Influence of hamstring flexibility on the knee joint position sense

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Abstract

Introduction: Different factors have been put forward as positive or negative influences on the knee joint position sense; however, the effects of hamstring flexibility have not been the object of extensive research. Objective: To study the influence of hamstring flexibility on the knee joint position sense. Methods: The knee joint position sense of 31 adults was tested actively to extension to a 45° range of knee flexion, in both the dominant and non-dominant limb. Hamstring flexibility was assessed through the sit and reach test. Based on the results, participants were divided into high and low flexibility categories. Intergroup analysis and tests of the association between flexibility and repositioning errors were performed. Results: No significant differences were found between the two categories of flexibility and repositioning accuracy. Similarly, no significant associations were found between flexibility and repositioning errors (p>0.05). Conclusions: These results suggest that hamstring flexibility does not affect knee repositioning accuracy, implying that both lower and higher flexibility do not impair the knee joint position sense.

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Introduction

Joint Position Sense (JPS) is a submodality of proprioception that measures the ability of an individual to memorize a given position and to actively or passively reproduce it, without the aid of vision.[1] Knee proprioception is mainly ensured by joint (Pacinian corpuscles and Golgi and Ruffini endings) and muscle mechanoreceptors (Golgi tendon organs and muscle spindles).[2,3] The respective contributions of these sources of afferent information have been debated, and research has established that the greatest contribution to JPS comes from the muscle mechanoreceptors,[4,5] especially the muscle spindles.

Muscle spindles are responsible for providing information about muscle length when being stretched, in order to consciously understand limb position.[6] Several authors state that these receptors can provide afferent information over the entire physiological range of motion of the joint.[7,8]

Different factors have been proposed as positive or negative influences on the knee JPS.[9-11] Earlier research on the acute effects of flexibility training incorporating muscle stretching exercises proved its beneficial effect on enhancing joint range of motion, but also its deleterious effect on some aspects of athletic performance, such as strength and power.[12-14] However, the effect of hamstring flexibility on knee repositioning accuracy has not been the subject of thorough investigation. To the best of our knowledge, only one study has assessed the association between flexibility and proprioceptive acuity,[15] which concluded that hamstring flexibility negatively affects knee JPS. However, the results of the study reveal a negative correlation between flexibility values and repositioning errors, which contradicts the conclusions of the study, since lower repositioning errors signify improved, not worse, accuracy. Therefore, further research is needed to clarify this question.

In this sense, the aim of this study was to investigate the influence of hamstring flexibility on the knee JPS, and, more specifically, its influence on knee extension repositioning accuracy.

Material and methods

Study design and sample

The study was approved by Ethics Committee of the Fernando Pessoa University. Each participant signed an informed consent that complies with the Helsinki Declaration of the World Medical Association, ensuring data anonymity and confidentiality, and barring use for any other purpose except this research. Participants were also informed that they could cease their participation in the study at any time without repercussions or need for justification.

Thirty-one adults (12 males; 19 females) participated in this research, with a median (interquartile range) age of 21.00 (1.00) years and a median (interquartile range) Body Mass Index (BMI) of 23.73 (5.39) kg/m.[2]

All participants were male or female students (aged between 18 and 30) recruited from the university community, with no history of injuries to the lower limbs in the previous 6 months. Excluded from participation were all those with a history of knee surgery; cardiorespiratory, neurological, vestibular or oncological pathology; taking medication that might affect motor control (analgesics, NSAIDs, myorelaxants, antibiotics); and participants who were pregnant or breast-feeding at the time of the study. Determination of the dominant limb was conducted according to the guidelines established by Porac and Coren.[16]

Assessment of Knee Joint Position Sense

The Knee Joint Position Sense (KJPS) was assessed using a 2D video system and placing markers over 4 bony protuberances (lateral malleolus; head of the fibula; lateral epicondyle of the femur; and halfway between the great trochanter and the lateral epicondyle of the femur),[17] held in place with double-sided adhesive tape. Joint angles were later calculated using Kinovea software.

A goniometer was used to set the target angle of 45° of knee flexion[17] in order to assess repositioning accuracy to extension (in a seated position). In both tests, after the target angle was set passively, participants were instructed to actively hold the position for 5 seconds, then to return to the starting position (90° flexion), and immediately afterwards to actively reposition the knee in the target position.[18] For each lower limb, three repositioning attempts were performed. All procedures were conducted with the participants blindfolded, in order to eliminate visual inputs.

Repositioning errors were reported as: Absolute Angular Error (AAE), which is the absolute value of the difference between the value of the target range and the range reproduced by the participant;[19] Relative Angular Error (RAE), defined as the arithmetic difference between the value of the target range and the range reached by the subject[19] (negative RAEs indicate a directional bias into the extension movement, and positive RAEs signal a bias into the flexion movement); and Variable Angular Error (VAE), defined as the standard deviation of the three repositionings.[20]

Flexibility assessment

Hamstring flexibility was assessed through the sit and reach test. For this test, participants sat on the floor barefoot and with their feet set approximately hip-wide against a testing box, with their knees extended. Then, they were instructed to place one hand over the other, and slowly reach forward as far as they could by sliding their hands along the measuring tape, and to maintain the maximum position for 2 seconds.[21]

In order to understand how different levels of hamstring flexibility might influence the KJPS, after collecting all participants' data from the sit and reach test, two categories of flexibility were established (low and high), taking into account the median of this variable (17.40cm). Participants with a median flexibility equal or lower than 17.40cm were placed in the low flexibility category, and those with values above 17.40cm were placed in the high flexibility category.

Statistical procedures

Statistical data were analyzed using the Statistical Package for Social Sciences (SPSS) software (26.0 version). AAE, RAE, VAE and anthropometric variables (age, BMI) are described as Median and Interquartile Range (Med; IQR). The Shapiro-Wilk Test was applied to help understand the distribution characteristics of the data. The statistical significance of differences of medians between the flexibility categories and variables like age, BMI, AAE, RAE and VAE were verified using the independent-samples Mann-Whitney U Test. In order to check for possible associations between flexibility and repositioning errors, the Spearman Correlation Coefficient was also calculated. For all analyses, the level of significance was set at $p<0.05$.

Results

No significant differences were found between the flexibility categories regarding age ($p=0.579$) or BMI ($p=0.220$) (Table 1).

Table 1. Comparison between low and high flexibility categories regarding age and BMI.

	Low flexibility (n=21)	**High flexibility (n=20)**	***p***
	Med; IQR	Med; IQR	
Age (years)	21.00; 1.00	21.50; 2.00	0.579
BMI (kg/m^2)	23.89; 4.88	24.67; 7.27	0.220

Legend: BMI: Body Mass Index; IQR: Interquartile Range; Med: Median

Source: The authors (2022).

No significant differences were found between the flexibility categories and the AAE (p>0.05). Also, participants from both flexibility categories tended to overestimate the target position. However, the RAE was not significantly different between the categories (p>0.05). Similarly, the consistency between the three repositionings given by the VAE showed no significant difference between the low and high flexibility categories, both for the dominant as well as the non-dominant limb (p>0.05) (Table 2).

Table 2. Comparison between low and high flexibility categories regarding AAE, RAE and VAE of the dominant and non-dominant limb.

		Low flexibility (n=21)	High flexibility (n=20)	*p*
		Med; IQR	Med; IQR	
AAE	**DL**	2.41; 4.15	4.00; 3.78	0.566
	NDL	3.11; 3.83	3.73; 3.21	0.489
RAE	**DL**	-2.41; 4.15	-4.00; 3.78	0.566
	NDL	-3.11; 3.83	-3.73; 3.36	0.734
VAE	**DL**	1.63; 2.15	1.40; 1.52	0.948
	NDL	0.90; 1.32	1.45; 1.69	0.171

Legend: AAE: Absolute Angular Errors; DL: Dominant Limb; IQR: Interquartile Range; Med: Median; NDL: Non-dominant limb; RAE: Relative Angular Errors; VAE: Variable Angular Errors

Source: The authors (2022).

No associations were found between hamstring flexibility assessed through the sit and reach test and repositioning errors, in both the dominant and non-dominant limb (Table 3).

Table 3. Association between flexibility and the repositioning errors of the dominant and non-dominant limb.

		Flexibility	*p*
		Correlation Coefficient	
AAE	**DL**	0.079	0.623
	NDL	0.027	0.868
RAE	**DL**	-0.079	0.623
	NDL	0.013	0.935
VAE	**DL**	0.014	0.931
	NDL	0.230	0.212

Legend: AAE: Absolute Angular Errors; DL: Dominant Limb; NDL: Non-dominant limb; RAE: Relative Angular Errors; VAE: Variable Angular Errors

Source: The authors (2022).

Discussion

This study seeks to evaluate the influence of hamstring flexibility on the KJPS.

Although proprioceptive signals from both agonist and antagonist muscles around a given joint contribute to the sensation of limb position, it is argued that the information from the muscles being stretched during the repositioning task is responsible for the most important contribution,[22,23] which can be attributed to the muscle spindle function.[6] According to this hypothesis, in a knee extension repositioning task, the hamstrings are expected to give the greatest contribution to the sense of position, since they are being stretched. Accordingly, different levels of flexibility of this muscle group may influence the KJPS. However, the results of the present study revealed no significant differences in repositioning errors between the low and high flexibility categories, suggesting that increased or diminished hamstring flexibility does not influence knee extension repositioning accuracy in the selected target position. In addition, no significant associations were found between flexibility and the repositioning errors.

To our knowledge, only the study of Akman and colleagues[15] has investigated the influence of hamstring flexibility on KJPS, through an analysis of both elite dancers and sedentary individuals. Although the flexibility assessment and the repositioning method were similar to those of the current study, three target ranges (20°, 40° and 60° of knee flexion) were tested. The authors analyzed the association between flexibility and active position sense, and reported significant negative correlations between these variables when repositioning to 20°. This finding is not aligned with our results, which do not suggest any positive or negative effect of hamstring flexibility on KJPS. Still, the conclusions of the study of Akman and colleagues[15] must be considered with caution since the authors concluded that higher values of flexibility negatively affected knee JPS in both dancers and sedentary participants. However, a negative correlation would mean that greater flexibility would lead to fewer repositioning errors, which represents a positive and not a negative effect on proprioceptive acuity that the authors failed to recognize. It is important to note that the results of Akman and colleagues[15] were especially noticeable when repositioning to 20° flexion. Repositioning to 40° flexion, a target similar to that of the present study, also revealed a significant negative association, although only in the subgroup of dancers.

With regard to directional bias, the results of the current study also failed to reveal differences between the flexibility categories, despite the probability of participants with lower hamstring stretching capacity sensing their legs in a more stretched position than actually happened (underestimation of the target position) and vice versa. However, the lack of studies on this topic does not allow these assumptions to be related to another research. Similarly, the consistency of repositionings was similar between participants with low and high flexibility. Nevertheless, as already stated, no articles with this assessment have been conducted in the past to confirm or refute these results.

Some limitations of the study should be recognized. First, the sample size was relatively small. Second, the chosen target position was not a range that required a significant stretching of the hamstring and, consequently, of the muscle spindle. This may explain the absence of differences between individuals with greater and lesser flexibility. However, according to the work of Olsson and colleagues[20] on the knee joint, muscle mechanoreceptors are more active in intermediate ranges, specially between 40° and 80° of knee flexion, and the chosen target position for this study was a range that lies within this interval. Moreover, only repositioning to extension was assessed, and flexion repositioning tasks could have provided additional relevant information. Third, the fact that the chosen test to assess hamstring flexibility was the sit and reach test, which, according to Mayorga-Vega and colleagues,[24] has a moderate mean criterion-related validity for estimating hamstring extensibility. Fourth, information regarding the menstrual cycle phase of female participants was not collected. According to Miyazaki and colleagues[25] the menstrual cycle has implications for flexibility measurement, since passive stiffness is significantly decreased during the ovulatory phase when compared with the follicular phase. In addition, Fouladi and colleagues[26] reported that female athletes have varying levels of KJPS during the menstrual cycle, with worse JPS at menses and greater accuracy during the mid-luteal phase.

Conclusion

These findings imply that higher or lower hamstring flexibility does not influence knee repositioning accuracy to extension, suggesting that having lower or higher flexibility does not impair the KJPS.

Further research on this topic should be conducted with more robust samples in order to confirm or refute the results presented in this paper, especially regarding directional bias between different levels of hamstring flexibility.

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Conflict of interest

The authors state that no conflict of interest exists. No author has any financial interest in or has derived any financial benefit from this research.

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