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Original Article

Neuromuscular efficiency of the vastus lateralis and biceps femoris muscles in individuals with anterior cruciate ligament injuries☆

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ABSTRACT

Objective: To analyze strength and integrated electromyography (IEMG) data in order to determine the neuromuscular efficiency (NME) of the vastus lateralis (VL) and biceps femoris (BF) muscles in patients with anterior cruciate ligament (ACL) injuries, during the preoperative and postoperative periods; and to compare the injured limb at these two times, using the non-operated limb as a control.

Methods: EMG data and BF and VL strength data were collected during three maximum isometric contractions in knee flexion and extension movements. The assessment protocol was applied before the operation and two months after the operation, and the NME of the BF and VL muscles was obtained.

Results: There was no difference in the NME of the VL muscle from before to after the operation. On the other hand, the NME of the BF in the non-operated limb was found to have increased, two months after the surgery.

Conclusions: The NME provides a good estimate of muscle function because it is directly related to muscle strength and capacity for activation. However, the results indicated that two months after the ACL reconstruction procedure, at the time when loading in the open kinetic chain within rehabilitation protocols is usually started, the neuromuscular efficiency of the VL and BF had still not been reestablished.

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Eficiência neuromuscular dos músculos vasto lateral e bíceps femoral em indivíduos com lesão de ligamento cruzado anterior

Palavras chave:
Ligamento cruzado anterior
Fadiga muscular
Biomecânica

RESUMO

Objetivo: Analisar a força e a integral da eletromiografia (IEMG) para obter a eficiência neuromuscular (ENM) dos músculos vasto lateral (VL) e bíceps femoral (BF) em pacientes com lesão de ligamento cruzado anterior (LCA) nas fases pré-operatória e pós-operatória, comparar o membro lesionado nos dois momentos e usar o membro não cirúrgico como controle.

Métodos: Foi feita a coleta de dados da EMG e da força de BF e VL durante três contrações isométricas máximas nos movimentos de flexão e extensão do joelho. O protocolo de avaliação foi aplicado nos momentos pré e pós-operatório (dois meses após a cirurgia) e obteve-se a ENM dos músculos VL e BF.

Resultados: Não foi encontrada diferença na ENM do músculo VL entre os momentos pré e pós-cirúrgico. Por outro lado, houve aumento da ENM do BF no membro não cirúrgico dois meses após a cirurgia.

Conclusões: A ENM fornece boa estimativa da função muscular por estar diretamente relacionada à força e à capacidade de ativação dos músculos. Entretanto, os resultados apontam que dois meses após o procedimento de reconstrução do LCA, quando normalmente são iniciadas cargas em cadeia cinética aberta nos protocolos de reabilitação, a eficiência neuromuscular do VL e BF ainda não está restabelecida.

Introduction

The anterior cruciate ligament (ACL) is one of the most important structures for stabilizing the knee joint and is one of the most frequently injured ligaments during sports activities.[1] ACL injury causes great incapacity for the limb and also some long-term problems such as osteoarthritis.[2] Even after surgical reconstruction and rehabilitation, significant deficits may remain, for example in relation to the knee extensor and flexor muscle strength.[3]

Muscle weakness subsequent to ACL injury generates imbalances between agonist and antagonist muscles during knee flexion and extension movements. These imbalances often cause difficulty in rehabilitation for individuals undergoing ACL reconstruction procedures. The persistent asymmetry in the torque ratio between knee extensors and flexors that is observed in this situation has shown that it is of great importance to attempt to identify and reverse the causes of persistent muscle weakness subsequent to ACL injury and reconstruction.[4]

Several factors need to be taken into consideration in relation to recovery of knee flexion and extension strength subsequent to ACL injury. The most important of these factors relate to muscle architecture and the integrity of the origin and insertion of the muscles, along with the efficacy of the neural activity that arrives at the motor plate.[5,6]

Neural factors relate particularly to the efficacy of activation of the motor units during muscle contraction. It is known that the greater the number of motor units recruited through a stimulus is, the greater the resultant muscle generated will also be.[7] Biomechanically, neuromuscular efficiency is calculated through the relationship between the amount of neural stimulus and the capacity to generate force that a muscle has.[8]

Thus, the relationship between the muscle force moment and the integrated electromyographic signal (IEMG), which is considered to be the best variable for describing the intensity of the neuromuscular effect during sustained muscle activity, has been used to estimate neuromuscular efficiency (NME).[9–11] This can be interpreted as an individual's capacity to generate a force moment in relation to his level of muscle activation.[8] Nonetheless, studies involving muscle architecture and electromyographic analysis have demonstrated that results from the vastus lateralis (VL) and biceps femoris (BF) muscles are easier to measure and, especially, more reproducible in relation to their agonists,[12,13] which makes these muscles appropriate representatives of the behavior of the knee extensor and flexor muscle groups, respectively.

The return to normal or to sports activities after ACL reconstruction usually takes place after the sixth postoperative month.[14] However, patients start to bear weight in open kinetic chain exercises and to subject the ACL to greater tension generally after the sixth postoperative week in accelerated protocols and after the twelfth postoperative week in conservative protocols.[14,15] Despite this, not much data exists regarding the state of neuromuscular efficiency at this stage of the rehabilitation.

Therefore, this study sought to analyze muscle force and IEMG in order to determine the neuromuscular efficiency of the vastus lateralis (VL) and biceps femoris (BF) muscles in patients with ACL injuries at two times: (1) just before the operation; and (2) during the postoperative phase, two months after a procedure to surgically reconstruct the ACL.