 300°/s. Contrarily, Andrade[24] has shown significant differences of PT of knee flexors in all analyzed angular speeds, opposed to Ferreira et al.[25] and Vidmar et al.[26] These inconsistent results were also found in studies concerning the differences between the lower limbs of football (soccer) athletes at the same angular speeds tested in our study. At 60°/s, Rahnama et al.[27], Zakas,[28] Da Fonseca et al.[29], Zabka et al.[30], Eniseler et al.[31], Daneshjoo et al.[32] and Teixeira et al.[33] did not find significant differences between both limbs, whereas Fousekis et al.[34] have shown significant differences of the extensor muscles. However, no statistically significant differences were found at 120°/s,[27] 180°/s,[28,29,31,32] and 240°/s.[30] The PT of knee flexor muscles of professional football (soccer) players have also found to be inconsistent. Some studies evidenced that there are no differences between both limbs at 60°/s[19,27,28,30,32] and at 180°/s,[19,28,32,35] whereas other studies have reported significant statistically difference between the limbs at 60°/s,[33,35] 120°/s,[27] 180°/s,[29,33,34] and 240°/s.[30] Comparisons of mean PT of the extensor and flexor muscles of the knee of football (soccer) and futsal athletes are relevant, given the similarities between both sports. Previous studies have shown there are no differences between football and futsal athletes when mean values of extensor and flexor muscles PT are compared at 60°/s, 180°/s and 300°/s,[36] as well as muscle strength of lower limbs.[37]

The mean flexors/extensors ratio of DL and NDL were compared and no statistically significant difference was found in any evaluation time at any angular speed

**Table 1.** Mean and Standard Deviation (±SD) Peak Torque of knee extensor and flexor muscles at DL and NDL of futsal athletes along pre and mid-season

| Angular Speed (°/s) | | PT Extensors (N/m) | | | PT Flexors (N/m) | | |
|---|---|---|---|---|---|---|---|
| | | Pre-season | Mid-season | p-value | Pre-season | Mid-season | p-value |
| 60 | DL | 234.79(±33.98) | 238.61(±28.97) | 0.635 | 132.07(±16.65) | 139.23(±19.45)* | 0.011 |
| | NDL | 241.41(±29.92) | 244.77(±24.85) | 0.518 | 130.05(±15.61) | 135.48(±14.01) | 0.078 |
| 120 | DL | 183.12(±51.25) | 200.76(±24.18) | 0.195 | 117.74(±12.66) | 122.62(±10.51)* | 0.026 |
| | NDL | 182.31(±51.02) | 204.81(±23.70) | 0.099 | 114.30(±12.20) | 121.30(±13.95)* | 0.008 |
| 180 | DL | 156.73(±17.37) | 170.27(±18.54)* | 0.007 | 97.97(±9.75) | 104.54(±11.11)* | 0.012 |
| | NDL | 155.12(±21.27) | 172.29(±21.46)* | 0.001 | 100.47(±16.55) | 108.30(±21.20) | 0.219 |
| 240 | DL | 126.45(±16.39) | 138.59(±18.94)* | 0.001 | 82.31(±12.02) | 89.22(±11.87)* | 0.019 |
| | NDL | 122.45(±15.95) | 138.39(±15.75)* | 0.001 | 82.07(±10.48) | 86.61(±13.17) | 0.066 |

PT = peak torque; DL = dominant limb; NDL = non-dominant limb. *Significant statistical difference ($p < 0.05$) between pre and mid-season evaluations.

**Table 2.** Mean and standard deviation (±SD) of the ratio flexors/extensors of knee muscles of both DL and NDL, at pre and mid-season evaluations

| Angular speed (°/s) | | flexors/extensors ratio (%) | | |
|---|---|---|---|---|
| | | Pre-season | Mid-season | p-value |
| 60 | DL | 56.94(±8.60) | 58.86(±9.01) | 0.439 |
| | NDL | 54.15(±5.65) | 55.75(±7.19) | 0.275 |
| 120 | DL | 60.94(±5.11) | 61.64(±7.05) | 0.662 |
| | NDL | 59.51(±4.20) | 59.41(±5.34) | 0.928 |
| 180 | DL | 62.57(±7.64) | 61.88(±7.90) | 0.694 |
| | NDL | 65.73(±6.73) | 63.12(±11.48) | 0.452 |
| 240 | DL | 65.74(±10.43) | 64.89(±8.99) | 0.692 |
| | NDL | 67.40(±6.20) | 62.78(±7.93) | 0.001* |

DL = dominant limb; NDL = non-dominant limb. * Significant statistical difference ($p < 0.05$) between pre and mid-season evaluations.

assessed. These findings are congruent with other previous studies regarding male futsal athletes at 60°/s,[24] as well as with studies on professional football players at 60°s,[27,29,30,32,38] 120°/s,[27] 180°s,[32,37,38] and 240°/s.[30] Only one study reported statistically significant differences between DL and NDL in the flexors/extensors ratio at 180°/s.[29] Not only the analysis of both limbs, the flexor/extensors ratio is also relevant for the prevention of injuries in the thigh and in the knee.[39,41] The mean values of flexors/extensors ratio were calculated for both limbs, at all the four angular speeds, during both evaluation time, and they ranged from 54.15% to 67.40%. These are within the normal range (between 50% and 80%), as suggested in the specialized literature.[42,44] The flexors/extensors ratio is given by the ratio between the concentric PT of the flexors and the concentric PT of the extensors[43], what shows the strength balance between the posterior muscles (flexors) and anterior muscles (extensors) of the thigh.[45]

The extensors and flexors PT of DL and NDL have shown significant differences between both pre and mid-season in all angular speeds we tested. The pre-season is a great moment for identifying muscle strength imbalances,[18,46] whereas the mid-season is an opportunity to analyze the training methods along the season, if necessary. As expected, the futsal practices of a regular season influence the muscle strength of the knee flexors and extensors of futsal athletes. Even though there has been no other study to evaluate the knee muscle strength of futsal athletes along a regular season, some studies have confirmed that training adaptations during the season was beneficial. During a short training period, 4 and 14 weeks respectively, Milanez et al.[47] and Freitas et al.[48] have shown a significant increase in aerobic performance of high-rank futsal athletes. Similarly, in the study conducted by Barbieri et al.[49] semiprofessional futsal players improved both aerobic and anaerobic capacities after 12 futsal specific training. Moreover, in a 31-week study, Matzenbacher et al.[11] evidenced improvements in aerobic resistance, acceleration, speed resistance and lower limbs strength of a sub-18 male futsal team, after training.

The effects of a regular season were also seen in football (soccer), with improvements in agility, however, no significant changes was found in the sprints or strength in the comparison of pre and mid-season.[50] Silva et al.[50] performed 4 isokinetic evaluations (two pre-season evaluations, one mid-season evaluation and the last one 42 weeks after the beginning of the season) in 23 professional football players at 90°s, and no significant differences were found in the extensor and flexor muscles. In this study, the comparison of the flexors/extensors ratio also indicated a significant increase at 240°/s in the NDL when pre-season was compared to mid-season. The considerable increase of PT in the extensor muscles as compared to the flexor muscles of NDL at 240°/s may explain this result. Nonetheless, these values are still within the normal range, and this result has no practical application.

The knee extensor and flexor strength analysis and the flexors/extensors ratio, at four angular speeds, at pre and mid-season did not evidence muscle asymmetry between the dominant limb and the non-dominant limb of male futsal athletes. The mean values of the flexors/extensors ratio were within the normal range, according to the specialized literature. The bilateral knee muscle strength imbalances analysis of football and futsal players is substantial, once theses muscle imbalances are usually related to lesions in sports that involve repetitive kicks.[27] A disproportional extensor strength may lead to imbalances in the ratio flexors/extensors, increasing the chance for musculoskeletal injuries.[45,52] These findings are consistent with the main results of previous studies with futsal and football, in which no imbalances was found neither in the bilateral strength of knee extensors and flexors, nor in the flexors/extensors ratio. Moreover, the results of our study emphasize that the knee muscle strength during mid-season were nearly all superior to the knee muscle strength of pre-season.

## CONCLUSION

These findings emphasize that the physical and the technical-tactical training prescribed by professional staff along a regular season was adequate allowing the athletes to increase muscle strength. Additionally, the work of these experts avoided muscle strength imbalances between both limbs of the knee flexors and extensors. However, additional studies that apply longitudinal design, with larger sample sizes, that assess different angular speeds and eccentrical isomeric isokinetic contractions may be beneficial to yield deeper comprehension regarding the muscle characteristics of futsal athletes.

## CONFLICT OF INTEREST

The authors disclose they have no conflict of interest.

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