

# Techniques of proprioceptive evaluation of the anterior cruciate knee ligament

## *Técnicas de avaliação proprioceptiva do ligamento cruzado anterior do joelho*

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### ABSTRACT

*The knee shows little stability because of its anatomical shape, and at the same time it has great flexibility, and for these reasons its function depends on muscular and ligamentous structures. A joint injury can cause changes in sensory information maintained by mechanoreceptors. The increasing interest in sports activities, combined with the knee's anatomical vulnerability and complexity, justifies the increasing number of patients with ligament injuries, especially the anterior cruciate ligament (ACL). What then would be the best way to evaluate the knee proprioception? The objective of this study was to identify the techniques of proprioceptive evaluation of the anterior cruciate knee ligament (ACL), and to determine whether a better technique is available. The method was to review the literature, including only those studies published in indexed scientific journals that referred to evaluation tools and/or knee proprioception measurement. The discussion of the different methods of evaluating ACL proprioception, according to the literature, included:*

*morphological anatomical studies; neurophysiologic evaluation, and clinical evaluation which was divided into three types: a) sense of static position; b) kinesthetic posture; and c) postural balance. Although proprioception is important to the final results of a treatment involving ligament injury, its evaluation is still a problem. The conclusion was that the ideal method should have high sensitivity and specificity, in addition to good reproducibility and accuracy. There is lack of consensus in literature regarding the best evaluation technique and the results are also contradictory, despite the balance evaluation being a modern technique used in major research centers, it was not possible to isolate the proprioceptive system from other systems: visual and vestibular.*

**Keywords:** Proprioception, Postural Balance, Anterior Cruciate Ligament, Evaluation

### RESUMO

O joelho apresenta pouca estabilidade, em virtude de sua forma anatômica, ao mesmo tempo em que possui grande flexibilidade, e por essas razões, sua função depende das estruturas musculares e ligamentares. Uma lesão na articulação pode causar alterações nas informações sensoriais mantidas pelos mecanorreceptores. Com o aumento do interesse por atividades esportivas, bem como a vulnerabilidade e complexidade anatômica do joelho justificam um aumento crescente do número de pacientes com lesões ligamentares, principalmente do ligamento cruzado anterior (LCA). Entretanto qual é a melhor forma de avaliar a propriocepção do joelho? Objetivo: Desta forma este estudo teve como objetivo identificar as técnicas de avaliação proprioceptivas do LCA do joelho, e se existe a melhor técnica. Métodos: Foi realizada uma revisão de literatura, tendo como critérios de inclusão os estudos publicados em revistas científicas indexadas, que se referiam a instrumentos de avaliação e/ou mensuração da propriocepção do joelho. Discussão: De acordo

com a literatura revisada, existem diferentes técnicas de avaliação da propriocepção do LCA, dentre elas: estudos morfológicos anatômicos; avaliação neurofisiológica; e avaliação clínica que é dividida em três subtipos: a) sentido da posição estática; b) cinestesia; e c) equilíbrio postural. Ainda que a propriocepção seja importante no resultado final de um tratamento que envolva uma lesão ligamentar, sua avaliação ainda é uma dificuldade. Conclusão: O método ideal deve ter alta sensibilidade e especificidade, além de boa reprodutibilidade e precisão. Porém não houve consenso na literatura referente à melhor técnica e os resultados são contraditórios, apesar da avaliação do equilíbrio ser uma técnica moderna e utilizada nos grandes centros de pesquisa, não é possível isolar o sistema proprioceptivo dos outros sistemas: visual e vestibular.

**Palavras-chave:** Propriocepção, Equilíbrio Postural, Ligamento Cruzado Anterior, Avaliação

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## INTRODUCTION

The knee has little stability due to its anatomical shape but, at the same time, it has great flexibility, and for these reasons, its functioning depends on muscular and ligamentous structures.<sup>1</sup> A joint injury can cause direct or indirect alterations in the sensory data transmitted by the mechanoreceptors. A direct trauma can cause ligamentous and capsular lesions, and may rupture less resistant nerve fibers and diminish proprioception.<sup>2-3</sup>

According to Voight & Blackburn,<sup>4</sup> Tookuni et al,<sup>5</sup> and Alonso et al<sup>6</sup> there are different ways to study and measure the neuromuscular control of the knee.

1<sup>st</sup> – Anatomical morphological studies: identify the mechanoreceptors in the specific joint structures.

2<sup>nd</sup> – Neurophysiologic evaluation: evaluate sensory thresholds, the speed of nervous conduction, and muscle stimulus-response time.

3<sup>rd</sup> – Clinical evaluation: evaluate the responses of the muscular, articular, and neurological components to the stimuli. Within the clinical perspective proprioception can be evaluated by measuring the components that constitute the proprioceptive mechanism, and they are divided into three subtypes:

a) Direction of the static position – which means conscious perception of the orientation of many parts of the body in relation to the others, evaluated through the positioning sense (afferent). This determines the ability of the individual to produce a pre-determined angle of amplitude of the joint movement;

b) Sense of speed of the movement, also called kinesthesia or dynamic proprioception, which evaluates the perception of the articular movement or the degree of angular dislocation;

c) Postural balance (efferent): evaluates the capacity to maintain balance through unbalancing stimuli.

The growing interest in sports activities, as well as the vulnerability and anatomical complexity of the knee justify the growing increase in the number of patients with ligamentous lesions. Nevertheless, what is the best way to evaluate the proprioception of the knee?

This article reports on the research done in studies on the theme, seeking to identify the techniques to evaluate the proprioception of the anterior cruciate ligament (ACL) of the knee, and see whether there is a better technique.

## METHODS

A review of the literature was made, following the criteria of inclusion of studies published in indexed scientific magazines, mainly in the last 30 years, in the period from 1978 to 2010, in the pre-established languages (English and Portuguese); and which referred to instruments for evaluating and/or measuring the proprioception of the knee to evaluate treatment results. Articles that described rehabilitation treatments of the knee without the utilization of these instruments were excluded, as well as those that did not possess sufficient methodological rigor to allow reproduction of the study.

### Procedures

Searches in the scientific articles were made based on electronic data from Medline, Lilacs, and Pubmed, with the following subject descriptors: evaluation, proprioception, postural balance, ACL.

To select the references pertinent to the theme researched, initially the simple combinations of these terms were used, either in English or in Portuguese, and afterwards, the research was refined according to the options that each database offered for such procedure:

- *Pubmed* – the search was refined with the following limits: “publication date”: 1978 to May of 2010; “humans”; “languages”: English.

- *Lilacs* – language: Portuguese; year of publication: 1982 (beginning of database) to May of 2010.

- *Medline* – language: English; year of publication: 1978 to May of 2010.

After reading the summaries of the articles found, those that fulfilled the criteria of inclusion and were identified as relevant to the development of this work were selected.

## Development

### Anatomical morphological studies

The first study was made by Freeman & Wyke<sup>2</sup> in 1967 and became a reference. Later other studies also have shown the existence of mechanoreceptors in the ACL of humans.<sup>6,7</sup>

The nerve tissue is 1% to 2.5% of the total volume of the ACL, and in it are found four types of nerve endings: Type-I Ruffini's Terminations; Type-II Paccini's Corpuscles; Type-III Golgi's Tendinous Organ, and Type IV-Free Nerve Terminations. All of them have different properties relative to the threshold of mechanical stimulus, production of afferent signals, adaptation period, and cessation of the stimulus.<sup>8-11</sup>

Denti et al<sup>12</sup> studied the mechanoreceptors present in the residual portion of ruptured ACLs, removed from 20 patients in the following phases: acute (five days), sub-acute (six months), and chronic (after 12 months), and demonstrated that, until three months after the lesion first occurred, there were still mechanoreceptors in the residual portion. After that period, there was a progressive decline, and after nine months few nerve endings were found.

In a histological study of animals in which there was reconstruction of the ACL with a patellar tendon graft and with an artificial graft, mechanoreceptors were found in the patellar tendon grafts after three months. In the artificial grafts, the mechanoreceptors were always absent regardless of the time between surgery and biopsy.<sup>12</sup>

In a study of individuals who suffered re-injuries, ten years after surgery mechanoreceptors were found in the grafts; however, these were considered non-functional.<sup>12</sup>

### Neurophysiologic evaluation

The somatosensory evoked potential test was used to measure the afferent electrical activity of the normal ACL. During the arthroscopic procedure, the ACL was electrically stimulated through strategically-placed electrodes to observe the response to the stimulus, and the cortical response was monitored through electrodes inserted subcutaneously in the head. In all the individuals, the electrical stimulation of the ACL produced measureable cortico-cerebral potentials showing direct evidence of the proprioceptive function of the ACL.<sup>13</sup>

Beard et al<sup>14</sup> evaluated individuals with ACL lesions more recent than 18 months and compared them with a control group and with the counterlateral limb. The anteroposterior dislocation of the tibia was evaluated with the KT1000 arthrometer and the latency of the ischiotibial muscles was measured by the somatosensory evoked potential. In the patients with ACL lesions there was increase in the latency time of the contraction reflex of the ischiotibial muscles, that is, they did not react to the dislocation at the same velocity as the counterlateral side or the control group. The functional instability of the knee was directly related to the increase in the reflex latency time for the contraction of the ischiotibial muscles.

Studies were made with adult dogs to determine whether the patellar ligament graft showed evidence of reinnervation when used for the reconstruction of the ACL. The native ligament was removed and rebuilt with the patellar tendon graft. The somatosensory evoked

potential was measured immediately after the surgery and in the subsequent months. Six months after surgery the evoked potential returned in two cases. Results have shown that, in some cases, the patellar tendon graft has presented evidences of reinnervation when used for the reconstruction of the ACL.<sup>15</sup>

Ochi et al<sup>16</sup> examined whether the somatosensory evoked potentials are detectable with direct electrical stimulation to knees where the ACL had been injured, reconstructed, and normal. The patients were divided into three groups: injured ACL group, reconstructed ACLs 18 months after surgery, and normal ACL group. Before the arthroscopic procedure, the individuals submitted themselves to the anteroposterior dislocation test of the tibia through the KT1000 arthrometer and the sense of positioning test. The ACL was stimulated electrically utilizing a bipolar electrode inserted into the residual portion in the injured group and into the medial portion in the normal ACL and in the graft group. Only 46% of the injured individuals responded to the stimulus whereas the other two groups had a 100% response to the stimulus. In the knee instability and sense of positioning tests, the injured ACL group presented values higher than the other two groups, which did not present differences between themselves. The results revealed that there is sensory reinnervation after reconstruction of the ACL, and that there is improvement in the mechanical limitation and function of the knee.

### Clinical Evaluation

#### *Evaluation of the sense of positioning*

The sense of positioning is evaluated documenting the ability of the individual to produce a pre-determined angle of articular movement.

Basically, this test is done in two ways: actively and passively; the examiner positions the limb to be tested at a pre-determined target angle, holds it in this position for a few seconds, to allow the patient to mentally process the target angle. Then, the examiner returns the limb to the initial position and asks the patient to actively reproduce the target angle. The passive test follows the same positioning as the active test, but the examiner places the limb at various angles, reports to the patient at which angle his/her articulation is positioned, allows the necessary time for mental processing by the patient, returns to the initial position, and afterwards initiates the test, placing the articulation passively in a determined angle and asking the patient what angle his/her articulation is at.<sup>17,18</sup>

Carter et al<sup>19</sup> evaluated individuals with ACL lesions through the sense of positioning

test and compared them with the counterlateral limb. The results demonstrated that the injured limb presents significant proprioceptive deficiency.

Researchers studied the effects of ACL rupture in the acute phase (average of six weeks) through the sense of positioning test and compared them with the normal counterlateral limb. The results showed that there was no difference between the injured and the counterlateral limbs.<sup>20</sup>

In another study of individuals with ACL lesion, the counterlateral limb and a control group without lesions were compared for their sense of positioning in the isokinetic dynamometer. The results presented no significant differences between the limbs and the groups.<sup>21</sup>

Individuals with post-reconstruction of the ACL were evaluated by means of their sense of positioning test and compared with the counterlateral limb. The results showed significant proprioceptive deficiency between the normal limbs and those reconstructed ten months after surgery.<sup>17</sup>

Iwasa et al,<sup>10</sup> seeking to investigate the time necessary after the ACL reconstruction surgery to recover the proprioception of the knees in humans, made a study evaluating the sense of positioning and compared the data between the pre and post surgical periods. Significant proprioceptive deficiencies were found at three and six months after surgery, but from 9 to 24 months there was a significant improvement; at 18 months they had reached a plateau.

In a study evaluating the sense of positioning in individuals who had had ACL reconstruction surgery, results demonstrated that three months after surgery a small decrease in the proprioception had remained when compared with the pre-surgical data and with the uninjured control group; six months after reconstruction, the process of proprioception was close to normal.<sup>11</sup>

Utilizing the sense of positioning test, Bonfim et al<sup>22</sup> demonstrated that the group that had had ACL reconstruction presented a decrease in the perception of the knee position at pre-determined angles one year after surgery when compared with the control group and the counterlateral limb.

A comparative study to evaluate the sense of knee position in individuals who were submitted to ACL reconstruction and in healthy individuals did not find any differences between the two groups in this regard after 11 months.<sup>23</sup>

#### *Evaluation of kinesthesia*

Contrary to the sense of positioning test that

evaluates the position of the articulation in space, kinesthesia has been traditionally evaluated for determining the perception of articular movement. Kinesthesia is measured determining the threshold of detection of passive movement. While the patient is seated and blindfolded, a passive movement is produced and the patient, either by pressing a button or stopping the movement, gives a sign that the movement has started and, depending on the type of measurement used, the time elapsed until the detection of the movement and the degree of angular dislocation are noted.<sup>4,23</sup>

Barrack et al<sup>24</sup> evaluated the threshold of passive detection of the movement in individuals with ACL lesions and compared them with the counterlateral side and to a control group. The results showed a decrease in the capacity to detect the movement of the injured limb.

Individuals with ACL injuries were tested by their threshold of passive detection of movement and by their amplitude of movement (AOM) of flexion and extension utilized to walk. The movement detections were more sensitive in the extension than in the flexion. The patients with ACL injuries presented a lower detection of movement when compared to the counterlateral side and to the control group.<sup>25</sup>

Pap et al<sup>26</sup> evaluated the threshold of passive detection for the beginning and end of the movement in patients with ACL injuries and compared it to the counterlateral limb and to the control group. The results demonstrated that there were no significant differences in the low angular velocities; however, with the increase of angular velocity there was more difficulty in detecting the beginning and end of the movement.

The threshold of passive detection of movement in individuals with isolated ACL injuries and with associated injuries, such as meniscal, chondral, and collateral ligament lesions treated conservatively were evaluated. The results demonstrated a lower detection of movement by the patients with associated injuries, especially those with chondral and meniscal injuries.<sup>27</sup>

In another study, the threshold of passive detection of movement was evaluated in individuals with ACL injuries treated conservatively. The results showed no significant differences when compared to the control group and to the counterlateral limb.<sup>21</sup>

Fridén et al<sup>28</sup> evaluated individuals who had had ACL reconstruction and compared them with the counterlateral side and with the control group. The results showed no significant differences in the capacity to detect movement between the opposite limb and the control group.

Individuals who had had the ACL re-

construction 24 months after surgery were evaluated. The test for passive detection of movement threshold was used in conjunction with surface electromyography. The results demonstrated that there were no differences in the capacity to detect movement between the limb that had suffered ACL reconstruction when compared to the control group and to the contralateral limb.<sup>29,30</sup>

Bonfim et al<sup>22</sup> demonstrated, through the test for passive detection of movement threshold that, one year after ACL reconstruction, the limb still presented a decrease in the capacity to detect movement when compared to the contralateral limb and to the control group.

Beynon et al<sup>30</sup> compared the precision, the reproduction of seven techniques for the sense of positioning test, and one technique for kinesthesia in normal individuals, and demonstrated that the kinesthesia was the most reproducible and precise technique.

### Evaluation of the Postural Balance

Postural balance control utilizes complex processes involving sensory and motor components. Keeping one's balance requires sensory detection of the body movement, integrating sensory-motor information with the CNS, and the proper execution of the musculoskeletal responses. The position of the body in relation to space is controlled by a combination of visual, vestibular, and somatosensory mechanisms. Balanced movement involves control and coordination via the chain of kinesthetic command.<sup>4,31-33</sup> All these processes are vital to the process of movement.<sup>4,31-33</sup>

In recent years, new techniques have appeared to evaluate proprioception which utilizes neuromuscular mechanisms that affect the dynamic stability of the articulation and the unilateral postural stability. These mechanisms are responsible for the muscular responses that maintain the dynamic stability of the joints and postural stability.<sup>18,30,34,35</sup>

Somatosensory, functional, visual, and vestibular evaluations can be made by computerized measurements of how well one maintains postural stability. These systems evaluate the neuromuscular control and quantify the ability of the individual to maintain quasi-static or dynamic postural stability on a stable and/or unstable surface.<sup>36-38</sup>

Riemann & Guskiewicz<sup>35</sup> used the term "postural balance" as the state of dynamic balance of the forces and moments of the body's action. Beard & Refshauge<sup>39</sup> defined balance as maintaining a position, moving voluntarily, and reacting to a disturbance.

Riemann & Guskiewicz<sup>35</sup> and Voight & Blackburn<sup>4</sup> defined the limit of stability via the maximum anterior-posterior or medial-lateral angles that maintain the vertical projection of the center of gravity within a support base. When the center of gravity exceeds these limits of stability, the individual will fall unless effective postural adjustments are made with the use of his/her upper limbs and trunk. Each one of these strategies to maintain balance has reflexive, automatic, and voluntary components that interact to make the response more compatible with the provocation.

The evaluation of patients with complete rupture of the ACL either with or without associated injuries in individuals without injuries was made to investigate the effects of two different treatment programs and the function of the lower extremity after an acute ACL lesion. One group received the neuromuscular training with a physical therapist weekly for a period of six to eight months while another group received self-monitored training and was guided to perform exercises in their residences for a year. The patients were evaluated at six weeks, and 3, 12, and 36 months utilizing stabilometry on a unipodal support and the horizontal jump test. The results showed that the two types of treatment showed high amplitude of movement at the center of pressure (COP) in both limbs. All the patients used wider balance movements to diminish the speed of movement as an adaptive neuromuscular mechanism. These findings persisted 36 months after the injury. Their functional performance, as measured by the unipodal jump was recovered in the supervised neuromuscular training group, while the self-monitored training group showed poorer performance.<sup>40</sup>

To evaluate the postural control in the sagittal and frontal planes in patients who had ACL reconstruction, 25 patients were evaluated 36 months after surgery and compared with the contralateral limb and with a control group without lesions. The antero-posterior dislocation of the tibia was evaluated with the KT1000 arthrometer (*EquiTest Neurocom*). The authors concluded that the postural balance in both groups was similar, except for the reaction and latency times in the sagittal plane, where the group that had had reconstruction were slower to detect the movement. The ACL was looser in the group that had suffered ACL reconstruction when compared with the contralateral side and with the control group. There was, however, no correlation with the posturographic variables.<sup>41</sup>

Bonfim et al<sup>22</sup> evaluated ten patients who had had ACL reconstruction more than a year

earlier and compared them with the contralateral limb and with a control group. The objective of the study was to evaluate any sensory deficit and its effects on proprioception and on motor function. The following were evaluated: 1) sense of positioning; 2) kinesthesia; 3) latency of the ischiotibial muscles; and 4) capacity to maintain posture in the vertical position. The results have shown that the reconstruction group presented: a decrease in the perception of the knee position, a high threshold for passive detection of the knee movement, and a long latency of the femoral biceps and the semitendinous and semimembranous muscles when compared with the control group and with the contralateral limb. On the strength platform in the bipodal position the postural balance was similar for both groups. In the unipodal position, both groups increased their average of balance amplitude, especially in the operated limb, with values higher at the medial/lateral center of pressure (COP<sub>ML</sub>) and at the anterior/posterior center of pressure (COP<sub>AP</sub>). The authors concluded that the individuals who had suffered ACL reconstruction showed poorer sensory-motor performance. The results indicate that the ACL is an important provider of proprioceptive information and that the mechanoreceptor injuries lead to a loss of motor function.

Tookuni et al<sup>5</sup> evaluated the postural control of patients with a unilateral ACL lesion and compared it with the contralateral limb and with a control group, using parameters from the FSCAN MAT<sup>®</sup> center of pressure. The results demonstrated that an ACL rupture compromises the balance in both limbs, however, this is more evident in the injured limb.

Alonso<sup>42</sup> compared the balance in sedentary individuals and football athletes with and without ACL reconstruction by moving the center of gravity, and evaluated the performance of the equipment and its applicability to the evaluation and treatment of patients with ligament lesions of the knee, utilizing the Biodex Balance System<sup>®</sup> (BBS) in two stability indices. The results showed the COG movement when the knees are evaluated: in both the operated (Operated Athletes) and sedentary groups it was less than the movement of uninjured athletes' knees. The movement of the center of gravity measured by the BBS equipment cannot be considered a trustworthy measurement of postural balance.

## DISCUSSION

The role of ligaments, as the structure that contains sensorial organs, seems to have great im-

portance in the functional performance of the individual. To provide the information of “risk” of articular destabilization is as important as the passive mechanical action of the ligament.<sup>5,9,14,15</sup>

According to Alonso et al<sup>43</sup> the proprioceptive system allows the body to maintain its static as well as its dynamic stability. This system must be whole to prevent injuries and must be rehabilitated afterwards, because the presence of an injury provokes a decrease in the excitation of the neuro-motor reflex, which can result in a decrease of the proprioceptive input to the CNS and/or an increase in the inhibitory activation of the interneurons within the spinal column. If all these factors are not restructured they can progress towards the degeneration of the joint and a continuing deficit in the articular dynamics, balance, and coordination.

There are four types of mechanoreceptors in the ACL with different mechanical thresholds, afferent actions, adaptations, and rest.<sup>9-11</sup> There are mechano-receptors in the grafts that substitute native ACLs.<sup>12,15</sup>

The instability caused by an ACL injury (anterior drawer and looseness) and the degenerative alterations (cartilaginous and meniscal) are provoked by the abnormal kinematics of the knee and by the decrease in mechanoreceptor action. Knee kinematics depends on mechanical stability and neuro-motor control.<sup>11</sup>

The loss of the proprioceptive information due to the ACL injury contributes to the aggravation of the instability because of the decrease of the kinesthetic sensation and the absence of stimuli for the muscle contraction reflex.<sup>10,11</sup>

Reconstruction techniques have been refined to reach better stabilization of the joint, but even so the post-surgery recovery is not satisfactory. The functional deficiency of the knee after the ACL reconstruction may be caused by the lack of neuro-motor control which can occur due to the substitution of the ACL by a graft and by the loss of the original mechano-receptors.<sup>22</sup>

The criteria to return to sports activity are the absence of pain, normal articular amplitude, the recovery of muscular function and cardiovascular capacity, and the recovery of neuromotor control or proprioception.<sup>6</sup>

The lack of precise evaluation techniques that involve the multiple aspects of proprioception and that could objectively quantify the improvement and evolution of the patient through rehabilitation and his/her conditions to return to daily and sports activities is one of the great difficulties in developing and improving these programs, for the evaluations are subjective.<sup>6,43</sup>

The quantification of proprioceptive deficits is important in evaluating joint injuries, in deciding on the treatments, the type of surgical reconstruction, and the rehabilitation efficacy.<sup>38</sup>

Proprioception cannot be measured, but studied through motor actions: distribute the weight on the lower limbs, change the posture, and stabilize the corporeal segments.<sup>6</sup>

There is histological evidence that demonstrates the existence of mechano-receptors in the human ACL<sup>2,7-11</sup> as well as in the graft tissue used to substitute the native ACL.<sup>12</sup>

Neurophysiologic tests provide us with the sensory thresholds and the velocity of nervous conduction,<sup>13,14,16</sup> but not with their relationship with the stabilizing motor action.

Clinical sense of positioning and kinaesthesia tests evaluate the muscular, articular, and neurological responses to the stimuli.<sup>5,10,11,17,19-22,24,25,28,29</sup>

The results for the sense of positioning evaluation are contradictory, Carter et al<sup>19</sup> and Mir et al<sup>23</sup> showed no differences between the injured and the counterlateral sides, however, other studies showed that the lower limbs behaved differently in these functional tests.<sup>20,21</sup>

Iwasa et al<sup>10</sup> and Fremerey et al<sup>11</sup> studied the sense of positioning to evaluate the recovery time of proprioception after ACL reconstruction. In the first study, they observed the proprioceptive deficiency until the sixth month, and the recovery occurred from nine to 24 months after surgery; and in the second study, normal proprioception was achieved in the sixth month.

Kinaesthesia, characterized by its capacity to detect a movement performed, diminished in the knees with ACL injury, when compared with the counterlateral side and with the control groups.<sup>5,21,24-27</sup> Bonfim et al<sup>22</sup> demonstrated the decrease in kinaesthesia one year after surgery. However, Fridén et al<sup>28</sup> and Risberg et al<sup>29</sup> demonstrated that there were no differences in the capacity to detect movement when compared with the counterlateral side and with the control group.

We agree with Beynon et al<sup>30</sup> who, comparing the precision and the reproduction of the sense of positioning techniques with kinaesthesia, demonstrated that kinaesthesia was the most precise and reproducible technique. The opposing results also collaborated in their mistrust of the measurement systems utilized, which are indirect and therefore fallible.

The main criticisms of these types of tests are due to the human ACL accommodating most receptors close to the osseous adhesions of the tibia and femur, while few receptors

are located within the dense connective tissue of the ACL.<sup>7</sup> Studies have demonstrated that the thresholds of detection of movement were better in the initial and final positions of flexion and extension, and worse in the medial positions, leading one to believe that the joint receptors do not contribute to the sense of position and movement, for they are not capable of informing the CNS about the joint's angle in the total course of the movement.<sup>9,25,28</sup>

The limitations to the clinical tests mentioned above are that none of them provides evaluation of the unconscious arch reflex necessary for dynamic stability of the joint, and do not reproduce any function employed in habitual activities.<sup>5</sup>

The efferent reflex responses, necessary for the regulation of tonus and of muscular activities, which can be evaluated through balance, were little used by individuals who suffered ACL reconstruction.<sup>42</sup>

The study of dynamic instead of static balance is important for finding out any balance impairment, postural instability, and the efficiency of rehabilitation techniques.<sup>43-45</sup>

The researchers' motives for evaluating balance are:

Those tests that simulate functional activities and the measurements of balance are the most appropriate means to evaluate the combination of the peripheral, vestibular, and visual contributions to neuromuscular control.<sup>5,43</sup>

1<sup>st</sup> - The data on balance can be used to plan specific exercises: balance control and reduction of falls.<sup>43,44</sup>

2<sup>nd</sup> - The evaluation of functions and movements facilitates prescriptions and improves results.<sup>43,46</sup>

3<sup>rd</sup> - The sensory and motor changes in individuals with ACL lesions are better studied, but their evolution after reconstruction is little described, possibly due to the difficulty in making a good evaluation.<sup>22</sup>

Birmingham et al,<sup>47</sup> Henriksson et al,<sup>41</sup> and Bonfim et al<sup>22</sup> studied proprioception through postural balance after ACL reconstruction. The different results found probably occurred due to the selection of patients and to the different equipment utilized in the measurement.

Even if proprioception is important in the final result, its evaluation is still difficult. The ideal method must have high sensitivity and specificity, in addition to good reproducibility and precision.

There is a need for equipment that can measure proprioception. Some study centers have developed their own methods and adapted equipment to perform tests of peripheral afference through the sense of positioning and

kinesthesia tests.

Postural balance has been related to proprioception, and the diagnostic systems employed evaluate the proprioceptive neuromuscular mechanisms of the quasi-static and dynamic joint stability and unilateral postural stability. These mechanisms are responsible for initiating the muscular responses that maintain joint and postural stability.<sup>18,30,31,34,35</sup>

The authors were unanimous in affirming that at higher levels of instability the amplitude of movement is greater. These results were found in all the studies, for there is a need for larger postural adjustments to maintain balance.<sup>40,42,48</sup>

In the studies of Bonfim et al<sup>22</sup> and Henriksson et al<sup>41</sup> the operated limb showed poorer performance when evaluated on the strength platform. Both genders differed in the Ochi et al<sup>16</sup> data, which used the somatosensory evoked potential and the sense of positioning. The data from Henriksson et al,<sup>41</sup> which used the balance evaluation through the *EquiTest Neurocom* equipment, did not show any differences between the groups; and the data from Alonso et al<sup>42</sup> showed better balance than in the counterlateral limb and the control groups (sedentary and recreational football players without surgery) in the *Biodex Balance System* equipment. Surgery continues to affect the joint's functional performance, even after the period considered sufficient for the complete reinnervation of the graft.<sup>10,22,28,29,42,49</sup>

In addition to ligament injuries and surgical processes, the proprioceptive and balance maintenance systems can be compromised by anthropometrical factors, such as biological aging, use of medication, neurological and systemic traumato-orthopedic diseases, lack of physical conditioning, sedentary lifestyle, and specific trainings (e.g: high performance sports), aside from intrinsic factors such as type of shoes, insoles, and types of pavement.<sup>43,31,50</sup>

## CONCLUSION

There are different techniques for evaluating the ACL proprioception: anatomic morphological studies; neurophysiologic evaluation; and clinical evaluation which is divided into three sub-types: a) sense of static position; b) sense of velocity of movement, also called kinesthesia or dynamic proprioception; c) postural balance.

Even though proprioception is important for the final result, its evaluation is still difficult. The ideal method must have high sensitivity and specificity, in addition to good reproducibility and precision.

There is no consensus in relation to the best technique to evaluate proprioception. The clinical evaluations of sense of positioning and kinesthesia present contradictory results. Despite balance evaluation being the most modern technique and utilized in big research centers, it is not possible to isolate the proprioceptive system from other systems: visual and vestibular.

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