Original article (short paper)

Quantitative evaluation of trunk muscle strength in wheelchair basketball players

Sileno da Silva Santos
Angélica Castilho Alonso
Júlia Maria D'Andréa Greve
Universidade de São Paulo, São Paulo, SP, Brasil

Abstract—Trunk muscle strength affects trunk controlling playing an important role in performance and to define the classes of wheelchair basketball players. Trunk control capacity differs among players and quantitative assessments of trunk muscle strength have not been investigated. The aim of this study was to identify and correlate quantitative measures of trunk muscle strength with the wheelchair basketball players' classification. Forty-two male wheelchair basketball players with spinal cord injury, amputation, post-poliomyelitis sequelae, and cerebral palsy had their trunk extension and flexion strength evaluated with isokinetic dynamometer. The classes 1.0, 2.0, 3.0, and 4.0 were considered for statistical analysis. Comparison of trunk muscle strength differed significantly between classes: 1.0 and 3.0; 1.0 and 4.0; 2.0 and 3.0; and 2.0 and 4.0. High correlation was found between the trunk muscle strength and players' classes. The findings of the present study showed a strong correlation of trunk muscle strength and wheelchair basketball classes being able to distinguish players in their classes. However, this quantitative method of evaluation of the trunk muscle strength cannot be solely used to make a decision on the full trunk control.

Keywords: classification, functional performance, wheelchair sports

Introduction

The wheelchair basketball (WCB) is a paralympic sport which is very popular among people with disabilities (Malone, Gervais & Steadward, 2002; Yildirima, Comertb & Ozengina, 2010). Athletes with different physical disabilities such as spinal cord injuries (SCI), amputations, post-poliomyelitis sequelae, and cerebral palsy are eligible to join teams (Gil-Agudo, Ama-Espinosab, & Crespo-Ruizb, 2010). Depending on the particular disability, each player has a unique physical capacity affecting players' trunk control and the performance of WCB movements (Genthon & Rougier, 2006). To ensure that players with different physical capacity make part in the same team for competition, there is a player's classification following the rules of the International Wheelchair Basketball Federation (International Wheelchair Basketball Federation [IWBF], 2014). The official player classification manual, classifies athletes into eight classes ranging from 1.0 to 4.5 based on their physical capacity of trunk control, lower limb function, upper limb function and hand function. In particular, the trunk movement and stability form the basis for player classification (IWBF, 2014).

The classification process of a new player starts in the beginning of a competition. In a practice section, prior to the competition, a panel of classifiers observe the athlete's trunk movements capacity according to the volume of action (IWBF, 2014; Goosey-Trofey, 2010) which is standardized for each class. After this initial observation, the classifiers indicate a temporary class among one of the eight classes of WCB. During the games, classifiers continuously observe the performance of the player and, by the end of competition, the classifiers confirm or modify his initial classification (IWBF, 2014). According to this, the classification of wheelchair basketball player is an observation-based classification.

The International Paralympic Committee has encouraged studies based on scientific principles of athletes' classification in paralympic sport (Tweedy & Vanlandewijck, 2011). Some studies have been conducted relating WCB players' performance with physiological responses and their classes (Brasile 1986, 1990; Malone *et al*, 2002; Doyle *et al*, 2004; Molik, Laskin, Kosmol, Skucas, & Bida, 2010) The results of these studies have stated that the athletes' game performance was related to their class. Despite the indication that trunk muscle strength plays an important role for players' capacity of trunk movements and consequently for classification (IWBF 2014), quantitative studies assessing this variable have not been conducted. A quantitative evaluation of this variable would bring objective data of this important aspect of players' classification supporting the observed-based classification. According to this, the aim of this study was to identify and correlate quantitative measures of trunk muscle strength with wheelchair basketball players' classification.

Materials and Methods

Study Participants

Forty-two male wheelchair basketball players of mean age 28.3±7.4 years (16-46) participated in this study during a competitive season. All participants had previously received an official regional, national or international classification as following: class 1.0 (n = 11), 2.0 (n = 11), 3.0 (n = 9), and 4.0 (n = 11). Players of class 1.0 and class 4.5 are those with lower and higher physical capacity, respectively. Free and informed consent form was signed by all participants before evaluations of their trunk muscle strength. The Ethics Committee of the University of Sao Paulo College of Medicine approved this study (n# 063/10). All tests were performed at the Movement Study Laboratory, Institute of Orthopedics and Traumatology of Hospital das Clinicas-SP.

Table 1. Characteristics of participants.

Class	n	Age (Years)	Body Mass (kg)	High (cm)	BMI (kg/cm^2)
1	11	28.0 ± 8.6	61.9 ± 16.5	166.5 ± 14.0	22.5±7.1
2	11	26.5 ± 6.5	61.2 ± 14.0	157.9 ± 13.8	24.7±5.4
3	9	27.0 ± 9.3	68.7 ± 12.4	157.9 ± 13.8	24.9±9.4
4	11	27.9 ± 8.6	74.6 ± 17.2	172.1 ± 11.3	25.5±4.5
Group	42	28.3 ± 7.4	66.5 ± 15.7	165.0 ± 15.8	24.7±6.0

Data are expressed as mean and Standard deviation (±).
n= number of subjects; Kg= kilogram; cm=centimeters; Kg/cm^2 =Kilogram/square centimeter.

Table 2. Distribution of subjects according to disabilities and wheelchair basketball classes.

	Disabilities						
Class	**sci**	**amp**	**polio**	**sb**	**cd**	**art**	**CP**
1	9			1		1	
2	5	1	4	1		1	
3	2	1	3	1			1
4	1	8	1		1		
Total	17	10	8	3	1	2	1

Sci=spine cord injury; amp=amputation; polio=poliomyelitis sequelae; sb= spine bifida; cd=congenital deformity, art=arthrogryposis; cp=cerebral palsy.

Testing Protocol

Trunk muscle strength evaluation: isokinetic dynamometry

For this study, we used the Biodex System-3 isokinetic equipment (model: Biodex Multi Joint System, Biodex System Inc.; software version 4.5) to measure trunk muscle strength in isometric mode (Fleck & Kraemer, 1999). The athletes had undergone prior spinal joint warm-up and familiarization with the equipment. They were positioned in accordance with the manufacturer's standards, in a semi-standing position (Biodex, 2013). The initial position of the trunk was at 90° in relation to the femur, and the knees were flexed at 45° in relation to the lower legs. Stabilizing bands secured using Velcro were positioned around the trunk, waist, legs and feet. The axis of the dynamometer was aligned with the iliac crest with the range of motion limited to -15° of extension and 15° of flexion. During the test, the athletes were instructed applying force into a fixed bar in front of their chest for flexion and, against a back hold support for trunk extension. They exerted maximum trunk flexion and extension strength alternately for five seconds each, in a total of ten repetitions, with intervals of 15 seconds of rest between the repetitions. In order to define the angular amplitude and number of repetition, it was conducted a pilot test with athletes who had higher level of impairments. The mean of highest peak torque (PT) and the radio between the peak torque in flexion and extension were the variables selected to be analyzed. These isokinetic variables describe the muscle's strength capabilities (Biodex, 2013).

Statistical analysis

All data were analyzed with SPSS software for Windows (v.18) and Minitab (v.16) and are expressed as means within the athletes' distributed into WCB classes. The Shapiro-Wilk test confirmed that the data presented a non-normal distribution, and comparisons between the classes were made using the Kruskal-Wallis test with Bonferroni correction. The Spearman correlation coefficient was used to correlate the trunk muscle strength with the wheelchair basketball classes. A *p*-value <0.05 was accepted as significant (Fisher & Van-Belle, 1993).

Results

Trunk muscle strength

Trunk muscle strength progressively increased with the athletes' classes. Players of class 1.0 and 4.0 showed the lowest and the highest values, respectively. Comparing the athletes of different classes, there were significant differences between the mean peak torque during trunk flexion and extension between the following classes: 1.0 and 3.0; 1.0 and 4.0; 2.0 and 3.0; and 2.0 and 4.0. The ratio between the trunk flexion and extension was also significantly different in the comparisons between classes 1.0 and 3.0; 1.0 and 4.0; and 2.0 and 4.0 (Table 3).

Correlation of trunk muscle strength and WCB classes

There was a strong correlation between wheelchair basketball classes and all isokinetic variables measured during extension and flexion of the trunk: (Peak torque extension; Peak torque in flexion; and, Ratio between flexion/extension (Table 4).

Table 3. Comparison of isokinetic variables of trunk muscle strength according to the WCB classes.

Variable	Class 1	Class 2	Class 3	Class 4	
PT extension					1 vs. 3 p = 0.004*
(N/m)	65.0	108.0	218.5	341.3	1 vs. 4 p < 0.001*
					2 vs. 4 p = 0.003*
PT flexion					1 vs. 3 p = 0.006*
(N/m)	43.5	69.9	144.7	129.5	1 vs. 4 p < 0.002*
Flex/Ext ratio					1 vs. 4 p = 0.002*
(%)	107.3	77.9	51.0	42.8	2 vs. 4 P = 0.007*

Kruskal-Wallis test with post-hoc Bonferroni correction;
* $p \leq 0.05$; PT, peak torque; Legend: N/m=Newton per meter; Flex/Ext=Flexion/Extension; %=percentage.

Table 4. Correlation of isokinetic variables stratified by WCB classes.

Class	PT extension r(p-value)	PT flexion r(p-value)	Flex/Ext ratio r(p-value)
1.0	0.509(0.110)	0.196(0.282)	-0,836(<0.001)*
2.0	0.864(<0.001)*	-.109(0.375)	-0.482(0.067)
3.0	0.117(0.383)	0.733(0.012)	-0.433(0.122)
4.0	0.082(0.405)	0.645(<0.05)*	-0.491(0.063)
Total	0.806(<0.001)*	0.691(<0.001)*	-0.631(<0.001)*

r=Spearman's correlation coefficient; PT=peak torque; *p*-value=level of significance $p<0.05$.

Discussion

This study aimed to identify and correlate quantitative measures of trunk muscle strength with the wheelchair basketball players' classification. The mean peak torque during players' flexion and extension of the trunk has shown that the lowest values were found among players of classes 1.0 and 2.0. Athletes with cervical and upper- and mid-thoracic spinal cord injuries, who have partial control over the trunk, are the classic examples of athletes in classes 1.0 and 2.0. The lower peak torque of the trunk extensor musculature, i.e., the musculature working against gravity, may provide the conditions for developing postural abnormalities and respiratory disorders (Schilero, Spungen, Bauman, Radulovic, and Lesser, 2009). This contributed to lower levels of players' physical capacity seen in class 1.0 and 2.0. The highest trunk muscle strength was found in athletes of classes 3.0 and 4.0, which were composed of athletes with higher physical capacity. Athletes in classes 3.0 and 4.0 were those with amputations or impairments after polio and they had less loss of their physical capacity due to the preservation of upper body musculoskeletal structures (lower limb amputees). These important factors contribute towards the higher peak torque values seen in classes 3.0 and 4.0. The results of flexion/extension ratio (Brown, 2008) have shown that the athletes in classes 1.0 and 2.0 had higher flexion/extension ratios than did the athletes in classes 3.0 and 4.0. These results always need to be discussed with care. It means that flexor trunk muscle strength predominated over extensor trunk muscle strength in classes 1.0 and 2.0, but not in the other classes. All isokinetic results are concordant with studies that have analyzed physical and physiological performance of WCB players and their classes (Brasile 1986, 1990; Malone *et al*., 2002; Doyle *et al*., 2004; Vanlandewijck *et al*., 2004; Molik *et al*., 2010).

Due the indication that disabilities impact the capacity of trunk control (IWBF, 2014), it is easier to identify players of class 1.0 and 4.0. In this case, an observation-based classification is enough to identify players of these classes. On the other hand, it is not easy to identify players of classes 1.0 and 2.0; 2.0 and 3.0; and 3.0 and 4.0. These are "neighboring classes" and the impact of disability on the trunk capacity control present a greater variability.

This situation can be verified comparing the trunk muscle strength with WCB classes. The results have shown differences in players of classes 1.0 and 4.0; 1.0 and 3.0; and, 2.0 and 4.0 showing that an observation-based classification might bring doubts for classifiers in the "neighboring classes". The strong correlation found in this study support the indication that trunk muscle strength must be considered as important aspect of players' classification (IWBF 2014; Gil-Agudo *et al*., 2010).

The players' classification is well established in WCB, but scientific evidence is still pursued once it is an observed-based classification (Tweedy & Vanlandewijck, 2011). Despite the indication that quantitative evaluation of disability cannot be taking account into wheelchair basketball players' classification (Brasile, 1990), a combined system of observed-based and quantitative evaluation of players' capacity can contribute to a justified and fair classification of athletes (Vanlandewijck, Spaepen, Lysens, 1995). It is necessary to have in mind that a quantitative evaluation of the trunk muscle strength cannot be solely used to make a decision of full trunk control. It is necessary to consider other factors such as disabilities, wheelchair and, players' strategies to maintain their balance in the seated position, and function of the upper and lower limbs (IWBF 2014).

Conclusion

No studies have investigated quantitatively the trunk muscle strength of WCB players. This study suggests that a quantitative assessment of trunk muscle strength might contribute towards providing objective data about players' trunk control, thereby supporting the current classification of WCB players. The findings of the present study showed a strong correlation of trunk muscle strength and wheelchair basketball classes being able to distinguish players in their classes. However, this quantitative method of evaluation of the trunk muscle strength cannot be solely used to make a decision on the full trunk control.

References

Biodex. (2013). Biodex Multi-Joint System Pro. *Setup/Operation Manual.* Retrivied from: http://www.biodex.com/sites/default/files/835000man_06159.pdf.

Brasile, F.M. (1986). Wheelchair basketball skills proficiencies versus disability classification. *Adapted Physical Activity Quarterly,* 3, 6-13.

Brasile, F.M. (1990). Performance Evaluation of Wheelchair Athletes: More Than a Disability Classification Level Issue. *Adapted Physical Activity Quarterly,* 7, 289-297.

Brown L.E. (2008). *Isokinetics in Human Performance.* Champagne IL/USA: Human Kinetics.

Doyle T.L.A., Davis R.W., Humphries B., Dugan E.L., Horn B.G., Shim J.K., & Newton R.U. (2004). Further Evidence to Change the Medical Classification System of The National Wheelchair Basketball Association. *Adapted Physical Activity Quarterly,* 21, 63-70

Fisher L.D. & Van-Belle G. 1993. *Biostatistics*. New York/EUA: John Wiley & Sons.

Fleck S.J., & Kraemer W.J. (1999). *Fundamentos do treinamento de forca muscular.* Porto Alegre, 2ª Edição: Artmed Bookman.

Genthon N., & Rougier P. (2006). Does the Capacity to Appropriately Stabilize Trunk Movements Facilitate the Control of Upright Standing? *Motor Control,* 10, 232-243.

Gil-Agudo A., Ama-Espinosab A.D., & Crespo-Ruizb B. (2010). Wheelchair Basketball Quantification. *Physical Medicine Rehabilitation Clinic North America*, 21, 141–156.

Goosey-Trofey V. (2010). *Wheelchair Sport.* Loughborough, UK: Human Kinetics.

International Wheelchair Basketball Federation IWBF. (2014). Oficial player classification manual. *International Wheelchair Basketball Federation,* Retrivied from: http://www.iwbf.org/images/a_classification/ClassificationManual2014-2018EnglishFinal.pdf.

Malone L.A., Gervais P.L., & Steadward R.D. (2002). Shooting mechanics related to player and free throw success in wheelchair basketball. *Journal of Rehabilitation Research & Development,* 39(6), 701-710.

Molik B., Laskin J.J., Kosmol A., Skucas K., & Bida U. (2010). Relationship Between Functional Classification Levels and anaerobic performance of wheelchair basketball athletes. *Research Quarterly for Exercise and Sport, 81*(1), 69-73.

Schilero G.J., Spungen A.M., Bauman W.A., Radulovic M., & Lesser M. (2009). Pulmonary function and spinal cord injury. *Respiratory physiology and neurobiology*, *166*(3), 129-141.

Tweedy S.M., & Vanlandewijck Y.C. (2011). International Paralympic Committee position stand—background and scientific principles of classification in Paralympic sport. *British Journal of Sports Medicine,* 45, 259-69. doi:10.1136/bjsm.2009.065060

Vanlandewijck ,Y.C., Spaepen, A.J., Lysens, R.J. (1995). Relationship between the level of physical impairment and sports performance in elite wheelchair basketball players. *Adapted Physical Activity Quarterly*, 12, 139-150.

Vanlandewijck, Y.C. *et al*. (2004). The relationship between functional potential and field performance in elite female wheelchair basketball players. *Journal of Sports Science*, 22, 668–675.

Yildirima, N.U., Comertb, E., & Ozengina, N. (2010). Shoulder pain: A comparison of wheelchair basketball players with trunk control and without trunk control. *Journal of Back Musculoskelet Rehabilitation*, 23, 55–61.

Authors' note

Sileno da Silva Santos, Angélica Castilho Alonso, Júlia Maria D'Andréa Greve are affiliated with the University of Sao Paulo College of Medicine. Movement Study Laboratory, Institute of Orthopedics and Traumatology of Hospital das Clinicas-SP.

Corresponding author

Sileno da Silva Santos
Av. João Peixoto Viegas, 195 Apto. 164, São Paulo, SP, Brazil.
Email: sileno@usp.br

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