



## CASE REPORT

# Torque and Electrical Activation of the Rectus Femoris Muscle at Distinct Joint Angles: A Case Study

Anelize CINI , Francesca SONDA , Isabel de Almeida PAZ , Ana Paula Janner ZANARDI  and Grazielle Martins GELAIN\* 



Department of Exercise Research Laboratory (LAPEX), Federal University of the State of Rio Grande do Sul, Brazil

\*Corresponding author: Grazielle Gelain, Department of Exercise Research Laboratory (LAPEX) of the Federal University of the State of Rio Grande do Sul, Brazil

## Abstract

The angulation of knee and hip joints affect isometric contractions of Rectus Femoris muscle (RF) during knee extension. Literature states that torque-angle relationship depends on muscle length and neuromuscular electrical activation. However, it is still not clear whether the maximum neuromuscular activation changes concomitantly with the change in the joint angles considering the presence of muscle shortening. We present a case study in which we analyzed changes in neuromuscular activation and peak torque of the RF at distinct joint angles of hip and knee.

## Keywords

Electromyography, Quadriceps, Torque, Torque-angle relationship

## Introduction

The search for evidence in the theories related to mechanisms of muscle contraction has led to the emergence of the torque-angle relationship [1]. Some studies report the influence of neural activation in this relationship. However, there is still no consensus among the authors whether neural activation remains constant regardless of the muscle length [2], or whether it increases [3-5] or decreases [6] with diminution of muscle length.

Some researchers have found that, during isometric contractions of RF at 70° of knee flexion, the ability to produce force also depends on the hip joint angle, which affects RF length too [7,8]. For instance, knee extension torque is greater at 80° of hip flexion than it would be at 0° [9]. However, one study found greater

torque and EMG activity of Maximal Voluntary Isometric Contraction (MVIC) close to 90° of hip flexion [10] while another study also found the highest activations between 60° and 80°, followed by 85° and 90° [6]. However, they did not correlate these results considering the muscle length of antagonistic musculature.

In addition, the change in hip and knee joint angles not only alters neural activation and length of the RF, but also of the hamstrings. For instance, when the hip joint angle is maintained at 80° during MVIC performed in different angles of knee extension, hamstring co-activation is present in all angulations [11,12].

Literature states that torque-angle relationship depends on both muscle length and neuromuscular electrical activation. However, it is still not clear whether the maximum neuromuscular activation changes concomitantly with the change in the joint angles. Thus, the aim of this study is to assess neuromuscular activation and peak torque of RF at distinct hip and knee joint angles.

## Case Report

Our subject was a 23-years-old female, 73 kg, 1.57 m, body mass index of 30.43, physically active, without known impairment of the musculoskeletal system affecting the spine or the lower extremities. She underwent flexibility assessment of hamstrings, soleus and gastrocnemius muscles of her right lower limb (dominant limb), which was followed by the assessment of extensor torque peak and neuromuscular electrical activation through surface electromyography.



**Citation:** CINI A, SONDA F, de Almeida PAZ I, ZANARDI APJ, GELAIN GM (2020) Torque and Electrical Activation of the Rectus Femoris Muscle at Distinct Joint Angles: A Case Study. Int J Sports Exerc Med 6:159. doi.org/10.23937/2469-5718/1510159

**Accepted:** February 19, 2020; **Published:** February 21, 2020

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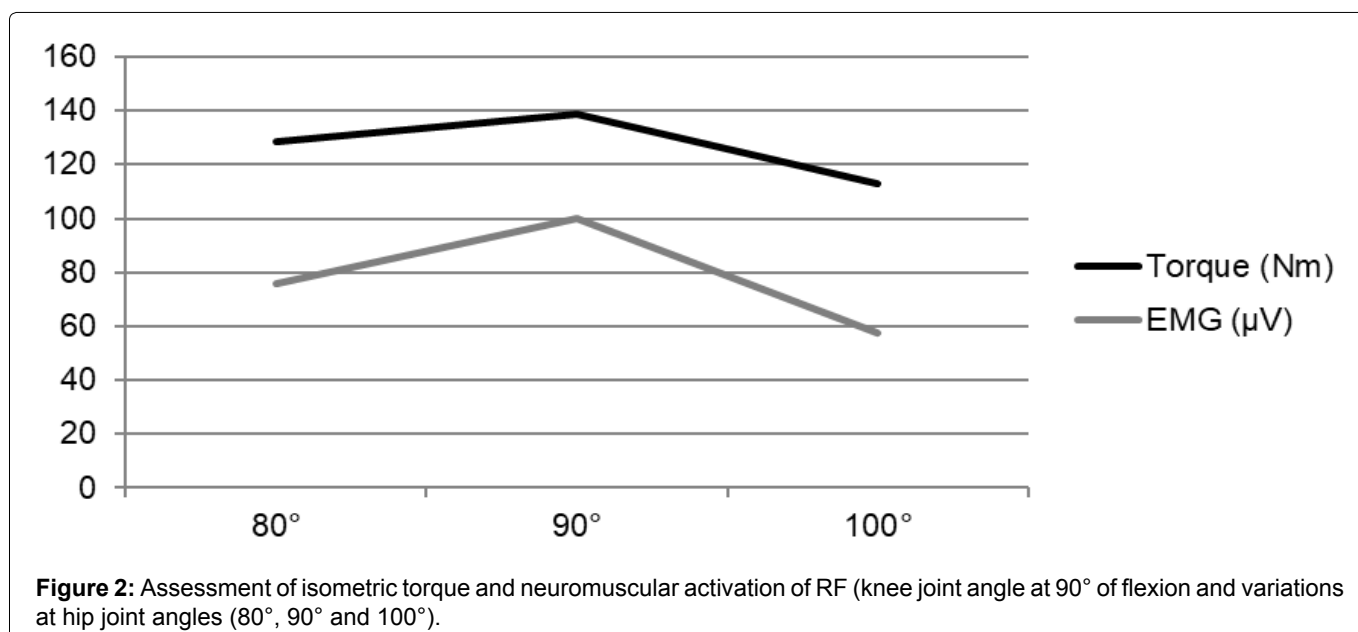
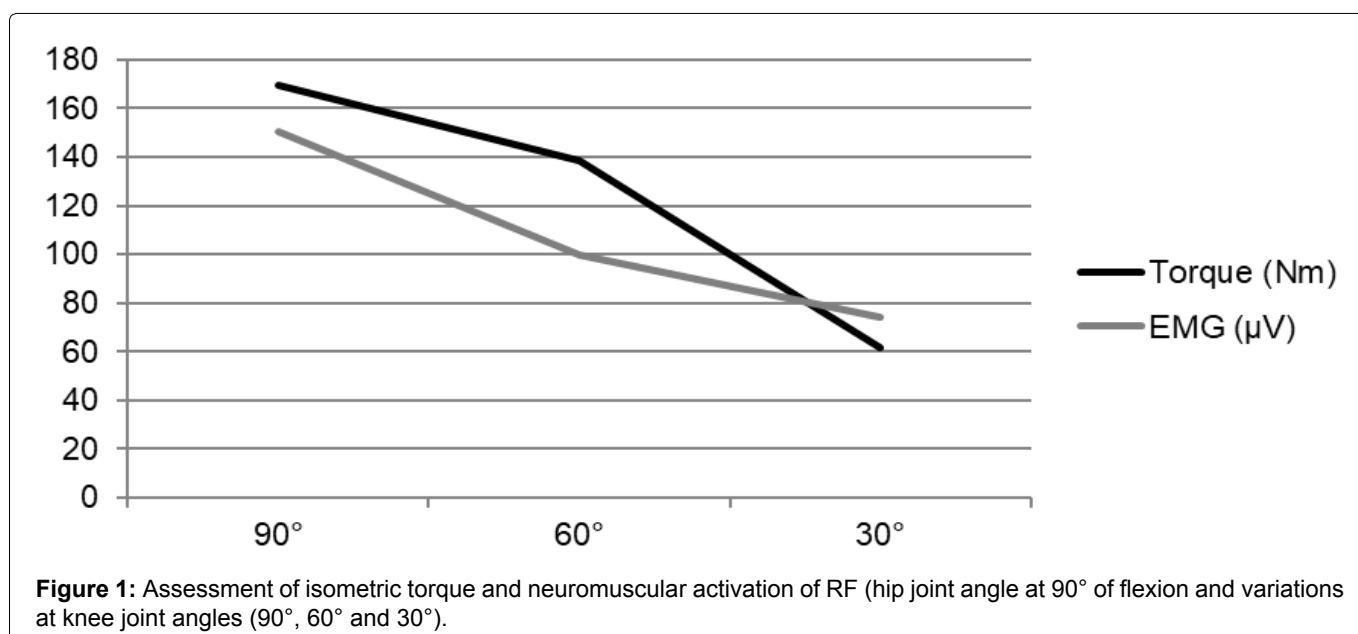
A universal plastic goniometer was used to evaluate ROM of joints. Knee extension was assessed in the supine position. The hip and knee were flexed at 90° keeping the ankle relaxed. From this position, her knee was passively and slowly extended by examiner 1, while examiner 2 ensured that no pelvic compensations occurred. The subject was oriented to communicate to the examiner the exact moment she felt tension in the hamstrings. That moment was considered the final position of the test, which resulted in 34° of knee flexion, indicating decreased muscle length. Muscle shortening is present if the individual cannot fully extend the knee (0°) while maintaining the hip at 90° of flexion [13,14].

To evaluate ROM of ankle dorsiflexion, the subject was positioned sitting forward in a backless chair with knees bent and feet pulled back toward chair enough to raise the heels slightly from the floor. A pressure on the thighs forced the heels towards the ground. The test showed 20° of ankle dorsiflexion (normal muscle

length). Angles less than 20° are indicative of shortening of soleus and gastrocnemius [15]. The subject remained seated for neuromuscular activation and force tests.

The assessment of neuromuscular activation was performed concurrently with maximal knee extension tests. Isometric contractions of extensors muscle of the right knee were performed on an isokinetic dynamometer (Biodex System 3, Biodex Medical System, USA). An electromyograph (Miotool 400, Miotec, Porto Alegre, Brazil), with 2 kHz frequency and 8 channels, was used to assess the electrical activity of the RF. We followed the recommendations of SENIAM (Surface Electromyography for the Non-Invasive Assessment of Muscles).

Primary, keeping the hip joint angle at 90° of flexion, the patient performed a warm-up protocol on the dynamometer, which consisted of 10 repetitions of knee flexion - extension at a speed of 90°/s<sup>-1</sup> applying submaximal force. Subsequently, an isometric torque evaluation was performed in three different knee joint



angles (30°, 60° and 90°), 0 degree being full knee extension. Three 5-second MVICs, with two-minute rest period in between, were performed at each knee joint angle. A second sequence of trials was performed keeping the knee at 60° of flexion while hip joint angle was fixed at three different angles: 80° (pelvic anteversion), 90° (neutral pelvis) and 100° (pelvic retroversion). Again, three 5-second MVICs, with two-minute rest period in between, were performed at each knee joint angle.

Electromyographic signals were analyzed using Miotec Suite software (fifth-order Butterworth bandpass filter, cutoff frequencies between 20 and 500 Hz). At 90° of hip flexion, electromyographic signals and torque values showed the greatest torque and activation of the RF occurred with the knee at a 90° of flexion (Figure 1).

When the knee was fixed at 60°, the greatest activation and torque production of the RF was observed at the 90° of hip flexion (Figure 2).

## Discussion

Several authors use angles between 60° and 75° of knee flexion to evaluate the maximal force production of knee extensors and flexors, but the hip angle for the best torque-angle relationship is 80° [8,16-18]. However, for this subject, the optimal angle for neuromuscular activation of the RF and quadriceps torque was 90° of flexion of hip and knee joint, corroborating with the findings of two other studies [19,20].

Agonist (quadriceps) activation and antagonist (hamstring) co-activation differ in knee extension angles during MVIC and contribute to the torque-angle relationship. The neuromuscular activation of the quadriceps is decreased when it is more stretched [12].

Compared to the vast muscles, one study reported the RF was more active at 90° and 120° angles of knee extension in open kinetic chain than in closed chain exercises [21]. This may have influenced the result obtained in this case once the exercise performed by the subject was in open kinetic chain.

We speculate that at 100° of hip flexion, the RF is activated in order to maintain body posture, what reduces the muscle capacity to produce torque in the extension of the knee. This finding may encourage the investigation of neuromuscular activation of hamstrings and other adjacent muscles considering antagonistic shortening.

## Conclusion

The peak torque and the highest neuromuscular activation of RF occurred at 90° of flexion of knee and hip joints. On the other hand, the lowest peak torque and neuromuscular activation occurred at 30° of knee extension and 90° of hip flexion. The muscle adaptation strategy varies for each individual and we speculate about the influence of the co-activation of the antagonistic musculature in the presence of muscular shortening.

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