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Original Article

Proprioceptive deficit in individuals with unilateral tearing of the anterior cruciate ligament after active evaluation of the sense of joint position☆,☆☆

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ABSTRACT

Objective: To ascertain whether the proprioceptive deficit in the sense of joint position continues to be present when patients with a limb presenting a deficient anterior cruciate ligament (ACL) are assessed by testing their active reproduction of joint position, in comparison with the contralateral limb.

Methods: Twenty patients with unilateral ACL tearing participated in the study. Their active reproduction of joint position in the limb with the deficient ACL and in the healthy contralateral limb was tested. Meta-positions of 20% and 50% of the maximum joint range of motion were used. Proprioceptive performance was determined through the values of the absolute error, variable error and constant error.

Results: Significant differences in absolute error were found at both of the positions evaluated, and in constant error at 50% of the maximum joint range of motion.

Conclusion: When evaluated in terms of absolute error, the proprioceptive deficit continues to be present even when an active evaluation of the sense of joint position is made. Consequently, this sense involves activity of both intramuscular and tendon receptors.

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Déficit proprioceptivo em indivíduos com ruptura unilateral do ligamento cruzado anterior após a avaliação ativa do senso de posição articular

Palavras-chave:
LCA
Sistema somatossensorial
Joelho

RESUMO

Objetivo: Verificar se o déficit proprioceptivo no SPA permanece quando pacientes com um membro LCA deficiente são avaliados por meio do teste de reprodução ativa da posição articular, em comparação com o membro contralateral.
Métodos: Participaram do estudo 20 pacientes com ruptura unilateral do LCA. Foi feito o teste de reprodução ativa da posição articular no membro LCA deficiente e contralateral saudável. Foram usadas as posições meta de 20% e 50% da amplitude articular máxima. O desempenho proprioceptivo foi determinado por meio dos valores de erro absoluto (EA), erro variável (EV) e erro constante (EC).
Resultados: Diferenças significativas foram encontradas para o EA em ambas as posições avaliadas e para o EC em 50% AAM.
Conclusão: O déficit proprioceptivo quando avaliado pelo EA permanece mesmo quando a avaliação do senso de posição articular é ativa e, consequentemente, envolve a atividade de receptores intramusculares e tendíneos.

Introduction

Appropriate kinematics for the knee depend on the mechanical stability of the joint that is provided by its static and dynamic components.[1,2] The ligaments furnish static stabilization and their main function is to enable normal joint kinematics and prevent abnormal and rotational movements that could damage the joint surfaces,[2] while dynamic stabilization is given by coordinated muscle contraction activity modulated by the neuromuscular system.[3,4] This system requires proprioceptive information from the joint kinesthesia and position[5–7] and from the force developed by the muscles.[8–10]

This information is obtained through acquiring afferent signals from the peripheral mechanical receptors that are found in the muscles, tendons, ligaments, joint capsules and skin.[11] Mechanical receptors have also been identified in the anterior cruciate ligament (ACL)[12] and it is believed that these contribute toward proprioception of the joint.[13,14] Thus, tearing of the ACL would lead to joint instability not only because of the impairment due to the mechanical restriction but also because proprioception is disturbed[14,15] and the capacity of the muscles acting on the knee to respond adequately to the loads applied is diminished.[15,16]

Proprioceptive deficits have been observed in patients with ACL tearing and have been correlated with reduced functional capacity.[7,17] These deficits have been identified in relation to the passive movement detection threshold (PMDT) and joint position sense (JPS), in comparison with normal individuals[18,19] and with the healthy contralateral limb.[19,20] Assessments of PMDT and passive JPS have been adopted preferentially for use in studies.[18,21,22] This practice is based on the assumption that the low angular velocities used would specifically stimulate the receptors of the capsule and ligament structures without stimulating the intramuscular and tendon receptors. In these procedures, the individuals' voluntary muscle activity is not involved. However, under normal conditions of human movement, voluntary muscle activity is always present.

There is little evidence to demonstrate that proprioceptive deficits, in the way in which they are assessed, would adversely affect patients with insufficiency of the ACL or a surgically reconstructed ACL.[22] Thus, procedures that involve voluntary muscle action and consequently stimulation of the muscle-tendon receptors should receive greater attention in evaluations on proprioception. JPS assessment with active positioning and reproduction may be an option for investigating proprioceptive capacity in a more functional manner. Thus, the present study had the aim of ascertaining whether the proprioceptive deficit regarding JPS continues when patients with a deficient ACL are evaluated by means of a test on active reproduction of joint position, in comparison with the healthy contralateral limb.

Materials and methods

Subjects

Twenty patients participated in this study: 12 men and 8 women of mean age 30.6 ± 4.5 years, mean weight 72.3 ± 14.2 kg and mean height 169.2 ± 8.9 cm. All of these patients presented unilateral tearing of the ACL. They were selected randomly from the waiting list for ACL reconstruction surgery. The inclusion criteria were: (1) age between 20 and 40 years; (2) absence of injuries to the ACL or any other structure of the contralateral knee; (3) not having undergone any surgery on the limb with the ACL tearing; and (4) not having any signs of joint degeneration (characterized by joint crepitation in any of the compartments of the knee). The exclusion criteria were: (1) chondral lesions diagnosed through magnetic resonance imaging; and (2) signs of osteoarthrosis on knee radiographs. All the patients were evaluated clinically by the

Table 1 – Clinical examinations.

Lachman and anterior drawer				
	–	+/+++	++/+++	+++/+++
Lachman	5	13	2	0
Anterior drawer	0	7	13	0
McMurray and pivot				
	–	+		
Bocejo	1	19		
Pivot	12	8		

same orthopedist (Table 1). This study was approved by the local ethics committee and the subjects were informed about the objectives and procedures through a free and informed consent statement, in accordance with Resolution 196/96 of the National Health Council.

Assessment of joint position sense

Instrument
An isokinetic dynamometer (CSMI, Humac Norm) was used in all the procedures.

Positioning
The subjects were positioned seated, with the lateral condyle of the femur aligned with the axis of rotation of the apparatus and the ankle fixed to an accessory rod for knee evaluation, by means of a Velcro strip (Fig. 1). Care was taken to position the popliteal fossa away from the limit of the seat, so as to enable complete joint movement and minimize skin stimulation in this region. The precision of the angle measurements was 1°.

Maximum joint amplitude
The MJA of the flexion–extension movement was determined by measuring the amplitude between the maximum extension (0°) and the maximum flexion of the knee.

Joint position reproduction test
The subjects were required to experience and then reproduce joint positions, in both cases through voluntary movements. The commands for carrying out the task were issued verbally by the evaluator and the direction of movement was from flexion to extension. Two target positions to be experienced were used: 20% and 50% of the MJA (0% = maximum extension). Both limbs were evaluated and the order of assessment was chosen randomly. Throughout the procedure, the patients were blindfolded. Variations of ±5° around the target position were allowed. When the subject violated this margin, the attempt was discarded. Five attempts in each target position were performed (10 in total).

Determination of the individual error and calculation of the proprioceptive acuity

The individual error value for each attempt made was determined through the difference between the position reproduced and the position experienced. The proprioceptive performance was determined by means of the values of the absolute error (AE), variable error (VE) and constant error (CE).

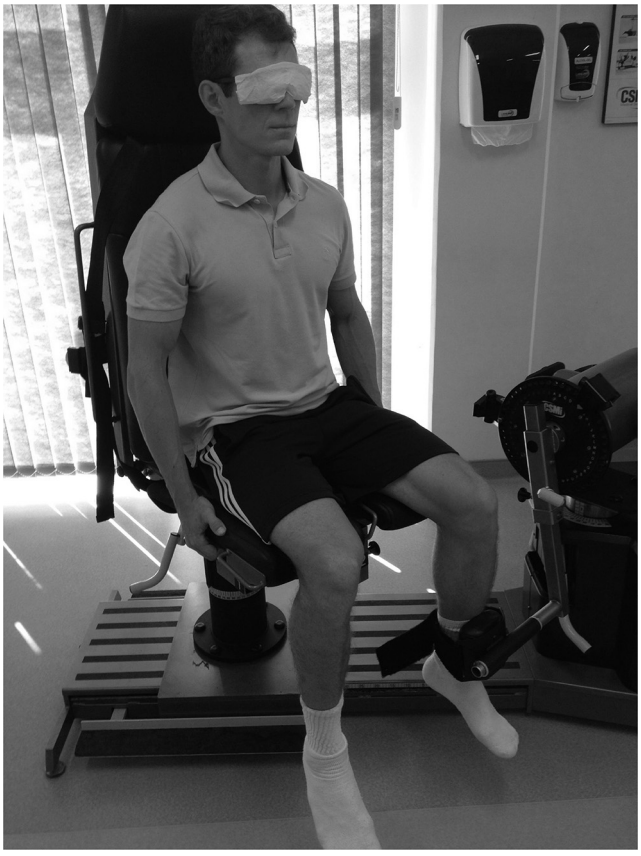

Fig. 1 – Subject positioned in the isokinetic dynamometer to perform the joint position reproduction test (sensing of position).

Schmidt and Lee[23] described the calculation of each variable in detail. Briefly, the AE is obtained through the arithmetic mean of the individual errors in the modulus and determines the individual's accuracy in reproducing the position; the VE is the standard deviation of the individual errors and determines the consistency of the reproductions made; and the CE is the arithmetic mean of the individual errors with their signs and determines the tendency for the position to be reproduced above or below the target (bias).

Statistical analysis

Descriptive statistics (mean ± SD) were used to describe the data. The dependent variables were the AE, VE and CE. The data were subjected to the Shapiro–Wilk test of normality. Comparisons were made between the affected ACL and the contralateral limb (control). The values determined for 20% and 50% of the MJA were compared using the *t* test for paired measurements. The calculations were performed using the Statistical Package for the Social Sciences software (SPSS Inc., Chicago, IL, USA) and the graphs were made using Sigma Plot (Systat Inc., Chicago, IL, USA). The statistical significance level established was $p \leq 0.05$.

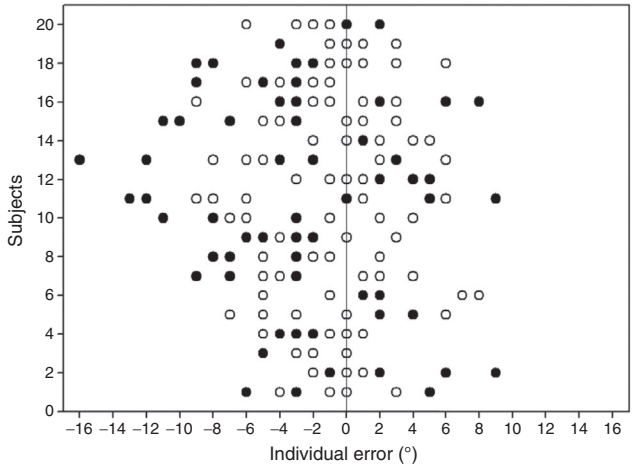

Fig. 2 – Distribution of the individual errors in the joint position reproduction test: 20% MJA. Black circles refer to the limb with the deficient ACL and white circles to the control limb. The continuous line represents the target position graphically.

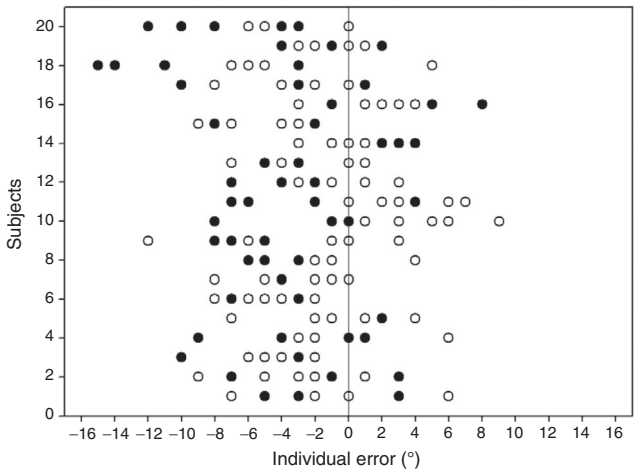

Fig. 3 – Distribution of the individual errors in the joint position reproduction test: 50% MJA. Black circles refer to the limb with the deficient ACL and white circles to the control limb. The continuous line represents the target position graphically.

Results

Time of injury, cause of injury and associated lesions

The mean time that elapsed until the data-gathering was 3.7 ± 1.2 years. The injuries mostly occurred due to sprains in situations of day-to-day life (45%), injuries not involving contact in recreational soccer (35%), falls (15%) and car accidents (5%). Associated lesions were seen in 14 patients: 13 in the medial meniscus and only one in the lateral meniscus.

MJA, 20% MJA, 50% MJA and positions experienced

The maximum joint amplitude determined for the ACL of the affected limb was 105.3° ± 11.8° and for the control limb, 111.2° ± 10.2°. The target positions calculated for the ACL at 20% and 50% MJA were 21.1° ± 2.4° and 52.6° ± 5.9°, respectively. The target positioned calculated for the control at 20% and 50% MJA were 22.2° ± 2.0° and 55.6° ± 5.1°, respectively. The positions experienced that were used in the joint position reproduction test were 0.3° ± 3.8° and 50.5° ± 7.2° for the ACL of the affected limb, while these positions in the control were 21.1° ± 3.0° and 52.4° ± 5.9°.

Individual errors

The values determined for the individual errors are demonstrated graphically in Figs. 2 and 3.

AE, VE and CE

The values determined for AE, VE and CE are listed in Table 2. The limb with the affected ACL generally demonstrated higher values (worse values). Significant differences were found in relation to the AE in both the positions evaluated and in relation to CE at 50% MJA.

Discussion

The ligaments have the function of mechanically restricting joint amplitude and limiting movement by means of a stable arc.[1,2] In addition, they supply proprioceptive information[24,25] and enable dynamic stabilization of the joint modulated by the neuromuscular system.[3,4] If this system is complete, it allows appropriate reflex motor responses and diminishes the possibility of occurrence of abnormal joint movements and subluxation.[2,16,26]

Patients with ACL injuries present proprioceptive deficits[18,20] and it has been proposed that these deficits are responsible for the feelings of functional instability and the falls reported by patients with anterior instability of the knee.[27] Proprioception of the knee has been evaluated through passive tests[6,28] in which the subjects' voluntary muscle action has not been present. The equipment generates passive movement through low angular velocities (approximately 0.5°/s) with the aim of selectively evaluating the capsule and ligament receptors.[29] Stimulation of the intramuscular and tendon receptors occurs continuously during voluntary motor activities. Therefore, it is important

Table 2 – AE, VE and CE determined for 20% and 50% MJA (mean ± SD).

	AE	VE	CE
20% MJA			
Deficient ACL	4.3° ± 2.0°[a]	3.2° ± 2.0°	−2.2° ± 3.3°
Control	2.9° ± 1.3°	3.0° ± 1.4°	−0.6° ± 1.5°
50% MJA			
Deficient ACL	4.2° ± 2.1°[a]	2.8° ± 1.1°	−3.3° ± 3.1°[a]
Control	3.5° ± 1.3°	2.8° ± 1.0°	−1.6° ± 2.8°

[a] Significantly different from the control limb.

to ascertain whether deficits in joint position sense continue to be present when an active method for testing JPS is used.

In this study, we evaluated JPS in patients with unilateral ACL injuries by using an isokinetic dynamometer with active measurements at 20% and 50% of the maximum joint amplitude. It was decided to use percentages of MJA, instead of absolute values, in order to be able to make relative comparisons between the subjects.[30] Significant differences were found at both the positions, using AE for the evaluation, and this demonstrates that limbs with a deficient ACL have lower accuracy in reproducing joint positions, in comparison with the healthy contralateral limb. Carter et al.[20] evaluated JPS in 50 patients with unilateral ACL injuries using an isokinetic dynamometer and found significantly different AE between the injured and control limbs ($9.42^\circ \pm 3.14^\circ$ and $7.1^\circ \pm 2.32^\circ$, respectively), thereby corroborating the results of Lee et al.[19]

No significant differences relating to VE were identified, which demonstrates that the individuals presented the same consistencies in reproducing joint positions, independent of the injury. The CE determined for both the limb with the deficient ACL and the healthy contralateral limb had negative values (repositioning of the limb below the target position). This behavior has also been identified by our group in individuals who were free from orthopedic injuries (unpublished data). In the present study, only the CE of 50% MJA reached a statistical difference. However, from the methods applied, it was not possible to obtain a physiological response for this behavior. VE and CE values are not commonly used in the literature, which impedes comparison of the results.

Conclusion

When the proprioceptive deficit is evaluated by means of the AE, it continues even when the assessment of joint position sense is active. Consequently, this involves activity of the intramuscular and tendon receptors. Future studies should include calculation of the variable error and constant error, so as to make it possible to compare the results and thus expand knowledge of the behavior of these variables.

Conflicts of interest

The authors declare no conflicts of interest.

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