Portuguese Journal of Sport Sciences
11 (Suppl. 2), 2011

THE EFFECT OF JUVENILE IDIOPATHIC ARTHRITIS ON LOWER LIMB MUSCLE ACTIVITY IN THE PROPULSION PHASE OF THE COUNTER MOVEMENT JUMP

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The purpose of this study was to investigate the effect of Juvenile Idiopathic Arthritis (JIA) on lower limb muscle activity during a countermovement jump (CMJ). Two groups of patient data were collected; 6 patients had unilateral arthritis, and 8 patients had bilateral arthritis. Activity of lower limb muscles was assessed using integrated EMG (iEMG) and peak EMG (pEMG) of the propulsion phase of the CMJ. Analysis of the unilateral patients compared the iEMG and pEMG differences of each muscle for the limb affected with arthritis versus the same muscles in the unaffected lower limb. Analysis for the bilateral group compared the left versus right side. No significance was found between sides when comparing lower limb iEMG and pEMG. It still needs to be determined if children who suffer from JIA have adverse muscle deficiencies as a result of the disease.

KEY WORDS: EMG, juvenile arthritis, countermovement jump

INTRODUCTION: Juvenile Idiopathic Arthritis (JIA) is defined as arthritis with an onset before the age of 16 years of age. JIA is the most common pediatric rheumatic disease and most often affects the knees, ankles, fingers, toes, wrists, elbows, and hips. Kulas (2001) found that 58% of children only have one joint affected. Electromyography (EMG) is a non-invasive method frequently used to measure muscle activity of selected muscles associated with a motion of interest. The counter movement jump (CMJ) motion strongly relies on the quadriceps femoris and triceps surae musculature making it ideal for investigating the properties of these tissues under dynamic conditions (Fukashiro, 1995). EMG combined with the CMJ has the potential to predict muscle deficiencies. The purpose of this study was to investigate the effect of JIA on lower limb muscle activity during the countermovement jump.

METHODS: The sample group consisted of sixteen children (4 males) aged 11.6 (± 3.1) years of age who have been diagnosed with JIA, and were in remission for at least one year. Six patients had unilateral JIA of the lower body, eight patients had bilateral JIA of the lower body, and two had JIA of the upper body. BTS FREEMG system (BTS Bioengineering, Milan, Italy) were placed bilaterally on four muscles; medial gastroctnemius (GAM), and the tibias anterior (TA), rectus femoris (RF), and biceps femoris (BF) according to SENIAM guidelines (Hermes, 2000). Prior to placement of each electrode, the area was swabbed with alcohol to reduce skin impedance.

After a warm-up, participants performed two sets of three maximal voluntary isometric ankle plantar flexion contractions with each leg using a robotic dynamometer (Multi-Joint System - Pro, Biodex Medical Systems, New York, USA). Ten maximal CMJs were performed on a two force plate setup with one foot on each force plate (Bertec Corp., Columbus, USA). The maximal CMJ were performed with the arms at the hips to control for the energy generated by the upper limbs. The five best trials were used for analysis.

The raw EMG data were bias removed, rectified, and filtered with 5 Hz low-pass Butterworth filter using SmartAnalyzer software (BTS Bioengineering, Milan, Italy). Isometric MVCs were used to normalize the EMG data for the CMJ. The CMJs were then time normalized using the propulsion phase of the jump, which begins when the participant is at the lowest point of the squat and the knees are most flexed, and continues as the participant extends their legs and trunk move upwards towards the takeoff, ending when the feet have left the ground. The peak EMG (pEMG) value was extracted and then individually averaged for the five trials for all eight muscles. The five trials of the propulsion cycle were averaged together for each muscle on both legs, and then the integral of average curve was taken, to provide integrated EMG (iEMG) for all muscles.

For the case of patients with bilateral JIA, the same pEMG values and iEMG were calculated for both the left affected side and the right affected side, and statistical t-tests using SPSS software were run to test for differences between the two affected sides (SPSS 15.0, IBM Corporation, New York, USA).. For the unilateral JIA group, the pEMG value and the iEMG for the affected side (GAM-A, TA-A, RF-A, and BF-A) and the unaffected side (GAM-U, TA-U, RF-U, and BF-U) were compared amongst the paired muscles to see if there was a difference between sides, and subsequently any unilateral deficits in lower limb muscle function.

RESULTS: The two patients who did not have lower body JIA were excluded in the analysis. No significance was found when comparing the iEMG and pEMG of the muscles of the affected limb to the unaffected limb for the unilateral JIA group. The iEMG and peak EMG results are summarized in figure 1 and the p-value results are summarized in table 1. Similarly, no significant difference was found amongst the iEMG and pEMG of the bilateral muscles when comparing the affected left limb to the affected right limb. The rectus femoris had the highest iEMG and peak EMG and the biceps femoris had the lowest iEMG and peak EMG value.

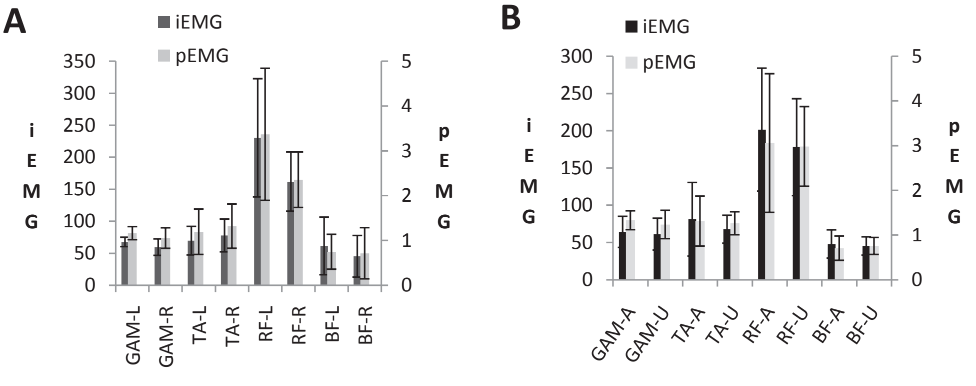

Figure 1: The iEMG and peak EMG for each muscle of the bilateral JIA group is depicted in panel A. Panel B depicts the unilateral JIA group.

Table 1
P-values for the comparisons of iEMG and pEMG amongst lower limb muscles for both the unilateral JIA group and bilateral JIA group. The muscles that were tested against each other appear in the column together

Bilateral	**GAM-L/GAM-R**	**TA-L/TA-R**	**RF-L/RF-R**	**BF-L/BF-R**
pEMG	0.336	0.622	0.105	0.899
iEMG	0.234	0.535	0.109	0.454
Unilateral	**GAM-A/GAM-U**	**TA-A/TA-U**	**RF-A/RF-U**	**BF-A/BF-U**
pEMG	0.554	0.865	0.92	0.728
iEMG	0.445	0.395	0.837	0.427

DISCUSSION: It was hypothesized that a deficit in the affected side would be found in the unilateral JIA group, and no deficit would be found in the bilateral JIA group because both sides were affected. Contrary to the hypothesis, no differences were found between the affected and unaffected side for the unilateral JIA group. As predicted, the bilateral JIA group had no differences between left and right.

All of the patients were in remission from JIA for at least one year before the study took place. It is speculated that their remission status may account the lack of reduced muscle activity in the affected side of the unilateral JIA group. Patients who are actively suffering from symptoms of JIA may have a more pronounced reduction in muscle activity. Furthermore, the lack of controls in the study made it difficult to draw any conclusions about whether the bilateral JIA group were muscularly deficient in any way, but as mentioned it was observed that no iEMG and pEMG differences exist between the left and right affected legs.
The use of isometric plantar for the MVC is not ideal, because the rectus femoris is not strongly activated during that motion. This can lead to a misleadingly low EMG signal that was used in MVC normalized. The cause of the high rectus femoris iEMG and pEMG results may be directly related to this limitation.
More analysis on the kinetic and kinematic data from the study can further establish a connection regarding the differences in affected and unaffected lower limb, specifically whether one side is favoured over the other. The total scope of the effects JIA has on dynamic muscle activity needs to be established because it is important to get more conclusive data on whether children with JIA have muscular deficiencies. Herzog (2003) found that unilateral strength discrepancies can cause adverse joint loading, and can lead to or accelerate joint degeneration. This is of particular concern for children with JIA and other populations with pre-existing degenerative diseases.
The negative repercussions of joint problems for children with JIA influence the child's ability to participate in physical activity. JIA affected children take part in fewer physical activities than controls of the same age, and have lower aerobic capacity (Brostrom, 2002). Physical activity has been identified as a significant positive determinant of bone mineral density. In JIA a significant concern is the prevalence of JIA children that participate in no weight-bearing or little weight-bearing activities. If these habits continue into adult life further problems can arise, such as osteoporosis (McDonagh, 2001).

CONCLUSION: Contrary to the hypothesis, there were no significant differences found in the iEMG and pEMG between affected and unaffected sides in the unilateral JIA group. This indicates that arthritis status does not produce unilateral muscular deficiencies during the CMJ for JIA patients in remission. No differences in iEMG and pEMG muscle function exist among the right and left sides of bilaterally affected JIA patients. This agrees with the hypothesis that no difference would be found, however a control group would have also allowed for comparisons to be made for the unilateral to assess whether overall muscle function was different between healthy and arthritic children. The lack of a control group is a limitation of the study. Further research is needed to more definitively establish the relationship between arthritis status and muscle function for children with JIA. More robust forms of analysis such as kinematics, kinetics, and mechanography analysis, a larger subject pool and a control group are recommended.

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Acknowledgements
The authors thank Daniel Varin and Stephanie Nowak for their efforts to the success of the project.