ELECTROMYOGRAPHIC INTER-LIMB ASYMMETRY IN BENCH PRESS EXERCISE IN ELITE PARALYMPICS WEIGHTLIFTERS

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The purpose of this study was to describe inter-limb asymmetry in three muscle groups in a sample of Paralympic weightlifters during an 80% RM bench press. The sample was composed of 7 subjects belonging to the Chilean elite powerlifting. Surface electromyography was assessed in major pectoral, deltoid anterior and triceps brachii. The magnitude of the response was calculated through root mean square (RMS). Symmetry Index was calculated for an interlimb differences measure. Only the pectoralis major muscle showed significant differences between limbs (right 84.7 ± 41.3; left 66.1 ± 19.3 RMS) (p=0.05) and the SI median greatest value (19.74 ± 24.59%). Anterior deltoid showed high individual differences in two athletes with upper 80% SI values. More studies should assess asymmetry with the objective to decrease this injuries risk factor.

KEY WORDS: Inter-limb Asymmetry, Paralympic Biomechanics, EMG, Muscle activity.

INTRODUCTION: The selection of strength exercises represents important elements in sports training and performance. One of the most frequent and recommended exercises is the bench press exercise. This exercise is widely used by professionals of physical activity and sports to achieve strength increases in the upper limbs, both in conventional and paralympic sports (Lehman, 2005). In the case of competitors in Paralympic weightlifting, they must first meet the minimum disability criteria in order to participate (Committee, 2015). Frequently, these athletes make changes in the bench press in terms of grip width, in addition to the levels of body inclination, which has shown certain variations in the recruitment of motor units (Hernández-Rodríguez et al., 2001) (Lehman, 2005) (Aedo-Muñoz, Herrera-Valenzuela, Bustamante-Garrido, & Letelier-Castro, 2014). Surface electromyography evaluations determine the electrical activity used by the superficial muscles, estimating the neuromuscular activity generated, in terms of the frequency and amplitude of these signals (Cifrek, Medved, Tonkovic, & Ostojic, 2009, Basmajian & De Luca, 1985, Konrad, 2005). Currently, several studies have characterized the electromyographic activity in the bench press for different inclinations (Hernández-Rodríguez et al., 2001, Aedo-Muñoz et al., 2014, Padulo, Laffaye, Chaouachi, & Chamari, 2015),grip width has also been noted as a factor (Lehman, 2005). However, the differences in neuromuscular control, measured with EMG, show a high relationship in relation to risk of injury that athletes could present during their physical preparation (Zebis et al., 2011). These asymmetries between extremities are studied even through kinetic instruments in different sports (Schiltz et al., 2009, Andrade et al., 2013), being the electromyographic activity the measure that delivers higher level of asymmetry, even greater than the kinetic and kinematic (McAllister & Costigan, 2019). However, the evaluation of Paralympic athletes is scarce. The purpose of this study is was to describe EMG inter-limb asymmetry in three muscle groups in a sample of Paralympic weightlifters during an 80% RM bench press execution.

METHODS:
The sample was composed of 7 elite para-powerlifting who have been members of Chilean teams for over 5 years. Throughout the study, they subjects continued with their normal daily training. Prior to testing, a short explanation of the study was provided. This was accompanied

immediately by a standardized warm up protocol, which consisted of a series of 10 bench press of 40% RM, followed by 10 minutes of stretching exercises. After the warm up, the subjects were introduced to the protocol, with an incremental intensity of; 50%-60%-70%-75% RM every five-minutes. The evaluation procedure consisted of every subject performing a sub-maximal test of 80% RM. The gathered information was: surface electromyography activity in pectoralis major, anterior deltoideus and triceps brachii. The position of the electrodes was marked on the skin according to the SENIAM® (Stegeman & Hermens, 2007). The electromyography signal was recorded with Delsys® Trigno, using silver surface bipolar electrodes (99%, 1 mm width and 10 mm length), with an inter-electrode distance of 10 mm. (Delsys Model Inc. Boston. M. USA). The signals registered were pre-amplific, with a common mode rejection ratio of 92dB and a gain of 1kHz (Delsys Inc. Boston. USA). The electromyography signs were processed in a macrocomputer, with IGOR PRO Wavemetrics 5.01, and were rectified completely and passed through a 6Hz low-pass digital filter. The onset muscle activation was defined as basal level, which corresponded to the average amplitude recorded in a window before activation, with a threshold corresponding to the baseline value plus 10 standard deviations from that window. When the onset of the muscular electrical activity was determined, the magnitude of the response was calculated through RMS (root mean square). It was not possible to perform a Maximum Voluntary Contraction (MVC) normalisation due to the training restrictions of the sample.
The descriptive statistics used were the median, major and minor values, and percentiles 25 and 75, as a measure of dispersion. The comparison between the right side and the left side of each subject was carried out using the Wilcoxon test. The "symmetry index" (SI) was calculated through the following equation:

$$\mathrm{SI} = \frac{\mathrm{X_R} - \mathrm{X_L}}{\frac{1}{2}\,(\mathrm{X_R} + \mathrm{X_L})} \times 100\%$$

Where SI = Symmetry Index, X_R = Value of the right side, X_L = V Value of the left side
SI corresponds to the percentage of asymmetry of one of the sides in relation to the other (VanZant, McPoil, & Cornwall, 2014). When SI = 0, this indicates the existence of perfect symmetry. If the value is negative, then it is assumed that the asymmetry goes to the left side, and, if it is positive, to the right side.
The respective "SI" indices were compared in the three muscle groups evaluated through ANOVA-style analysis of variance. The Bonferroni method was used as post hoc. A "$p \leq 0.05$" was considered as a value of statistical significance. Effect sizes were calculated as Cohen's d.

RESULTS: Table 1 shows the descriptive data for each of the 7 athletes. It is then possible to see that the group is heterogeneous regarding age and personal best weight. From the observation of the EMG values, it can be seen that there is an inequality between the RMS values, of the right and left sides, for the three muscular portions evaluated in each one of the subjects. However, based on the Wilcoxon test, it was established that there were no significant differences between the right and left sides in triceps brachii ($p = 0.16$), anterior deltoid ($p = 0.94$), but they were observed in the pectoralis major ($p = 0.05$). Effect sizes were large for triceps brachii ($d = 0.41$) and pectoralis major ($d = 0.58$), but low ($d = 0.11$) for the anterior deltoid.
The median of the SI for each muscle group was -14.92%, 4.44% and 19.74%, for triceps brachii, anterior deltoideus and pectoralis major respectively. Figure 1 shows the SI values obtained for each of the subjects. There it is observed that, for the triceps brachii muscle group, subjects 1 and 6 show the greatest differences (SI = -74.5% and -64.2% respectively), asymmetries oriented towards a predominance by the left side. In previous deltoideus, the greatest asymmetries were observed in subjects 2, 6 and 7, with SI values of -105.6%, 80.6% and 62.8% respectively. In the pectoralis major group, subject number 6 showed the greatest asymmetry, with SI = 62.2%, followed by subject 1 with SI = -21.3%.

Table 1: Descriptive values of RMS in each of the muscle groups studied, for each subject.

Athlete	Age (years)	PB (kg)	80% PB (kg)	Triceps Brachii (rms) Right	Triceps Brachii (rms) Left	Anterior Deltoid (rms) Right	Anterior Deltoid (rms) Left	Pectoralis Major (rms) Right	Pectoralis Major (rms) Left
1	23	106	84.8	111.8	244.6	148.4	184.0	43.5	53.9
2	38	180	144.0	311.2	361.4	131.7	426.1	103.6	94.5
3	29	65	52.0	129.3	131.3	184.5	209.8	69.5	56.3
4	19	106	84.8	95.2	83.5	103.8	77.9	58.9	46.4
5	22	115	92.0	137.3	130.9	169.8	162.4	60.1	49.4
6	37	182	145.6	63.1	122.7	283.1	120.5	166.1	87.2
7	45	175	140.0	156.8	182.4	191.8	100.1	91.2	74.8
Minimum	19.0	65.0	52.0	63.1	83.5	103.8	77.9	43.5	46.4
P25%	22.0	106.0	84.8	95.2	122.7	131.7	100.1	58.9	49.4
Median	29.0	115.0	92.0	129.3	131.3	169.8	162.4	69.5	56.3
P75%	38.0	180.0	144.0	156.8	244.6	191.8	209.8	103.6	87.2
Maximum	45.0	182.0	145.6	311.2	361.4	283.1	426.1	166.1	94.5
			Wilcoxon	0.16		0.94		0.05	
			Cohen´s d	0.41		0.11		0.58	

PB = Personal Best; RMS = root mean square; P25% = 25% percentile; P75% = 75% percentile

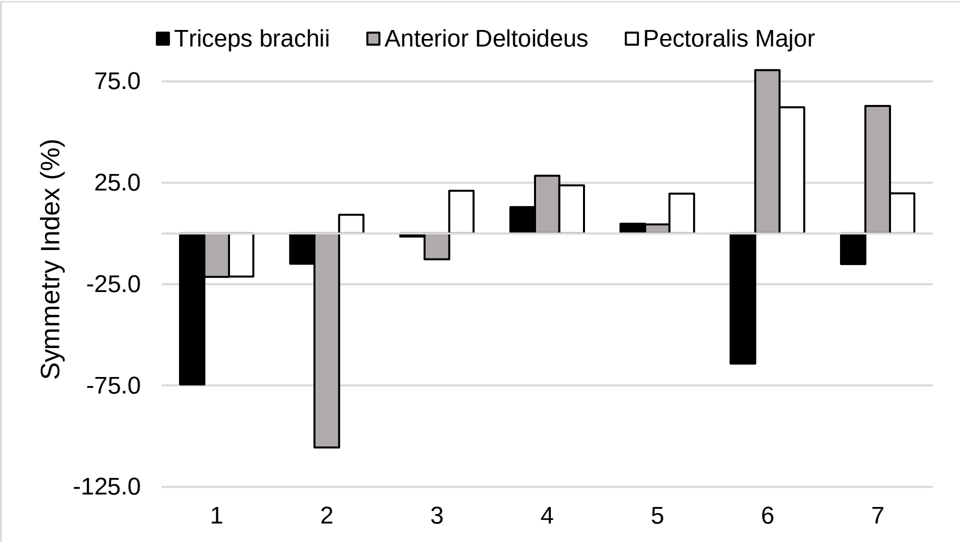

Figure 1: A descriptive graph of the SI values obtained for each subject, for each muscle group.

From the individual analysis, subject No. 6 is had the highest SI values and holds the highest personal best. This tendency is repeated in subject 2, who is the next best in personal best lifts and has the greatest asymmetry in the anterior deltoid. Subjects 3, 4 and 5 presented the lowest SI values, not exceeding the 24% asymmetry value. No significant differences between SI values were noted within muscle groups (F = 1.87, p = 0.21).

DISCUSSION: The aim of this study is to describe the inter-limbs asymmetries that the EMG signal presents in three distinctive muscle groups, in a sample of paralympics weightlifters. The sample used in this study is small to generalize its behavior, determining a starting point for future research. In this regard, it is necessary to comment that there is little officially published literature that has based its experiences on this type of sample. Additionally, to date there are no studies that have focused on the variable of asymmetry of muscle activation in the bench press exercise.

What is most relevant of the results found is the fact that the only muscle group that presents significant inter-limbs differences is the pectoralis major, which is the most requested during this exercise (Schoenfeld, Contreras, Vigotsky, & Ogborn, 2016), a result that agrees with the fact that this muscle group has the highest median SI values, close to 20% asymmetry and with predominance towards the right side. Due to the importance that this muscle group has for the execution of the aforementioned exercise, it is necessary to pay attention to the presence of these asymmetries, as it is known that this is a predisposing factor for injuries in other parts of the body (Ning, Haddad, Jin, & Mirka, 2011).

Another interesting result is that the highest absolute values for SI were recorded in the "anterior deltoideus" muscle group, with a value that exceeded 100% asymmetry towards the left side, which indicates that the left side exerts a similar EMG activity to the double of the opposite side, and in another individual with a value of 80.6% towards the right side. This result indicates a need to begin to monitor throughout the training process the different adaptations experienced by both sides of the body, in order to safeguard a correct and efficient execution of the technique (Rahnama, Reilly, Lees, & Graham-Smith, 2003). It is possible that a larger sample could register differences in those muscles that this study did not observe.

CONCLUSION: Within a sample of Paralympic athletes it was possible to establish the presence of high levels of asymmetries in the EMG activation of the muscle groups "pectoralis major" and "anterior deltoideus". The need to have more studies that tend to the evaluation of asymmetries is established, with the objective of reducing this risk factor and avoiding the appearance of injuries.

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