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RELIABILITY OF THE ELECTROMYOGRAPHIC PARAMETERS OF FREQUENCY DOMAIN FOR CHARACTERIZATION OF THE PATELLOFEMORAL PAIN SYNDROME

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SUMMARY

Despite the patellofemoral pain syndrome (PFPS) exhibit high incidence its etiology remains obscure. It is believed that one cause of PFPS is an imbalance in Vastus Medialis (VM) and Vastus Lateralis (VL) activation, but there are few studies that investigated electromyographic parameters in the frequency domain of these muscles. Therefore, the aim of this study was to test the reproducibility of electromyographic parameters in frequency domain to characterize the PFPS. Were evaluated 29 pain-free women and 22 women with PFPS. The signals were obtained during stair climbing and the muscles analyzed were VM and VL. The electromyographic variables were examined in relation to the reproducibility, using $ICC_{2, k}$ (intraclass correlation coefficient), SEM (standard error of measurement) and MDD (minimum detectable difference). Were also conducted *t* test for comparison between the groups. The results revealed that median frequency and normalized bands of low B1 (15 to 45Hz), medium B2 (45 to 96Hz) and high frequency B3 (96 to 400Hz), showed high reproducibility, with low EPM and MDD for both groups and muscles. The medium frequency band B2 showed a statistically significant difference in the comparison between groups. Therefore, it is concluded that the parameters in the frequency domain are reliable and accurate, and the medium frequency band B2 is able to characterize the PFPS.

INTRODUCTION

The patellofemoral pain syndrome is one of the most frequent complaints in clinical practice. This disease often affects athletes and sedentary female population [1, 2]. It is characterized by diffuse pain retropatellar and its exacerbation occurs commonly during everyday activities such as climbing and descending stairs, squats, among other functions [3]. Despite the high incidence its etiology remains unknown. It is believed that one of the causes is an imbalance between the VM and VL [3,2]. In this context the study of muscle activity by Electromyography (EMG) has focused mainly on the analysis in the time domain. However, the parameters analyzed by this analysis method remain under investigation, and therefore inconclusive [4]. Thus, there is a gap in relation to the investigation of parameters in the frequency domain to characterize the PFPS. Therefore, the aim was to test the reproducibility of electromyographic parameters of frequency domain and its

ability to characterize individuals with PFPS during a test of stair climbing.

METHODS

Subject: It were evaluated 51 women divided into two groups: control group (CG) and PFPS group (PFPSG). The CG was composed of 29 women without signs or symptoms of PFPS with a mean age of 20.42 ± 2.33 years, mean weight 57.94 ± 8.51 kg and average height of 1.64 ± 0.05 m. The GPFPS was composed of 22 women with PFPS, with a mean age of 22.65 ± 2.08 years, mean weight 61.79 ± 10.65 kg and average height of 1.64 ± 0.06 m. The classification of subjects was made by three physiotherapists and exclusion criteria were [5]: signs or symptoms of any other disease in the knee, recent history (within three months) of this joint surgery, history of patellar subluxation, meniscal lesion, ligamentous instability, osteoarthritis, patellar tendon pathology, presence of neurological disease, presence of inflammation or symptoms of overuse and previous physiotherapy (at least 6 months). All subjects signed an informed consent.

Instrumentation: It was used an EMG model ADS 1000 - AC1160 of the LYNX ®. To capture the electrical activity of the VM and VL muscles were used two pairs of Ag/AgCl electrodes with 10mm in diameter. The electrodes were placed according to the motor point, prioritizing the muscle belly. Signals were captured on a sampling frequency of 4000 Hz with a digital low-pass filter of 500 Hz and high pass 20Hz, amplified with a final gain of 1000 times. For storage and pre-processing of digitized signals was used BioInspector software (LYNX ®). The collection of the electromyographic signal was performed during the functional gesture of climbing stairs. For this task the individual was asked to climb seven steps, and coupled to the fourth step was a force plate to detect the exact moment that the individual touched the ground. Speed and rhythm were self-controlled, resembling the usual functional activity. The tests were run in two days, each test consisted of ten stair climbing trials.

Signal Processing: The EMG signals were processed in Matlab®. The FFT (Fast Fourier Transform) was used to calculate the median frequency (MF) and normalized power spectrum was divided into three bands called low (15 to 45Hz), medium (45 to 96Hz) and high frequency (96 to 400Hz).

Statistical Analysis: A descriptive statistical analysis was performed to the variables MF, low frequency band (B1), medium frequency (B2) and high frequency (B3) of VM and VL muscles. In addition, were calculated the intraclass correlation coefficient ($ICC_{2, k}$), the SEM and MDD. The values of $ICC_{2, k}$ comprised between 0.00 to 0.25 - indicates little reproducibility, 0.26 to 0.49 - poor reproducibility, 0.50 to 0.69 - moderate reproducibility, 0.70 to 0.89 - high reproducibility and from 0.90 to 1.00 - very high reproducibility [6,7]. The *t* test was used to compare mean values of variables between groups.

RESULTS AND DISCUSSION

The table 1 shows mean and standard deviation and reproducibility of electromyographic parameters of VM and VL muscles of both groups. It was observed from a global analysis of the results, that the $ICC_{2, k}$ showed high levels of reproducibility. Furthermore, SEM and MDD showed low values, indicating a good reproducibility with absolute precision and high sensitivity in detecting differences between test and retest. Based on these results is noted that the parameters of the frequency domain are reproducible with few random effects for the VM and VL muscles during stair climbing, both the control group and the PFPSPG. Therefore, the characterization of both groups by means of the electromyographic variables was possible. It should be noted that this study is original in the evaluation of the reproducibility of EMG parameters in the frequency domain during stair climbing, especially in regards to a specific and comprehensive analysis of the frequency spectrum of EMG signal. Moreover, the variable B2 showed significant

difference when comparing the groups for the two muscles. Thus, considering that B2 is reproducible, accurate and able to discriminate healthy individuals from patients with PFPSPG, it can be used as a standard reference for diagnostic tests.

CONCLUSIONS

The results showed that the variables, MF and frequency bands are reproducible and accurate measurements. It can be noted, also, that the band of medium frequency B2 was categorical in the differentiation of groups, allowing the characterization of them.

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Table 1. Index reproducibility of MF (Hz) and normalized signal intensity of the low (B1), medium (B2) and high frequency band (B3) of VM and VL in the control group (CG) and the PFPSPG (GPFPS).

	VM		VL	
	GPFPS	GC	GPFPS	GC
Fmed (Hz)				
Day 1 (M±SD)	57.44 ± 12.42	52.71 ± 8.0	56.77 ± 12.95	53.77 ± 11.87
Day 2 (M±SD)	55.89 ± 8.14	51.37 ± 7.44	56.12 ± 10.51	55.57 ± 12.43
ICC (IC - 95%)	0.82 (0.57 – 0.92)	0.83 (0.65 – 0.92)	0.89 (0.74 – 0.95)	0.85 (0.68 – 0.93)
SEM (%)	5.8 (10.23%)	4.05 (7.78%)	5.25 (9.30%)	6.16 (11.26%)
MDD (%)	0.16	0.11	0.14	0.17
B1(u.n.)				
Day 1 (M±SD)	47.84 ± 12.13	55.68±10.56	48.18 ± 11.18	54.96 ± 12.98
Day 2 (M±SD)	49.89 ± 11.47	56.0±8.52	49.25 ± 11.42	52.68 ± 12.64
ICC (IC - 95%)	0.85 (0.66 – 0.94)	0.87 (0.74 – 0.94)	0.73 (0.34 – 0.88)	0.84 (0.67 – 0.92)
SEM (%)	5.83 (11.93%)	4.53 (8.11%)	7.43 (15.25%)	6.58 (12.22%)
MDD (%)	0.16	0.12	0.20	0.18
B2(u.n.)				
Day 1 (M±SD)	32.90 ± 8.42*	28.21±5.0*	31.90 ± 7.28*	25.88 ± 4.93*
Day 2 (M±SD)	32.84 ± 8.03	27.74±4.67	31.40 ± 7.99	26.29 ± 4.75
ICC (IC - 95%)	0.90 (0.76 – 0.96)	0.81 (0.61 – 0.91)	0.85 (0.65 – 0.94)	0.80 (0.57 – 0.90)
SEM (%)	3.52 (10.70%)	2.71 (9.68%)	3.87 (12.22%)	2.81 (10.77%)
MDD (%)	0.09	0.07	0.10	0.07
B3(u.n.)				
Day 1 (M±SD)	1.76 ± 1.26	1.47±0.78	1.81 ± 1.34	1.86 ± 1.14
Day 2 (M±SD)	1.59 ± 0.87	1.43±0.61	1.81 ± 1.07	2.06 ± 1.16
ICC (IC - 95%)	0.63 (0.12 – 0.85)	0.91 (0.81 – 0.96)	0.88 (0.73 – 0.95)	0.91 (0.81 – 0.95)
SEM (%)	0.79 (47.30%)	0.28 (19.31%)	0.54 (29.83%)	0.45 (22.95%)
MDD (%)	0.02	0.007	0.01	0.01

*Indicates significant differences (p<0.05).