

Differences of free-throw shot in wheelchair basketball and conventional players

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ABSTRACT

Wheelchair Basketball (WB) follows almost the same rules as Conventional Basketball (CB). **Objective:** Evaluate the electromyographic (EMG) activation of the pectoralis major (PM), anterior deltoid (AD), and triceps brachii (TB) muscles during shooting in CB and WB athletes and to verify whether there is any difference in muscle activation between the categories. **Method:** Comparing two groups in a transversal study, CB and WB, in which eleven individuals submitted to an electromyographic examination, of muscles PM, AD, TB on the extremity that was doing the shooting. We used a 4-channel EMG (Miotec/Brazil) (2000Hz/channel). **Results:** Comparing the muscles, the CB group showed a significant difference: greater AD muscle activation compared to the others; however in the WB group, no differences were found. When comparing between the groups, the PM muscle showed greater activation in the WB group, while the AD muscle was more active in the CB group. The TB muscle showed no difference between groups. **Conclusion:** From these results, the athletes from the CB and WB groups showed differences in muscle activation during shooting. However, both groups activated the AD the most, followed by the TB. The least active muscle was the PM, and these differences were more visible in the CB group.

Keywords: Sports for Persons with Disabilities, Basketball, Upper Extremity, Electromyography

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Received on November 21, 2014.

Accepted on September 14, 2015.

DOI: 10.5935/0104-7795.20150028

INTRODUCTION

Shooting is considered the most important element of basketball.¹ In dealing with wheelchair basketball (WB), the athletes are known to have varying degrees of physical limitations so, to assure fair competitions, a functional classification was created in 1982. This system is based on observation of the athletes' movements and their abilities demonstrated while playing the adapted sport.²

The classification is made by a skilled team evaluating a group of actions performed by the athlete in his wheelchair. Each player receives a score ranging from 1.0 to 4.5 and the sum of a team's players on the court cannot total more than 14 points.² As for the wheelchair suitable for playing basketball, there are some regulations that have been established by the International Wheelchair Basketball Federation (IWBF). The measurements of the court and the rules of the wheelchair game follow the rules of conventional basketball exactly.³

Electromyography (EMG) is defined by the measurement of the algebraic sum of the action potentials of the motor units of a muscle by means of electrodes, which makes it possible to study the electrical activity of muscles during a certain activity, which can prove whether a proposed rehabilitation exercise is effective, and if and when a muscle is solicited during a certain movement.⁴

There are only a few studies in the literature evaluating electrical activity in the muscles involving shooting a basketball and that compare conventional basketball and wheelchair basketball athletes. After verifying which muscles are most summoned in the shooting activity, preventive activities can be emphasized that can reduce the frequency of injuries in conventional basketball players as well as in WB athletes. Whether a distinct training approach is necessary for these two groups remains unknown, despite their making the same movements in the same sport, nor is it known whether their musculature is activated in the same manner.

OBJECTIVE

The objective of this study was to electromyographically evaluate the pectoralis major (PM), the anterior deltoid (AD), and the triceps brachii (TB) muscles during shooting,

and compare the activity of the muscles between conventional and wheelchair basketball players, as well as to compare the activation between the muscles in each group.

METHOD

This was a cross-sectional study, including participants of CB and WB from the metropolitan region of Porto Alegre, in the state of Rio Grande do Sul, and was approved by the Committee on Ethics in Research at the *Centro Universitário Metodista* of the IPA under protocol No. 264/09. All the athletes signed the terms of informed consent.

Included in this study were 11 males who had been playing basketball for at least one year-6 in the CB group and 5 in the WB group. Their ages ranged from 25 to 45 years and they all played at least twice a week. Excluded from this study were those presenting symptomatic injuries for less than 3 months on the upper extremities for either group, or lower extremities for the CB group. The WB players were unilateral amputees with a functional class between 3.5 and 4.5 and they all used wheelchairs as a means of routine locomotion.

The EMG signal from the PM, AD, and TB muscles were collected during free-throw movements by using a 4-channel *Miotool* 400 electromyography machine (*Miotec*®/Brazil) with a sampling frequency of 2,000Hz per channel (14-bit resolution, common mode rejection of 110db) using 2.2 cm diameter bipolar electrode pairs (Ag/AgCl from *Meditrace*, Canada) and *Miograph* 2.0 software. Skin impedance was reduced by shaving, and asepsis with 70% alcohol, following the guidance from the International Society of Electrophysiology and Kinesiology.⁵ The electrodes were all positioned according to the norms of the SENIAM project (Surface Electromyography for the Non-Invasive Assessment of Muscles). The reference electrode was set on the anterior tibial tuberosity on the same side as was being evaluated.

There was an initial ten-minute free warm-up where they did free-throws, lay-ups, and passes. Then the players each shot their free-throws, the second successful of which was validated, and considered for the study. Those who did not make 2 of their 5 attempts waited for 3 minutes and tried again. The shots were made on a basket of the same height and distance,

on the free-throw line, as adopted by the FIBA (International Federation of Basketball) and by the IWBF for conventional players as well as wheelchair players. The ball adopted for this study was the same for all the individuals, weighing 0.555kg.

The WB players used a wheelchair that complied with the requirements demanded by the IWBF and the ranges contained in their functional classification cards.

For later normalization of the muscle activation data of each athlete in the tested tasks, maximum voluntary isometric contractions (MVIC) were made in the muscle function test position before the free-throws.⁶

To analyze the EMG signals, the SAD 32 program (version 2.61) was used, adopting the following procedures: removal of continuous component, elimination of gain, filtering, and signal cut. The signals were submitted to the filtering process by 3rd-order FFT Butterworth filters (20-500Hz). The RMS value (root mean square) was calculated for all the muscles evaluated, and then normalized by the RMS and MVIC values of each muscle of each individual. To analyze the data, the averages of the normalized RMS values were calculated for each muscle within each group.

The Shapiro-Wilk test was used in the statistical analysis to verify the normality of the data distribution. To compare between groups, the Student T-test was used for non-paired samples. The single-factor ANOVA was used for comparisons within the groups. The GraphPad Prism program (version 5.0) was used adopting a significance level of $p < 0.05$.

RESULTS

The characteristics of the groups are described in Table 1. A significant difference was noted as to height and weight variables regarding the characteristics of the sample.

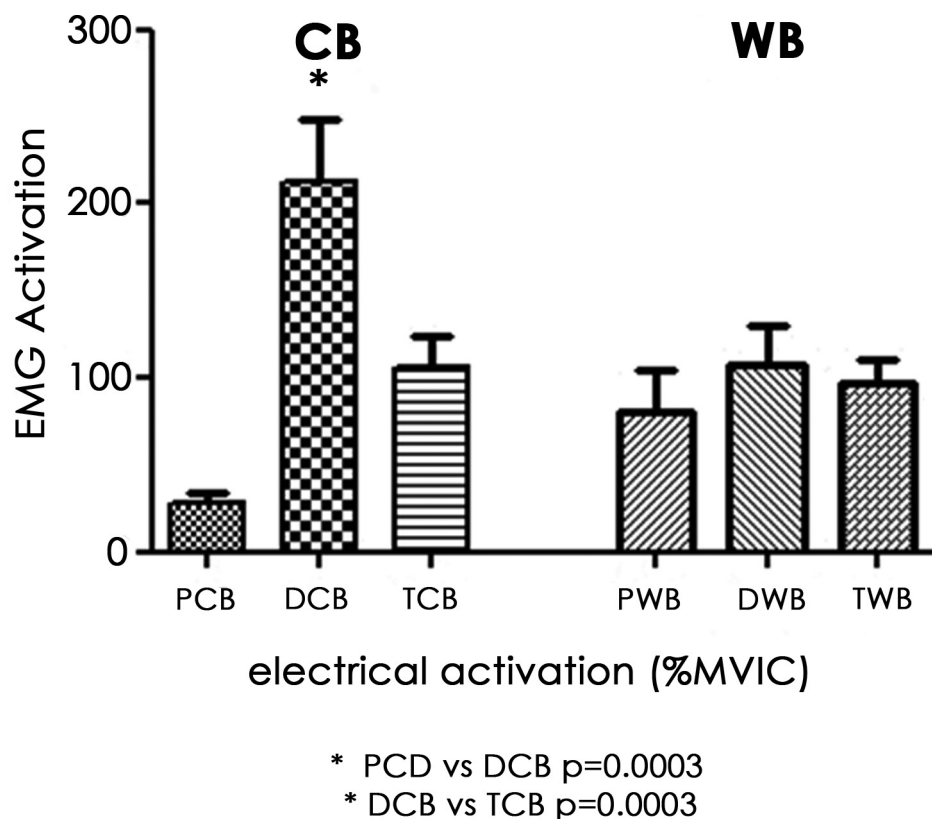
Comparing between the electrical activation of the muscles within the CB group, a statistically significant difference was found, where greater activation of the AD muscle was observed in relation to the PM muscle ($p < 0,001$) and in relation to the TB muscle ($p < 0.001$) (Figure 1). The WB group, however, showed no statistically significant difference between the muscles evaluated.

Comparisons between the two groups show that the electromyographical activity of the PM muscle was greater in the WB group

Table 1. Characteristics of the CB and WB groups

Characteristics	CB (n = 6)	WB (n = 5)	P value
Age (years)	32.17 ± 1.96	35.60 ± 2.62	0.311
Height (m)	1.92 ± 0.03	1.740 ± 0.06	0.016
Weight (Kg)	107.2 ± 7.55	78.20 ± 5.70	0.016
BMI (Kg/m ²)	28.84 ± 1.40	26.19 ± 2.63	0.375
Training time (years)	14.83 ± 3.06	08.00 ± 2.78	0.137

*Legend: CB = Conventional Basketball; WB = Wheelchair Basketball; n = number of subjects; p = statistical significance value ($p < 0.05$)

**Figure 1.** Comparison of EMG activation between the CB group and the WB group

($p < 0.05$) (Figure 2) while the AD activation was greater in the CB group ($p < 0.05$) (Figure 3).

The TB muscle presented no statistically significant difference when comparing between the groups (Figure 4).

DISCUSSION

The present study did not verify any statistical differences regarding average age, time of practicing the sport, or BMI between the groups in spite of showing

a statistical difference between these players' weights and heights.

Despite their heights having a statistical difference, the WB group was measured in orthostasis even though they practice their sport in the sitting position, because this difference would be greater if we took the height of the seated subject into consideration. The height of the player influences the shooting. Okazaki et al.⁷ reported that during free-throws the knee flexion is less relevant due to the height of the players—the taller the player the less the legs move, with the upper extremities being the

main engine in performing the movement. In a contrasting study by Okazaki et al.,⁸ they state that the thrust from the lower extremities is also of great importance in improving the shot for it increases the body leverage and allows the ball to be released from a higher position in relation to the basket.

Studies contend that the person's height and leg thrust can influence the execution of the shot.^{7,9} This gives the WB group a great disadvantage in free-throwing since they are down lower (sitting) and cannot use their legs for thrust. Therefore it is likely that the WB group adopts distinct strategies to make this movement. Studies from Elliott¹⁰ and Miller & Bartlett¹¹ suggest that a greater shoulder flexion allows the subjects to increase the height of their release of the ball. This being the case, the WB group needs a greater activation of the shoulder muscles to make this shot. This is what the study by Schwark et al.¹² claims—that there is a greater demand from the shoulder during a wheelchair free-throw; the upper arm tends to remain more in a vertical position than what is observed for a conventional player making a shot.

This research observed the activations of the AD, PM, and TB muscles in the WB group similar to other muscles evaluated, probably by the angle of the sports movement being higher than in the CB group, by playing sitting down, and by not having the assistance of the leg muscles. Another study states that, in this modality, there is greater strength required due to the increased distance to the basket and that there is a reduced ability to generate force due to the lack of available energy from the lower extremities.¹³ This concurs with the study by Malone et al.¹⁴ which argued that, since WB players are positioned lower and have to generate propulsion mostly from the upper body, it is reasonable to expect that the skill would need to be somewhat modified.

We agree that this distinct shooting strategy is necessitated by the non-use of the lower extremities and by the low positioning for making this movement. These factors can be directly related to the variability of the movement, allowing similar activations to be generated among the evaluated muscles. Another fact that contributes to such a similarity of activation is that these three muscles generate the main thrust from the wheelchair¹⁵

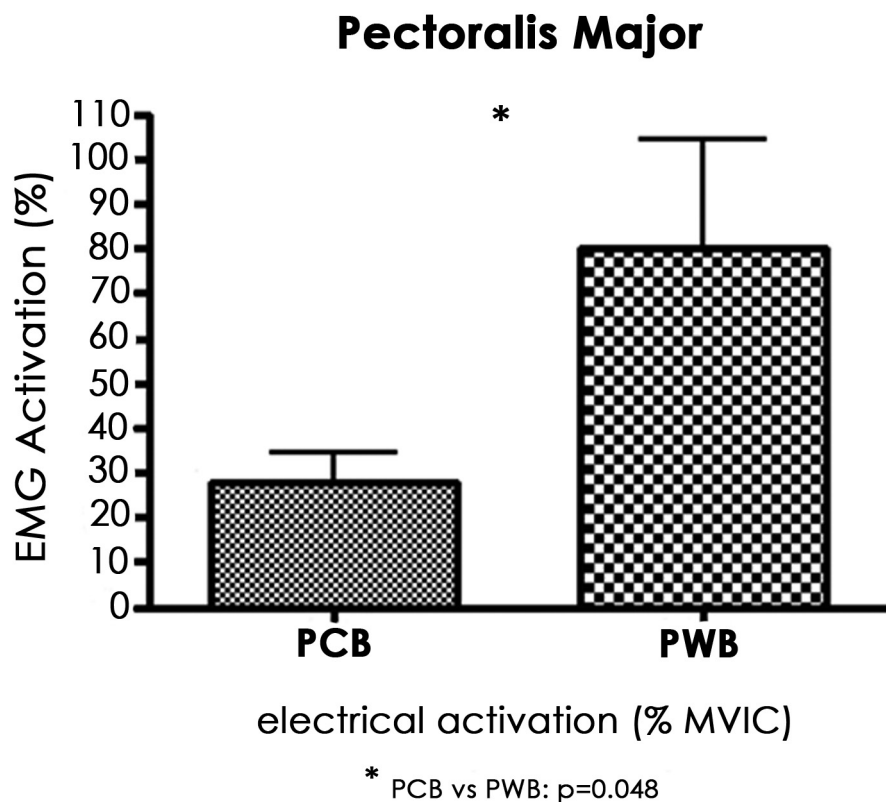


Figure 2. Comparison between groups of the Pectoralis Major muscle.

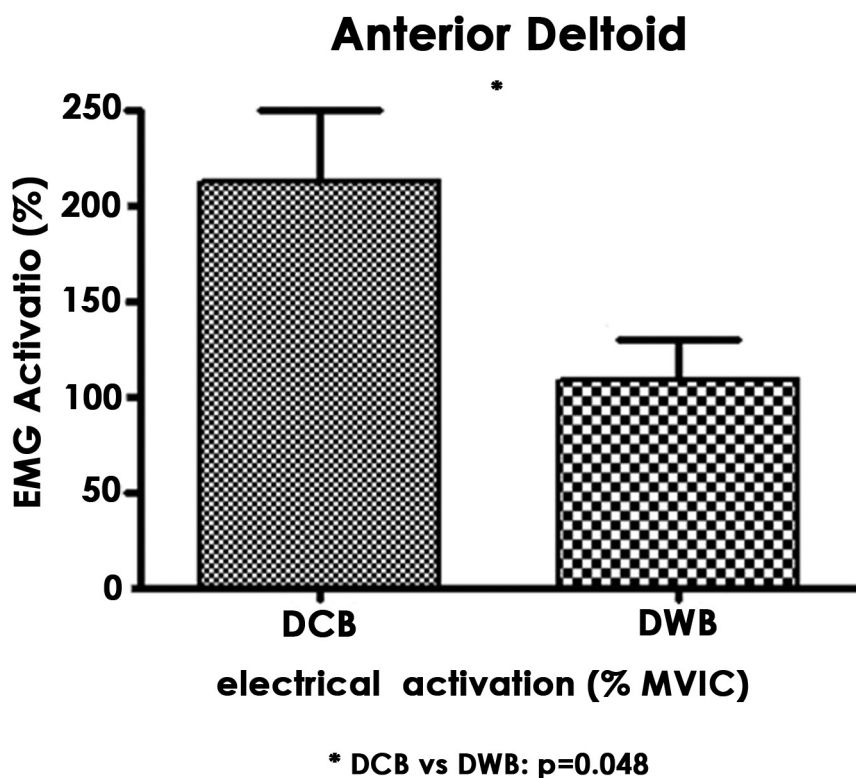


Figure 3. Comparison between groups of the Anterior Deltoid muscle

The AD muscle along with the rotator cuff are necessary driving components for shoulder flexion and joint stabilization,¹⁶ which justifies their greater activation in both groups. In the CB group this activation is more visible, possibly because there is less activation of the PM muscle for them. In the WB group the greatest activation is also in the AD, however a similar activation can be seen in the PM muscle; this may be a type of compensation and also because this muscle is heavily used in the locomotion of these players.

Some authors have considered the elbow extension as the most important movement in shooting, for this joint is considered most responsible in maximizing the speed at the instant of releasing the ball.^{13,17,18} The TB muscle, responsible for this movement, was activated similarly between the two groups, suggesting that it is a standard. In a study by Zachry et al.,¹⁹ during the CB shooting, the EMG was evaluated for the medial deltoid and the TB. In that study the TB was more activated, whereas in the present study the TB was the second most activated in both groups.

A recent study by Ozmen et al.²⁰ showed the importance of a training program for explosive strength in the upper extremities in the sprint speed and agility of WB athletes. Muscle strength is very important for competitive wheelchair basketball players. This is why it is fundamental to identify which muscles are most activated in the fundamental act of basketball: shooting.

The differences in muscle activation of the upper extremities between conventional and wheelchair basketball athletes was verified in this study. This information can be important in improving technique while training the athletes as well as for basing physiotherapeutic conduct during treatment and preventing injuries to these athletes. This study evaluated a small sample due to the difficulty in finding WB players that would fit into our inclusion criteria, which could be considered a limitation to this work.

CONCLUSION

Considering the results of the present study, one could conclude that the athletes from the WB and the CB groups showed differences in electrical activation during the shooting movement. However, both groups activated the AD the most, followed by the TB, and the least was the PM; these differences were most visible in the CB group.

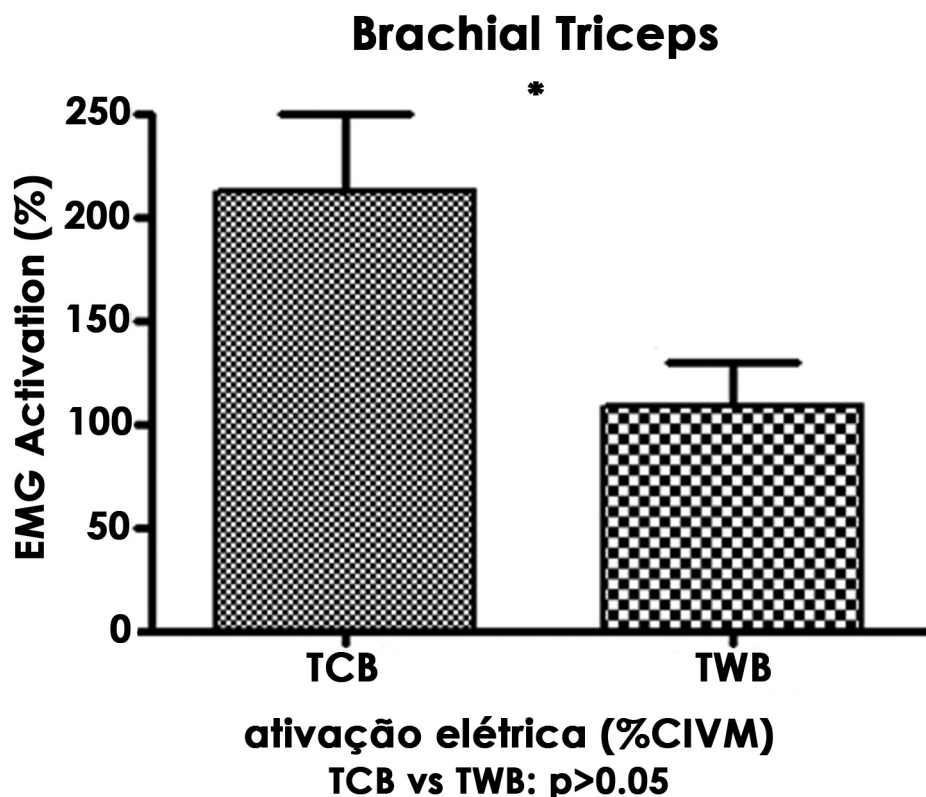


Figure 4. Comparison between groups of the Brachial Triceps muscle.

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