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Variation of knee joint-position sense of soccer players during one season: an exploratory study

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ABSTRACT

Introduction: The distribution of injuries during a competitive season in soccer is not consensual. It is suggested that muscle fatigue may be an underlying factor of increased risk of injury when load is high during the season since an impairment in the muscle mechanoreceptors' function has been reported, affecting the necessary proprioceptive acuity to maintain the joint stability.
Objective: To assess the variation of knee joint-position sense of soccer players during one season.
Methods: Twenty-three semi-professional soccer players (12 males and 11 females) participated in the study. Knee joint-position sense was assessed through the absolute, relative and variable angular errors of both limbs over three different moments (early-season; mid-season; and late-season). The selected target angles were 20° and 45° (for the knee extension test), and 45° and 100° (for the knee flexion test), following a non-weight bearing condition and an active repositioning method.
Results: Absolute, relative and variable angular errors of the soccer players did not change significantly over the three moments of assessment ($p>0.05$).
Conclusion: The knee joint-position sense of the assessed soccer players did not vary during the season and also no injuries were observed, suggesting that they were able to maintain the integrity of joint and muscle mechanoreceptors, enabling an appropriate reaction to internal and external joint disturbances.

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RESUMO

Introdução: A distribuição de lesões ao longo de uma época competitiva no futebol não é consensual. Sugere-se que a fadiga muscular possa ser um fator subjacente ao aumento do risco de lesão quando a carga é elevada durante a época, já que tem sido relatada uma deterioração na função dos mecanorrecetores musculares, afetando a acuidade propriocetiva necessária para manter a estabilidade articular.
Objetivo: Avaliar a variação da sensação de posição articular do joelho em jogadores de futebol ao longo de uma época.
Métodos: Vinte e três jogadores de futebol semi-profissionais (12 do sexo masculino e 11 do sexo feminino) participaram no estudo. A sensação de posição articular do joelho foi avaliada através dos erros angulares absolutos, relativos e variáveis de ambos os membros em três momentos distintos (início, meio e final da época). Os ângulos-alvo selecionados foram 20° e 45° (para o teste de extensão do joelho) e 45° e 100° (para o teste de flexão do joelho), seguindo uma avaliação em cadeia cinética aberta e através de reposicionamento ativo.
Resultados: Os erros angulares absolutos, relativos e variáveis dos jogadores de futebol não sofreram alterações significativas ao longo dos três momentos de avaliação ($p>0.05$).
Conclusão: A sensação de posição articular do joelho dos jogadores de futebol avaliados não variou durante a época e também não foram observadas lesões, sugerindo-se que estes foram capazes de manter a integridade dos mecanorrecetores articulares e musculares, permitindo uma reação adequada a perturbações articulares internas e externas.

Introduction

Soccer is considered the most popular sport worldwide, with an estimated number of 270 million players. [1] Considering the high number of practitioners, the number of injuries is also high.[2]

The distribution of injuries during a competitive season is not consensual among epidemiological studies in soccer. In one hand, a higher prevalence in the later phases of seasons is described.[3] On the other hand, other studies report more injuries in periods corresponding to pre- or early-season months.[4,5] In fact, according to Jeong, Reilly, Morton, Bae and Drust[6] the pre-season is considered the period with higher training load, since there is a need of an optimal physical conditioning to increase performance during the season. Additional studies also report that musculoskeletal injuries occur mostly in the final 15 minutes of trainings and matches.[2,7,8] All this evidence suggests that muscle fatigue may be an underlying factor of increased risk of injury when load is high.[9]

Different investigations previously reported a decrease on neuromuscular control and dynamic knee stability after muscle fatigue,[10,11] which can lead the athlete to a greater susceptibility of injury.[11] Fatigue has long been described as also having a negative impact on the knee proprioception of soccer players, and especially on the joint-position sense (JPS),[12,13] described as the ability to memorize a demonstrated joint angle, and to reproduce it without the aid of vision.[14] Effectively, it has been demonstrated that muscle fatigue impairs the muscle mechanoreceptors' function, especially the muscle spindle, affecting the sensorimotor system and the integration of the proprioceptive input required to maintain an adequate functional joint stability.[15,16]

Despite this evidence, the conducted investigations assessing the effect of muscle fatigue on the knee JPS of soccer players have described mainly its acute effects. However, considering the different demands of load during one season, to date, none longitudinal study has been conducted to assess the variation of knee JPS over one complete season, which would be useful in this context to identify and relate injury events to the exposure of soccer players to muscle fatigue. In that sense, the aim of this study is to assess the variation of knee JPS of soccer players during one season.

Materials and Methods

Participants

A convenience sample of twenty-three soccer players (12 males and 11 females) participated in this longitudinal study (mean age: 21.4 ± 3.2 years; mean height: 1.68 ± 0.1

m; mean body mass: 64.1 ± 13.1 kg). Participants were recruited from two Portuguese semi-professional soccer teams from the north, where all the data was collected. Inclusion criteria were: male or female soccer players; aged between 18-30 years; and with no history of knee injuries within the past 6 months. Participants were excluded if there was: history of knee surgery; a diagnosed cardiorespiratory, vestibular or neurological disorder; positive knee integrity tests; taking medication with an influence on motor control; and pregnant or breast-feeding participants. All participants did not suffer any injury during the assessed season. Medical history was self-reported. One physical therapist assessed the following knee integrity tests: the anterior and posterior drawer, the Lachman test, and the valgus and varus stress tests.

To determine the dominant limb, participants were questioned regarding the lower limb they used to execute different tasks, such as kicking a ball.[17] The right lower limb was the dominant limb in 19 (83%) participants.

The Ethics Committee of the Fernando Pessoa University approved the experimental protocol. Every participant signed an informed consent, declaring their acceptance to participate in the study, and all procedures were conducted according to the Declaration of Helsinki.

Assessment of knee joint-position sense

Both knees were assessed following a non-weight bearing condition and active repositioning method. All participants were blindfolded, using shorts, and were tested in two test positions: in the sitting (for the knee extension test) and in a prone position (for the knee flexion test).

For the knee extension test, participants were in the sitting position, and started with the knee flexed at 90°. Then, the investigator moved the leg passively and slowly to extension to one of the target angles, demonstrated by a goniometer. Participants were instructed to maintain and memorize the position for five seconds, and after that period, they were asked to return to the 90°, and immediately after, to actively reposition the knee to the target angle, holding it for five seconds. For this test, participants repositioned to two distinct target angles: 20° of flexion, an extreme angle of the knee range of motion (ROM), to mainly target the joint mechanoreceptors; and 45° of flexion, an intermediate angle of the knee ROM, mainly target the muscle mechanoreceptors.[18,19]

For the knee flexion test, participants were lying down in the prone position with the knee fully extended (starting position). From this position, the investigator slowly moved the leg to flexion, towards one of the target angles, also determined by a goniometer. Participants had to actively keep the test position for five seconds, return to the starting position, and to actively reposition the knee to the target angle immediately after, holding it for five seconds.[12,20] For this test, participants were also tested for two different angles: 45° of flexion, an intermediate angle of the knee ROM, mainly targeting the muscle mechanoreceptors; and 100° of flexion, an extreme angle of the knee ROM, mainly targeting the joint mechanoreceptors.[19,21,22] For both positions, participants performed three repositioning attempts. The same investigator conducted all the procedures, and the order of the tests, angles and limbs was randomized. The knee JPS of participants was assessed in the months of September, January and June, corresponding to the beginning of the season, the mid-season and late season, respectively.

Knee angles were assessed using an inertial motion sensor, Xsens MTx (Xsens, Enschede, Netherlands) for each limb, placed medially and below the anterior tibial tuberosity.[23]

Three repositioning errors were calculated considering: the absolute angular error (AAE), describing the absolute value of the difference between the value of the target angle and the angle reproduced by the participant[24]; the relative angular error (RAE), calculated by the arithmetic difference between the value of the target angle and the angle reached by the participant[24]; and the variable angular error (VAE), calculated from the standard deviation of the three repositioning attempts.[22]

Statistical analyses

Statistical analyses were performed using SPSS software version 26, considering a level of significance of 5%.

The Shapiro-Wilk test was used to assess the normality of data distribution, which was not verified. Therefore, variables were described with Median and Interquartile Range, and the non-parametric test of Friedman (for paired samples) was used to assess the variation of AAE, RAE and VAE across the three assessed moments of the season.

Results

For both limbs, in the knee extension and knee flexion tests, the AAE, RAE and VAE in the intermediate and extreme angles did not change significantly during the season (p>0.05) (Table 1, 2 and 3, respectively).

Table 1. Variation of AAE during the season (in degrees).

		Early Season	Mid-Season	Late-Season	*p*
		Mdn; IQR	Mdn; IQR	Mdn; IQR	
Extension Test	**DL 20°**	3.56; 6.39	2.40; 3.73	3.63; 4.27	0.411
	DL 45°	2.53; 5.10	3.72; 4.04	2.41; 5.74	0.568
	NDL 20°	1.99; 3.40	1.89; 4.40	2.34; 2.45	0.568
	NDL 45°	5.34; 4.39	2.84; 4.31	4.82; 3.58	0.260
Flexion Test	**DL 45°**	5.15; 5.03	5.64; 3.05	3.97; 8.67	0.676
	DL 100°	2.04; 3.71	2.48; 6.03	3.22; 3.20	0.878
	NDL 45°	5.88; 6.14	6.24; 5.48	7.06; 7.74	0.738
	NDL 100°	2.79; 4.05	3.94; 6.33	2.60; 3.48	0.054

Notes. Mdn: median; IQR: interquartile range; DL: dominant limb; NDL: non-dominant limb

Table 2. Variation of RAE during the season (in degrees).

		Early Season	Mid-Season	Late-Season	*p*
		Mdn; IQR	Mdn; IQR	Mdn; IQR	
Extension Test	**DL 20°**	-2.76; 7.73	-1.28; 6.23	-0.58; 6.25	0.183
	DL 45°	-2.53; 5.15	-3.72; 5.39	-2.03; 6.01	0.878
	NDL 20°	-1.48; 4.82	-0.85; 4.58	-1.36; 3.42	0.676
	NDL 45°	-5.34; 5.29	-2.84; 4.44	-4.01; 3.65	0.738
Flexion Test	**DL 45°**	-4.13; 9.85	-5.43; 5.91	-3.96; 11.48	0.438
	DL 100°	-0.71; 6.09	-1.89; 6.66	-0.28; 6.54	0.209
	NDL 45°	-5.70; 6.91	-4.24; 7.31	-5.99; 10.30	0.676
	NDL 100°	-0.79; 4.37	-3.83; 8.30	-0.24; 5.75	0.119

Notes. Mdn: median; IQR: interquartile range; DL: dominant limb; NDL: non-dominant limb

Table 3. Variation of VAE during the season (in degrees).

		Early Season	Mid-Season	Late-Season	*p*
		Mdn; IQR	Mdn; IQR	Mdn; IQR	
Extension Test	**DL 20°**	0.93; 1.65	1.30; 1.33	0.99; 1.27	0.957
	DL 45°	0.93; 0.80	1.34; 1.03	1.19; 1.11	0.260
	NDL 20°	0.81; 0.82	1.11; 1.45	1.16; 0.89	0.296
	NDL 45°	1.53; 1.30	1.33; 0.92	1.69; 1.23	0.119
Flexion Test	**DL 45°**	3.03; 3.14	2.63; 1.95	2.41; 3.05	0.738
	DL 100°	1.31; 1.69	1.61; 2.13	1.35; 1.36	0.840
	NDL 45°	2.54; 2.64	1.93; 1.81	2.05; 1.70	0.676
	NDL 100°	1.57; 1.31	2.28; 2.54	2.12; 1.78	0.738

Notes. Mdn: median; IQR: interquartile range; DL: dominant limb; NDL: non-dominant limb

Discussion

This study aimed to assess the variation of knee JPS of soccer players during one season. The assessment was conducted in two different positions: in a sitting and in a prone position, to verify the integrity of mechanoreceptors during knee extension and flexion. The relevance of conducting these two assessments is related to the fact that epidemiological studies in soccer report that 37% and 13% of the reported muscle injuries occur in the hamstrings and quadriceps muscle groups, respectively.[2]

There is no consensus regarding the distribution of injuries during a competitive season in soccer. Giza, Mithöfer, Farrell, Zarins and Gill[3] describes a higher prevalence in the later phases of seasons, while Le Gall, Carling, Reilly, Vandewalle, Church and Rochcongar[4] and Le Gall, Carling and Reilly[5] report more injuries in periods corresponding to pre- or early-season months, considered the period with higher training load.[6] Additional studies also report that musculoskeletal injuries mostly occur in the final 15 minutes of trainings and matches,[2,7,8] suggesting that muscle fatigue may be an underlying factor of an increased risk of injury when load is high.[9]

In soccer players, muscle fatigue has been previously described as having a negative impact on the knee JPS,[12,13] impairing the muscle mechanoreceptors' function, and affecting the sensorimotor system and the integration of the proprioceptive input required to maintain the joint stability. However, despite of the different demands of load during one season, this evidence was only stablished in terms of acute effects.

To the authors knowledge, this study is the first addressing the variation of knee JPS during one season. Nevertheless, the main finding was that the knee JPS of soccer players did not change significantly over the assessed season, suggesting that neuromuscular control and knee stability was preserved, which may have contributed to the absence of musculoskeletal injuries during the season of the assessed soccer players. This knowledge may suggest a more probable multifactorial nature of injuries[25] and that proprioceptive acuity by itself may not be merely related to an increased risk of injuries in different phases of one season. In fact, besides muscle fatigue,[26] other neuromuscular factors have been argued to contribute to an increased risk of knee injuries, such as an imbalance and/or decreased strength of quadriceps and hamstrings,[26,27] or decreased core strength,[26] which probably are similarly relevant parameters to assess in soccer players during the season. Nevertheless, proprioceptive deficits have also been associated with an increased risk of non-contact knee injury.[26] This proposes that the assessment of proprioceptive acuity in athletes remains relevant, as this will allow the identification of the individuals with a deficit. Indeed, if the afferent information that reaches the central nervous system from the mechanoreceptors is not accurate,

the appropriate motor responses to ensure the joint stability may be also affected,[28] causing an unadjusted or insufficient response to joint disturbances. The fact that the JPS did not vary during the season and that no injuries were observed, suggests that the assessed players were able to maintain the integrity of their joint and muscle mechanoreceptors, which enabled them to react appropriately to internal and external joint disturbances.

Some study limitations should be recognised. The demonstration of the target angles was performed through a passive positioning. However, according to Pickard, Sullivan, Allison and Singer[29] the muscle contraction before the reposition induces a higher precision in JPS. Second, the sample size was small, which may impact the generalization of the present findings. Third, objective measures of muscle fatigue were not collected in order to also assess the levels of fatigue during the season and its relation to proprioceptive acuity. Finally, the stage of the menstrual cycle of the female players was not considered, although previous investigations report variations in JPS accuracy during the cycle.[30] Nevertheless, previous research confirms that there are no differences in knee JPS related to sex.[31,32]

Conclusion

The knee JPS of the assessed soccer players did not vary during the season and also no injuries were observed, suggesting that they were able to maintain the integrity of joint and muscle mechanoreceptors, enabling an appropriate reaction to internal and external joint disturbances.

In future studies, it is recommended that researchers address the identified limitations, conducting a similar study design with a more robust sample. Additionally, future studies should also analyse whether not only proprioceptive acuity, but also other discussed variables, predict the occurrence of injuries.

Conflict of interest

The authors have no conflicts of interest to disclose.

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