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RELATIONSHIPS BETWEEN ANAEROBIC PERFORMANCE, FIELD TESTS, AND FUNCTIONAL LEVEL OF ELITE FEMALE WHEELCHAIR BASKETBALL ATHLETES

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ABSTRACT
Purpose. The aim of this study was to evaluate the associations between anaerobic performance (AnP), applicable field tests, and the functional classification levels in female wheelchair basketball athletes. **Methods.** Female wheelchair basketball athletes (N = 23; Category A, n = 9; Category B, n = 14) from the Canadian national team were evaluated using field tests and the 30-second Wingate Anaerobic Test. Measures of peak power output (PP), time to achieve peak power (tPP), mean power output (MP), and a fatigue index (FI) were used to assess AnP. A test battery evaluating seven wheelchair basketball skills was applied. Student's t test was used to identify differences between the two main functional categories (A and B). Spearman's rank correlation coefficient and Pearson's product-moment correlation coefficient were calculated to determine the significance of all relationships between the parameters of AnP, the results of the field tests, and the eight functional classification levels of the athletes (1.0–4.5 pts.). **Results.** In all analyzed parameters, except for the field test measuring shooting skills, the results of AnP were significantly higher for Category B players. Significant relationships were observed between athletes' classification level and AnP and the field tests except for tPP, the 5 m sprint, and the shooting test. The strongest association was observed for MP and PP, MP and FI, PP and FI (p = 0.001). **Conclusions.** Strong associations were found between the functional classification level and AnP of the female wheelchair basketball athletes. The strongest correlation was confirmed between MP, PP, and the field test measuring the two-handed chest pass, suggesting that this test can be used to indirectly assess the anaerobic performance of female wheelchair basketball athletes.

Key words: wheelchair basketball, female athletes, anaerobic performance, field tests, functional level

Introduction

Wheelchair basketball was established in the United States at Veterans Administration hospitals in 1945/1946 [1, 2]. It was designed to motivate and improve the efficiency of the rehabilitation process for men with spinal cord injuries wounded during World War II. The rules of wheelchair basketball were adopted from those in able-bodied basketball and the game was regulated by the International Wheelchair Basketball Federation (IWBF) [3].

In order to complete in wheelchair basketball, players are assessed using a functional classification system developed by the IWBF to allow for even levels of competition. Classifiers observe the performance-based functional abilities of disabled players during a match and classify them on a five-point scale: 1.0, 2.0, 3.0, 4.0, and 4.5 points, where a higher number signifies better functional ability. However, players with functional abilities bordering between two neighboring point classes may be classified as 1.5, 2.5, or 3.5 point players. Wheelchair basketball players can then play according to class, where Category A is for 1.0–2.5 point players and Category B for 3.0–4.5 point players. However, the total number of points of a five-person basketball team on the court cannot exceed 14 points at the championship level or 14.5 points for national league competitions [3, 4].

Previous studies have shown that wheelchair basketball is largely characterized by intermittent efforts [5]. Coutts determined that players spend 64% of the time propelling their wheelchairs during a game and spend the remaining 36% engaged in wheelchair braking [5]. His results also suggested that wheelchair basketball players perform both aerobic (e.g., during a free play situation) and anaerobic exercise (e.g., during offense or defense situations and when handling the ball). Researchers have begun to pay more attention on evaluating what type of exercise effort is exerted by wheelchair basketball players and also on ways to better evaluate their anaerobic performance, as anaerobic exercise has been found to play a larger role in wheelchair basketball than in other sports practiced by wheelchair athletes [6]. Hutzler et al. emphasized that the level of field performance of wheelchair basketball players largely depends on their anaerobic performance [7]. Goosey-Tolfrey indicated that short-term efforts are especially important in wheelchair basketball, suggesting that

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improved anaerobic performance, especially in the case of Category A players, could influence on-court ability [8].

Many authors have reported the 30-second Wingate Anaerobic Test to be a reliable tool in the measurement of anaerobic performance of wheelchair basketball players albeit this method requiring a laboratory setting [7, 9–12]. However, it is important for researchers and coaches to be able to assess the efficiency of athletes, especially in terms of their anaerobic performance, by using more easily accessible field methods. In this regard, Vanlandewijck et al. [12] found correlations between anaerobic performance and wheelchair basketball skills such as the figure-eight drill, figure-eight with the ball, layup, zone-shot, passing for accuracy, and 20 m sprint. Molik et al. [13] also tested the reliability of various field tests including the 20 m sprint, two-handed chest pass for distance, slalom with the ball, slalom without the ball, bilateral handgrip, and a shooting test. De Grootet et al. [14] additionally confirmed the reliability and validity of the 20 m sprint with the basketball and skills or drills such as the basketball pick up, suicides, lay-up, spot shot, and passing for accuracy.

Many authors have also assessed the relationship between the performance level of wheelchair basketball players and their classification level [9, 10, 12, 15, 16]. De Lira et al. [9] investigated aerobic and anaerobic performance in a homogenous sample of players and showed correlations between their functional classification level and aerobic capacity (peak oxygen – VO_2peak) and anaerobic performance (peak power output, relative peak power output, and mean power output). The authors confirmed that the functional classification system used in wheelchair basketball is a representative of players' ability on the court and their level of aerobic and anaerobic performance. Vanlandewijck et al. [17] showed that the performance of female wheelchair basketball players is dependent on their functional abilities. Molik et al. [11] also found significant differences between the anaerobic performance of Category A and B players. Nevertheless, Molik et al. [10] then found that the level of anaerobic performance of 1.0–2.5 point players (Category A) does not significantly differ from 3.0–4.5 point players (Category B), which may suggest that the classification system for wheelchair basketball athletes should in fact be modified [10].

Therefore, it is prudent that additional research should be conducted on this issue, especially in the use of field tests that may help coaches and trainers to better evaluate the anaerobic performance of wheelchair basketball athletes while also taking into account the players' functional classification level. Therefore, the aim of this study was to further evaluate the associations between anaerobic performance (AnP), applicable wheelchair basketball field tests, and players' functional classification levels.

Material and methods

Twenty-three elite female wheelchair basketball players belonging to the Canadian national team participated in the study. Research was conducted in May 2007, after the Canadian team had won their fourth consecutive world championship, at the team's training camp in Winnipeg, Canada.

Nine participants were Category A players (six paraplegics, one tetraplegic, one with spina bifida, and one had cerebral palsy) whereas the remaining 14 played in Category B (two with spina bifida, one had cerebral palsy, four with lower limb amputations, five had a minimal disability, and two had paresis of a lower limb). The Category A and B participants were 25.8 ± 5.4 and 29.1 ± 10.1 years old with 8.1 ± 6.7 and 7.4 ± 6.7 years of competitive experience, respectively. Body mass was 56.8 ± 12.9 kg for Category A players and 65.4 ± 12.4 kg for Category B players (Tab. 1).

The participants' anaerobic performance was assessed using the 30-second Wingate Anaerobic Test. The test was performed on an Angio arm crank ergometer (Lode, Netherlands) and monitored with Wingate ver. 1.07b software included with the ergometer [18]. The test was performed with the participant sitting in their wheelchair with the axis of rotation of the ergometer set level to the shoulder joint.

The test protocol consisted of a 2 min warm-up on the ergometer at 60 rpm at a workload of 50 W. After the warm-up, the participant was provided a short period of rest and instructed about the test procedure. The workload during the Wingate test was individually calculated for each participant using their body mass and functional capability. Upon the start of the test, the participant cranked the pedals as fast as possible for 30 sec during which verbal motivation was provided.

Anaerobic performance was assessed by measuring peak power output (PP), defined as the highest 5 sec maximum power value recorded during the Wingate test measured in watts (W), the time to reach peak power output (tPP) measured in s, and mean power output (MP) as the mean power achieved during the 30 sec test measured in watts (W). Additionally, a fatigue index (FI) was calculated, characterizing the loss of power from PP to the lowest recorded power value and expressed as W/s.

Based on a review of field tests frequently used wheelchair basketball players [13], a test battery was assembled to measure the following seven parameters:

Table 1. Characteristics of the female wheelchair basketball players

	Category A	Category B
n	9	14
Age (years)	25.8 ± 5.4	29.1 ± 10.1
Competitive experience (years)	8.1 ± 6.7	7.4 ± 6.7
Body mass (kg)	56.8 ± 12.9	65.4 ± 12.4

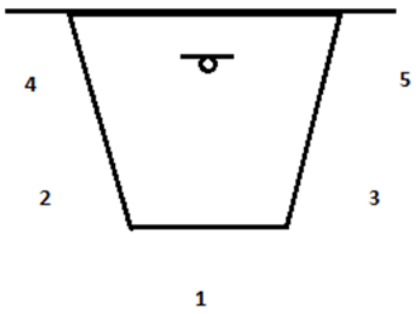

Figure 1. The five shooting spots used in the shooting test

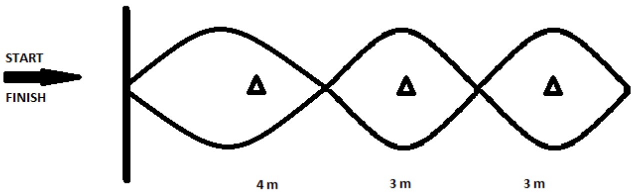

Figure 2. A representation of the slalom course used with and without the ball

- bilateral handgrip – measured by squeezing a DR3 manual handgrip dynamometer connected to a WTP003 tensometer using software ver. 3.1 (JBA, Poland); the participant performed the test seated in their wheelchair with the test arm fully extended and not touching the wheelchair and the recorded result was the combined value for the right and left hand.
- chest pass – performed with the participant in their wheelchair with both feet placed on the footrest; the large wheel axle was lined up with the starting line; the participant was encouraged to use both arms equally to push the ball and the result was the maximum distance the ball travelled, best of three attempts.
- shooting – the participant took ten shots from five different places around the basket (Fig. 1); the result was the number of successful baskets.
- 5 m sprint – performed with the large wheel axle lined up with the starting line; the participant pushed as hard and as fast as they could on a 5 m course and result was the time in seconds, fastest of two attempts.
- 20 m sprint – with the large wheel axle lined up to the starting line, the participant pushed as hard and as fast as they could on a 20 m course; the result was the time in seconds, fastest of two attempts.
- slalom (with the ball) – with the large wheel axle lined up with the starting line, the participant pushed as hard and as fast as they could on a slalom course while dribbling the ball; the result was the time in seconds, fastest of two attempts (Fig. 2).
- slalom (without the ball) – with the large wheel axle lined up with the starting line, the participant pushed as hard and as fast as they could on a slalom course; the result was the time in seconds, fastest of two attempts (Fig. 2).

Statistical analyses were performed using SPSS ver. 21 software (IBM, USA). This included one-way analysis of variance (ANOVA) and Levene's test to compare the parameters measuring anaerobic performance and the field tests. Student's t test was used to identify the differences between the two functional categories (A and B). Spearman's rank correlation coefficient was calculated to determine the significance of all relationships between the parameters of anaerobic performance (AnP), the results of the field tests, and eight possible point classifications (1.0–4.5 pts.). Pearson's product-moment correlation coefficient was used to examine the relationship between the parameters of AnP and the results of the field tests. The level of significance for all statistical procedures was set at 0.05.

Results

Comparison of the Category A and Category B players by the results obtained in the 30-s Wingate Anaerobic Test and the applied field tests is shown in Table 2. Cate-

Table 2. Comparison of the results obtained in the 30-s Wingate Anaerobic Test and field tests among the Category A and B wheelchair basketball players

Test parameter	Category A (1.0–2.5 pts.)	Category B (3.0–4.5 pts.)	*p*-value
MP (W)	145.9 ± 25.7	232.4 ± 43.5	0.001*
PP (W)	250.6 ± 57.6	384.9 ± 83.9	0.001*
tPP (s)	4.8 ± 0.6	4.4 ± 0.2	0.03*
FI (w/s)	5.6 ± 1.8	8.5 ± 2.4	0.007*
Handgrip (kg)	50.3 ± 24.3	69.5 ± 24.3	0.03*
Chest pass (m)	8.0 ± 1.1	9.8 ± 1.7	0.009*
Shooting (%)	40.7 ± 24.3	53.4 ± 19.6	0.17
5 m sprint (s)	2.2 ± 0.1	2.0 ± 0.2	0.03*
20 m sprint (s)	6.4 ± 0.3	5.9 ± 0.4	0.008*
Slalom without ball (s)	10.5 ± 0.9	9.5 ± 0.6	0.01*
Slalom with ball (s)	12.4 ± 2.6	10.7 ± 1.4	0.049*

MP – mean power output, PP – peak power output, FI – fatigue index, tPP – time to achieve peak power,
* statistically significant values ($p < 0.05$)

Table 3. Relationships between anaerobic performance parameters (30-s Wingate Anaerobic Test), field tests, and the functional classification level of the wheelchair basketball players

	Classification level	
	ρ	*p*-value
MP	0.803	0.001*
PP	0.726	0.001*
tPP	–0.280	0.196
FI	0.664	0.001*
Handgrip	0.522	0.011*
Chest pass	0.683	0.001*
Shooting	0.361	0.091
5 m sprint	–0.395	0.062
20 m sprint	–0.552	0.006*
Slalom without ball	–0.520	0.013*
Slalom with ball	–0.636	0.001*

MP – mean power output, PP – peak power output, FI – fatigue index, tPP – time to achieve peak power, * statistically significant values ($p < 0.05$)

gory B players achieved significantly better results in all of analyzed parameters except in the shooting test.

There were significant correlations between the athlete's classification level and all the parameters measuring anaerobic capacity and the field tests except for tPP, the 5 m sprint, and the shooting test (Tab. 3). Additional analysis found that MP, PP, and the chest pass test had the strongest relationship with an athlete's functional classification level.

Table 4 presents correlation analysis of the parameters measuring anaerobic performance. The strongest associations were observed in MP and PP, MP and FI, PP and FI ($p = 0.001$), where $p = 0.001$ (Tab. 4).

Correlation analysis found significant correlations between the handgrip and chest pass tests (ρ = 0.449) and the handgrip test and 20 m sprint (ρ = –0.429). The chest pass test and 20 m sprint were both significantly correlated with all other field tests (Tab. 5). The shooting test and slalom without the ball were significantly correlated with all tests except for handgrip. Moreover, the 5 m sprint was significantly correlated with all field tests except the handgrip test and slalom with the ball.

Table 4. Relationships between the parameters of anaerobic performance measured by the 30-s Wingate Anaerobic Test

		MP	PP	tPP	FI
MP	ρ	1.000	0.969*	–0.496*	0.887*
PP	ρ		1.000	–0.509*	0.967*
tPP	ρ			1.000	–0.444*
FI	ρ				1.000

MP – mean power output, PP – peak power output, FI – fatigue index, tPP – time to achieve peak power, * statistically significant values ($p < 0.05$)

For the parameters measuring anaerobic performance, there were statistically significant correlations between MP and PP and all the applied field tests except for the 5 m sprint (Tab. 6). The strongest association was observed between MP and PP and the chest pass (ρ = 0.797 and ρ = 0.816, respectively; $p = 0.001$).

Discussion

Researchers have emphasized the benefits of physical activity for physically disabled individuals, citing improved cardio-respiratory function, increased aerobic capacity of trained athletes, or better upper limb anaerobic performance by those practicing wheelchair basketball [19, 8, 20], although there is one study stating that wheelchair basketball did not lead to an improvement in anaerobic performance [8]. However, due to the anaerobic nature of wheelchair basketball [5–8] and the need of coaches to indirectly assess the anaerobic performance of their athletes without using complicated and costly methods, the aim of this study was to investigate the relationships between anaerobic performance (AnP), applicable field tests, and the functional classification system used in wheelchair basketball.

This study found that there were significant differences between the level of AnP and the employed field tests, confirming previous findings on a group of male wheelchair basketball players [10]. Our study demonstrated that there were correlations between the func-

Table 5. Relationships between field tests performed by the wheelchair basketball players

		Handgrip	Chest pass	Shooting	5 m sprint	20 m sprint	Slalom without ball	Slalom with ball
Handgrip	ρ	1.000	0.449*	0.131	–0.260	–0.429*	–0.354	–0.296
Chest pass	ρ		1.000	0.704*	–0.620*	–0.721*	-0.632	-0.668*
Shooting	ρ			1.000	–0.416*	–0.468*	–0.752*	–0.778*
5 m sprint	ρ				1.000	0.849*	0.559*	0.416
20 m sprint	ρ					1.000	0.721	0.623*
Slalom without ball	ρ						1.000	0.904*
Slalom with ball	ρ							1.000

* statistically significant values ($p < 0.05$)

Table 6. Relationships between mean power output (MP) and peak power output (PP) and the field tests performed by the wheelchair basketball players

	MP	PP
	ρ	ρ
Handgrip	0.573*	0.581*
Chest pass	0.797*	0.816*
Shooting	0.490*	0.504*
5m sprint	–0.391	–0.450*
20m sprint	–0.519*	–0.556*
Slalom without ball	–0.529*	–0.531*
Slalom with ball	–0.531*	–0.505*

MP – mean power output, PP – peak power output,
* statistically significant values ($p < 0.05$)

tional classification of wheelchair basketball players and the achieved field test results and the analyzed parameters of AnP. One exception was the lack of correlation between the functional classification level and the shooting test, and the 5 m sprint and the time to reach maximum power (tPP).

The most significant relationships were observed between players' functional classification level and MP and PP, where the strongest relationship with MP and PP was the two-handed chest pass test. Therefore, it appears that this test can be used to as indirectly assess anaerobic performance in wheelchair basketball players. Although coaches could employ the other tests used in this study, their relationship with AnP is not strong as in the case of performing the chest pass. This test can assist coaches looking for new solutions to monitor the training process and measure progress in physiotherapy among disabled individuals practicing wheelchair basketball.

Molik and Kosmol [21] previously confirmed the possibility of using field tests to assess training progress and the changes in the fitness level of wheelchair basketball players [21]. However, Hutzler et al. noted differences between women and men and the results of tests quantifying anaerobic performance [7]. The authors found that PP and MP had significantly larger differences in women than in men.

In addition, it should be noted that the majority of the above-mentioned studies focus on male wheelchair basketball players, whereas few studies have analyzed this aspect on a female population.

It is interesting to note that if there are indeed correlations between anaerobic performance and the selected field tests and the functional level of the players, then an improvement in the results of field tests may affect the functional level of the players and therefore lead to improved player efficiency among female wheelchair basketball players [22].

Vanlandewijck confirmed that the functional classification of female wheelchair basketball players using a 5-point scale (1.0–4.5 pts.) is an accurate representation of their level of functional ability [17]. However, in the future, researchers should continue to check and update the criteria used to determine the functional classification of wheelchair basketball players due to the ongoing general improvement of training methods and materials, the growing interest of this sport among women, advances in technology (better designed and lighter wheelchairs), and the efforts of disabled individuals to improve their functional capabilities.

Conclusions

Strong relationships were found between functional classification level and the anaerobic performance of the analyzed elite female wheelchair basketball players. It addition, Category B players (3.0–4.5 pts.) had significantly higher levels of AnP and performed better in the field tests than Category A players (1.0–2.5 pts.). Among this group of athletes, the strongest correlation was found between mean power output (MP) and peak power output (PP) and the results of the two-handed chest pass test. This suggests the chest pass test can be used to indirectly assess the anaerobic performance of female wheelchair basketball athletes.

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