Journal of Yoga & Physical Therapy
Kelencz et al., J Yoga Phys Ther 2013, 3:2
DOI: 10.4172/2157-7595.1000134

Research Article | Open Access

Behavior of Electromyographic Signal in Different Angles during Knee Flexion

Carlos A Kelencz*[1,2], Priscilla A de Sousa[3], Wellington B Vieira[3], Flávia F Manfredi de Freitas[3], Lucas Nery[3], Regina Carla P Silva, Luciana Chiavegato[3] and Cesar F Amorim[3]

[1]*Centro Universitário Ítalo Brasileiro–São Paulo, Brazil*
[2]*Universidade Estácio de Sá–São Paulo, Brazil*
[3]*Universidade Cidade de São Paulo–São Paulo, Brazil*

Abstract

The present work proposes a biomechanics and performance analysis of an electromyography (EMG) signal during the squat exercise. More specifically the tests were made considering different angles of knee flexion, 90° and 130°. The results showed considerable differences between right and left side when power and muscular performance were compared. This result leads us to believe that weight training is not enough to achieve muscle balance. It is suggested that to improve results and performance on both sides a neurological adaptation is necessary. In addition, it was possible to determine with precision the moment when the muscle fibers are more recruited during the execution of the squat in both angles.

Keywords: Biomechanics; Exercise; Motion analysis

Introduction

This exercise can be considered one of the most complete in weight training, because it involves a high number of joints and muscles during its execution. It is an excellent way to fortify the muscles of the thigh, hip and innumerable other muscles In general, athletes that execute the exercise present innumerable restrictions about the correct angles (position) to achieve better results during its execution. For example, short amplitudes during the exercises can recruit a small number of motor units but this is not a general consensus, justifying a deeper study around this exercise.

The amplitude limitation of knee flexion, besides reducing the efficiency of the exercise, can diminish the functionality of everyday movements, decreasing the life quality of the athlete. Moreover, studies that characterize the efficiency of the exercise in different angles and overloads, and the correct angle of activation of the muscles involved in the exercise are not common. The use of overloads as a training component is responsible for improving the strength or muscle power. More than this, it also causes modifications in the skeleton structure; the bones are fortified with the exercises.

The mechanical requests represent a formative stimulation which modifies the composition and general structure of the bone in specific ways. They expose it to an increase of mineralization, a thicker cortical layer and formation of a more adapted and functional trabecular bone, positioned in accordance to the corresponding to the strengths lines according to request. Opposite to what is observed in the striate musculature exaggerated and permanent request of the bone does not lead to a significant increase capacity, on the contrary, in some cases there can be pathological break. These factors become the study of this important movement to understand the influences of loads and different amplitude in a general physiological context [1].

The present work is focused on a quantitative analysis of the signal of surface electromyography of the activity of the straight muscles of the thigh, femoral biceps long head and spine erectors, in two distinct situations, knee flexion in angles of 90° and 130°.

Methods

For the experiment ten (10) female practitioners of weight training volunteers average ages 21.5 ± 2 years, with no muscle/skin illnesses history were selected. They were college students with similar anthropometrics. Before the experiment they were informed of the procedures during the collecting (registers) of the EMG signals and signed a consent term [2-6]. The Committee of Ethics in Research with Human beings approved the research under nº L130/2005/CEP. The volunteers have the following characteristics: females; between the ages of 19 and 24 years; good health conditions; weight-training practitioners for at least two years without a history of skin or muscle illnesses; capable of producing knee flexion with precision; capable of understanding the nature and objective of the study, also the risks; capable of cooperating with the researcher and according to the protocol. That is confirmed by the signature of the term of free and clarified consent. The exclusion criteria were: having any articulation limitation; not practicing weight-training or being practitioners for less than 2 years; not being able to squat [7]. The first position is defined by the body in standing position, which occurs at the beginning of the exercise. The angle was drawn on the legs of the athlete to evidence the measure. The signal was obtained using a 16 channel module (EMG System do Brazil LTDA), consisting of a signal conditioner with a band pass, range with cut-off frequencies at 20-500 Hz, with an amplified gain of 1000 and a common mode rejection ratio>120 dB. The goniometer electronic was used in one of the channel synchronized with the electromyography to recognize the movement during muscle contraction. All data were processed using specific software for acquisition and analysis (EMGLab v2.0), a converting plate for A/D 16 bits signal converting analogical to digital with a sampling frequency of anti-aliasing 2.0 KHz for each channel [8,9].

For all data an active bipolar superficial electrode was used.

***Corresponding author:** Carlos A Kelencz, Centro Universitário Ítalo Brasileiro–São Paulo, Brazil,E-mail: carlos.ak@ig.com.br

Received June 19, 2013; **Accepted** July 19, 2013; **Published** July 22, 2013

Citation: Kelencz CA, de Sousa PA, Vieira WB, Manfredi de Freitas FF, Nery L, et al. (2013) Behavior of Electromyographic Signal in Different Angles during Knee Flexion. J Yoga Phys Ther 3: 134. doi:10.4172/2157-7595.1000134

Citation: Kelencz CA, de Sousa PA, Vieira WB, Manfredi de Freitas FF, Nery L, et al. (2013) Behavior of Electromyographic Signal in Different Angles during Knee Flexion. J Yoga Phys Ther 3: 134. doi:10.4172/2157-7595.1000134

Electrodes were fastened to the skin, previously cleaned with alcohol and guided by bone prominence and the route of the muscle fibers. The electrode intended to capture electromyography signal from the biceps femoral long head was placed at the midpoint of a limb between the fibula head and the ischial tuberosity. In the case of the straight femoral muscle, the electrode was placed on the muscular body, on the anterior aspect of the thigh, midway between the superior border of the patella and the anterior superior iliac spine. The electrodes for the spine erector were located 10 cm above of the iliac joint sacrum and 10 cm from the sides. The electrodes were fixed using a conductive gel with adhesive tape at the mid line of the muscle belly with their detection surface perpendicular to the muscle fibers [10,11]. During the analysis and mathematical processing, the data were normalized by Maximum Voluntary Contraction (MVC). In all procedures the capture and analysis of EMG signals follow the recommendation of the International Society Electrophysiology Kinesiology (ISEK) [11,12].

Results

The study of the exercise was done in two phases: descending (eccentric phase) and ascent (concentrically phase), for the movement with 90° as well as the 130° movement of knee flexions. The goniometer electronic in one of the canals of the electromyography was previously calibrated and synchronized with the electromyography signal used. The results were processed using the time and amplitude simultaneously providing a better precision of when the frequency peak occurs during the movement execution. (Tables 1 and 2) show the statistics for the movement in 90° ascent and descending phases, both sides, straight muscle. In (Tables 3 and 4) the values for ascent and descending phases for 130° are presented.

For power test and muscular activities the movements were compared in two distinct angles for the left sides, initially. The first result is showed in Figure 1 for the descending exercise under 90° into the straight muscle of the thigh, left side.

Side	Mean µV	Sd
Left	259.34	86.31
Right	138.82	86.48

Table 1: Table with values of ascent phase for the straight muscle using Friedman ANOVA and Kendall Coefficient of Concordance. Coefficient of concordance=0.60368, average rank=0.55414, p<0.00005 for 90°.

Side	Mean µV	Sd
Left	258.81	134.65
Right	147.03	96.00

Table 2: Table with values of descending phase for the straight muscle using Friedman ANOVA and Kendall Coefficient of Concordance. Coefficient of concordance = 0.59901, average rank=0.54173, p<0.00022 for 90°.

Side	Mean µV	Sd
Left	265.57	112.09
Right	131.09	86.46

Table 3: Table with values of ascent phase for the straight muscle using Friedman ANOVA and Kendall Coefficient of concordance. Coefficient of concordance = 0.50893, average rank = 0.43878, p<0.00107for 130°.

Side	Mean µV	S d
Left	268.37	119.30
Right	119.43	61.35

Table 4: Table with values of descending phase for the straight muscle using Friedman ANOVA and Kendall Coefficient of Concordance. Coefficient of concordance=0.38127, average rank=0.29288, p<0.00935 for 130°.

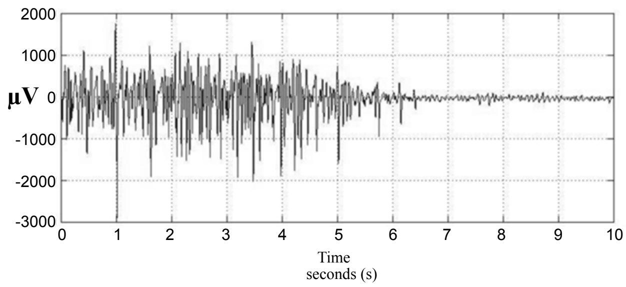

Figure 1: Electromyography signal and its transformed for the ascent phase obtained from the straight muscle of the thigh at 130°, left side.

The time scale is calibrated in accordance to the sample rate of the signal. It is possible to observe the moment when muscular contraction becomes more intense. The higher muscle activity is initiated under an angle of ± 65°, which correspond to the time value around 0.65, as shown in Figure 2. This observation is an important result for the proposed data analysis. It is possible to notice clearly a significant muscular activity during a short interval of time. Figure 3 shows the representation of the muscular activity averages during the movement period. An analysis of the left side and its processing through amplitude of EMG signal for 90° was made as a comparison criterion, (Figure 2). This angle clearly presents a lower muscular activity when compared with the right side at 130°.

This can be observed through the delay and decrease of the intensity in (Figure 2), which shows the average of power involved in the exercise, left side.

Discussion

This study leads us to conclude that the squat at 90° and 130°, presented significant activity for the muscles: straight thigh, femoral biceps long head and erectors of the spine, both in the concentrical phase and the eccentric phase. The biggest activity was registered in the concentric phase of the movement for the two angles of knee flexion where the straight muscle of the thigh was most active [13,14].

All volunteers presented higher activity for the straight muscle of the left thigh in all the situations. This can indicate that there was a bigger recruitment of motor units in this muscle, which in the case of this experiment is not the dominant side. This result was a surprise but is understood by the signal analysis. Despite the dexterous predominance, the necessity of compensation to maintain balance generates a higher muscular activity in the left side, this can easily be observed in figures.

Comparing these two angles of knee flexion we conclude that the biggest muscular fiber mobilization was the straight muscle of the left thigh, at the angle of 130°. A higher activity was also observed in the angle of 90° for femoral biceps left long head. The same occurs with the left erector which presented greater activity in 90° of knee, eccentric phase. It is also important to point out that the results obtained for the analysis of data already consider possible statistical shunting lines or the analysis is made observing the average standards. We conclude that there is a necessity to define differentiated training for the different sides considering the different muscular recruitment. The focus of training is usually greater muscle mass; however this does not guarantee the same performance. Therefore learning about the fiber recruitment involved escapes the simple control mass increase [15,16].

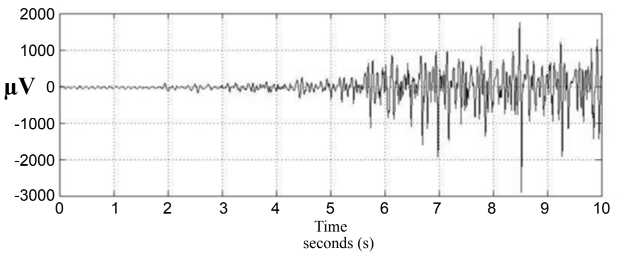

Figure 2: Electromyography signal and its transformed for the descending phase obtained from the straight muscle of the thigh at 130°, left side.

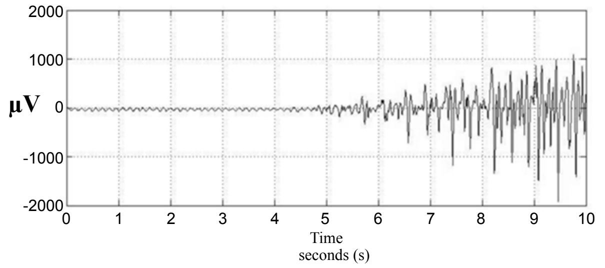

Figure 3: Electromyography signal and its transformed for the descending phase obtained from the straight muscle of the thigh at 90°, left side.

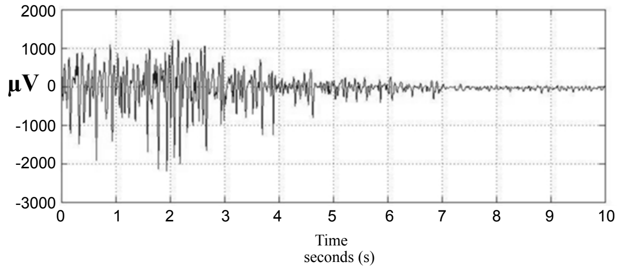

Figure 4: Electromyography signal and its transformed for the ascent phase obtained from the straight muscle of the thigh at 90°, left side.

In this stage the difference between the muscular conscription is clear (see white lines in Figures 1, 2 and 4). The differences between sides are due to the fact that training is more efficient on the right side of the athlete because a number of precision activities are frequently made by the right side. It is not a question of muscular power but of neurological strength. The highest training reflects in a higher capacity of recruitment of the muscles involved in the exercise in other words, optimization.

Limitation of the Study

The influence of the amplitude of muscle recruitment during the execution of closed kinetic exercises on muscle activation during movement of the lower limb are little discussed in detail factors that explain their correlations, characterized as a limitation this study.

References

1. Chandler TJ, Wilson GD, Stone MH (1989) The effect of the squat exercise on knee stability.. Med Sci Sports Exerc 3: 299-303.
2. Cram JR, Kasman GS, Holtz J (1998) Introduction to surface electromyography. Maryland. Aspen Publishers, Gaithersburg.
3. Perotto A, Delagi EF, Iazzetti J, Daniel M (2005) Anatomic guide for the Electromyographer the Limbs and trunk. Charles C. Thomas Publisher, 4th (edn), Springfield.
4. Johnson EW (1980) Practical electromyography. Williams and Wilkins, Baltimore.
5. Loeb GE, Gans C (1986) Electromyography for experimentalists. The University of Chicago Press, Chicago.
6. Sutherland DH (2001) The evolution of clinical gait analysis part 1: kinesiological EMG. Gait and Posture 14: 61-70.
7. Wright GA, Delong TH, Gehlsen G (1999) Electromyographic Activity of the Hamstrings During Performance of the Leg Curl, Stiff-Leg Deadlift, and Back Squat Movements. Journal of Strength and Conditioning Research 13: 168 - 174.
8. de Andrade AD, Silva TN, Vasconcelos H, Marcelino M, Rodrigues-Machado MG, et al. (2005) Inspiratory muscular activation during threshold® therapy in elderly healthy and patients with COPD. Journal of Electromyography and Kinesiology 15: 631-639.
9. Earl JE, Schmitz RJ, Arnold BL (2001) Activation of the VMO and VL during dynamic mini-squat exercises with and without isometric hip adduction. Journal of Electromyography and Kinesiology 11: 381-386.
10. Solomonow MA (1995) Practical Guide to Electromyography. Proceeding International Society of Biomechanics Congress XV. Jyvaskyla, Finland.
11. Williams KR (1987) Standardizing Biomechanical Testing in Sport. Res. Quart. Exercise Sport 58: 286–287.
12. Karlsson JS, Gerdle B, Akay M (2001) AAnalyzing surface myoelectric signals recorded during isokinetic contractions. IEEE Engineering in Medicine and Biology 20: 97-105.
13. Escamilla RF, Fleisig GS, Zheng N, Barrentine SW, Wilk KE, et al. (1998) Biomechanics of the knee during closed kinetic chain and open kinetic chain exercises. Medicine Science Sports and Exercise 30: 556-569.
14. Neitzel JA, Davies GJ (2000) The Benefits and Controversy of the Parallel Squat in strength Training and Rehabilitation. Strength and Conditioning Journal 22: 30-37.
15. Escamilla RF (2001) Knee biomechanics of the dynamic squat exercise. Medicine and Science in Sports and Exercise 33: 127-141.
16. Isear JA Jr, Erickson JC, Worrell TW (1997) EMG analysis of lower extremity muscle recruitment patterns during an unloaded squat. Medicine and Science in Sports and Exercise 29: 532-539.