The physiological response of athletes with impairments in wheelchair basketball game

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Abstract

Purpose. The aim of this study was to analyze the physiological response of WB athletes related to type of impairment and functional classification in game situations

Material and methods. Fifteen male players from Polish National Wheelchair Basketball Team were observed during friendly and championships games (2017 and 2018). Heart rate (peak and average – HR_{peak} and HR_{av}), number of sprints were monitored for each player per a full game by Polar Team Pro. Five HR zones were calculated for each athlete based on VO_{2peak}, anaerobic threshold, HRmax, body weight and age (aerobic laboratory test). Heart rate reserve (HRR) and percentage heart rate reserved (%HRR) were calculated. Results were compared between athletes related to the type of impairment (spinal cord injuries and other physical impairments) and functional classification (Group A – from 1.0 to 2.5 points; Group B – from 3.0 to 4.5 points).

Results. The results showed the specificity of WB games, i.e. all players were found in all five HR zones with different contribution. Players from Group A played less than players form the Group B in fifth HR zone (respectively, 15% and 21%) and had significantly lower HR_{peak} and HR_{av}, HRR, %HRR and did more sprints.

Conclusions. The current study confirmed differential specificity of a WB game. It was observed that there are significant differences in the physiological response between WB athletes representing different functional levels. This knowledge is important to plan preseason conditioning exercises for each individual WB athlete. Further studies are needed to better understand the physiological response of WB athletes.

Key words: adapted physical activity; game performance; heart rate; impairment; sport

INTRODUCTION

Wheelchair basketball (WB) is popular and well-known sports discipline for people with impairments. The importance of WB for athletes in their daily life was strongly underlined in the literature [1]. WB is a Paralympic team sport for individuals with physical impairment characterized by chronically disabling conditions which result in loss of use of the legs, e.g. spinal cord injury, cerebral palsy, musculoskeletal conditions, spina bifida, amputation, poliomyelitis, and others, which reduce ability to play running basketball as an able-bodied player [2-4]. All athletes are divided based on criteria of the functional abilities in five classes (functional classification 1.0, 2.0, 3.0, 4.0 and 4.5 points). The International Wheelchair Basketball Federation (IWBF) also mandates three subclasses (functional classification 1.5, 2.5, and 3.5 points) for athletes presenting mixed characteristics of two classes (functional classification 1.0 and 2.0, 2.0 and 3.0 or 3.0 and 4.0) [2, 3]. Moreover, the classification guide assigns athletes without pelvic control (functional classification 1.0-2.5 points) into Group A and those with pelvic control (functional classification 1.0-2.5 points) into Group B [2]. The greater the class (points), the greater the functional level of the athlete. In the current IWBF rules for international games, the point limit for the five players from one team on the floor at any one time is 14 points (i.e. 1.0 point + 2.0 points + 3.0 points + 3.5 points + 4.5 points = 14.0 points) [2, 3].

WB has been described as a dynamic and intermittent team game where team's success depends on technical, tactical and physical preparation of athletes [5]. Players push, stop and maneuver the wheelchairs, dribble and pass the ball, shoot and cooperate with teammates, as well as oppose opponents' movements in offensive and defensive parts of the game. Researchers analyze all of these elements to understand which specific factors of the game influence and decide the outcome of the game, and to better understand players' physiological responses in authentic conditions related to their specific disability and functional classification. For example, Perez et al. (2003)

checked physiological exigency in WB through heart rate (HR) monitoring during a competition (seven matches), and established the individual physiological response to game situations, tactical situations and player's functional classification among two WB athletes. Authors concluded that offensive situations with the ball are the most demanding situations during the game, and they underlined that WB game has intermittent physiological demands on the players [6]. They strongly recommended continuation of this type of research, because of the small number of subjects in their research.

Perez et al. (2007) expanded the previous study [6] to more subjects and they observed more matches (five WB athletes in eleven matches). The authors monitored athletes' heart rate to determine if the training plan was sufficient and they established that there are differences between the Group A (functional classification between 1.0 and 2.5 points) and Group B (functional classification between 3.0 and 4.5 points) in HR reserve (HRR), match periods and role distribution during a game [7].

Due to the scarcity of papers about WB athletes' physiological response during a game, the present authors decided to extend Perez et al.'s studies. The aim of this study is to analyze the physiological response of WB athletes in game situations across individual heart rate zones and number of sprints in relation to functional classification and disability type. This knowledge will help trainers and athletes to prepare appropriate training plans and to enable athletes to play at the highest level of their abilities.

MATERIAL AND METHODS

Participants

Fifteen male WB players representing Polish National Wheelchair Basketball Team were observed. Athletes were divided into two Groups, i.e. Group A (functional classification 3.0-4.5 points; n=7) and Group B (functional classification 1.0-2.5 points; n=8). There were no significant differences in age, body weight or body height between two athletes' Groups (table 1).

The researcher observed the athletes during three different tournaments: one friendly tournament before European Championships in Wałbrzych (Poland) in June 2017, European Championships in Tenerife (Spain) in June 2017, and one friendly tournament in Wałbrzych (Poland) in July 2018). To be included in these analyses a player had to participate in a minimum 30 minutes of active play in a match [8]. Players were observed and their physiological responses from 15 total games were analyzed.

The study was approved by the local bioethics committee and was completed in accordance with the ethical standards as described in the Declaration of Helsinki (KEIB-10/2016). All participants were asked to agree for participation in this study, and they were provided written consent.

Match monitoring

Heart rate (HR; HR_{peak}, HR_{av}, $\%HR_{av}$) and a number of sprints were monitored during each match by using downloadable, wirelessly Polar Team Pro (Polar Team Pro, Kempele, Finland). Heart rate parameters were frequency coded at 1-second registration intervals. All athletes wore a numbered heart rate chest strap during each match. All data files were downloaded to a computer after every match. Inactive time (e.g. half-time break, time outs in each match) was also registered by Polar Team Pro.

Match data analysis

To establish the maximal hear rate (HR_{peak}) for each player, aerobic performance laboratory testing was performed on the arm crank ergometer 1-4 weeks before the match (May 2017 and May 2018) the aerobic performance laboratory test was performed on the arm crank ergometer (Lode ACE; Groningen; the Netherlands) This protocol was proposed by Molik et al. (2017) [9]. To maximize trunk stability, the athletes used their own basketball wheelchairs and their strapping system (like during the game). The ACE was firmly affixed to a wall-mounted gymnastic ladder. The ergometer's rotation axis was set up on the athlete's glenohumeral joints level. Two assistants stabilized the athlete's wheelchair to minimize rotational movements during arm cranking. The resisting force in this test was systematically increased from 35 Watts every two minutes by 35 Watts. Participants tried to keep the speed level of 70 rpm. HR_{peak}, peak oxygen uptake (peak VO_2), minute ventilation (VE), anaerobic threshold (PPA) were collected. All physiological parameters were measured by K5 system (Cosmed, Italy) consisting of a mask and portable unit worn on the participant's back and by GARMIN sensor connected and compatible with K5. Breath-by-breath data were averaged over 10 s. The lactate concentration (LA_{max}) and drop in concentration of lactate (%LA) were measured before the first and the second test, during tests every 2 minutes as well as directly after the completion of the tests and in the 3rd, 6th, 9th and 30th minutes after the finish the test to assess PPA.

Five HR zones (I - 50-59%, II - 60-69%, III - 70-79%, IV - 80-89%, and V - 90-100%) were established by Polar Team Pro software. Polar Team Pro software counts sprints, if acceleration of movement is established. To establish acceleration, uniformly accelerated motion equation of was used. Time (t), velocity (v) and displacement (s) to uniformly accelerated motion equation was taken from 3 m and 5 m sprint tests. Players had performed these tests before this study, and average acceleration was set up as 1.5 m/s2. Based on acceleration the number of sprints was measured during a match by Polar Team Pro sensor (Polar's algorithm) that was placed on the chest strap (this is the same sensor that measures heart rate).

Additionally, heart rate reserve (HRR) and percentage of heart rate reserve (%HRR) were calculated. HRR is the difference between maximum heart rate in a game (HRpeak) and resting heart rate (HRrest) [10, 7]:

[1] $HRR = HR_{peak} - HR_{rest}$

Percentage of hearth rate reserve (%HRR) was calculated using the formula:

[2] $\%HRR = (HR_{av} - HR_{rest})*100/HRR$

Statistical analysis

All analyses were performed using the SPSS IBM Statistics 24 for Windows. means and standard deviation (*sd*) of the data were calculated. The distribution of the results was checked by using the Kolmogorow-Smirnow test. Results between athletes from Group A and Group B were compared with t-test for independent samples. The level of significance deemed acceptable was $p < .05$. Additionally, Cohen's formula was used to calculate effect size (ES). Following levels of effects were estimates: small 0.2, medium 0.5, and large 0.8 [11].

Table 1. Physical impairment and anthropometric characteristic of the elite wheelchair basketball athletes

Athlete	Age [years]	Body mass [kg]	Body height [cm]	Type of impairment	Functional classification (1.0-4.5 points)	Group (A-B)
1	27	77.1	185	PARAPLEGIA	1.0	A
2	36	61.6	173	PARAPLEGIA	1.0	A
3	33	75.6	185	PARAPLEGIA	1.0	A
4	18	72.9	197	OTHER	4.5	B
5	33	76.3	183	AMPUTATION (single above knee)	4.0	B
6	21	58.3	165	SPINA BIFIDA	3.0	B
7	40	78.0	196	PARAPLEGIA	1.0	A
8	36	86.6	186	CEREBRAL PALSY	3.5	B
9	21	75.0	170	SPINA BIFIDA	3.0	B
10	34	68.0	184	AMPUTATION (single above knee)	4.0	B
11	44	92.6	190	AMPUTATION (single below knee)	4.5	B
12	25	68.0	178	PARAPLEGIA	1.5	A
13	28	71.0	190	PARAPLEGIA	2.0	A
14	32	76.0	188	AMPUTATION (single above knee)	4.0	B
15	34	69.0	178	PARAPLEGIA	1.0	A
Group A						
$\bar{x} \pm$ sd	30.4 ± 5.4	71.5 ± 5.9	183.6 ± 7.9			
Group B						
$\bar{x} \pm$ sd	29.6 ± 9.1	75.7 ± 10.5	182.9 ± 10.5			
Total						
$\bar{x} \pm$ sd	30.0 ± 7.4	73.7 ± 8.7	183.2 ± 9.1			

$\bar{x}$ – mean; sd – standard deviation

RESULTS

Results of the heart rate parameters and number of sprints for athletes representing the Group A (functional classification 1.0-2.5 points), the Group B (functional classification 3.0-4.5 points), and total wheelchair basketball athletes were presented in table 2. There were significant differences and large ES between results achieved by athletes from the Group A and B in all parameters. Athletes representing higher functional abilities (Group B) achieved higher results of HR_{av}**,** $\%HR_{av}$, HR_{peak}, HRR, and %HRR. HR_{av} while Group A athletes' results were 120.9 and 136.2 from the Group B (p=0.001; ES=2.35). $\%HR_{av}$ was noted as 74.7 for athletes from the Group B and 67.2 from the Group A (p=0.001; ES=1.64). A significantly higher HR_{peak} was achieved by athletes from the Group B compare to athletes from the Group A (respectively, 183.4 and 174.4; p=0.001, ES=1.78). HRR and %HRR were higher for athletes from the Group B than from the Group A (respectively, 123.9 versus 113.7, and 62.4 versus 55.3; p=0.002 and ES=1.45 for HRR; p=0.004 and ES=1.40 for %HRR). The analyzes of %HRR showed that athletes from the Group A worked with lower intensity in the first heart rate zone compared to athletes from the Group B who worked in the Zone 2 (table 2).

Athletes from the lower functional classes (functional classification 1.0-2.5 points – Group A) sprinted more times during wheelchair basketball game. Group A athletes performed an average of 80.1 sprints per game, and athletes from the Group B 53.2, respectively (p=0.002, ES=1.42) (table 2).

Figure 1 shows characteristics of the work in different heart rate zones during wheelchair basketball matches. Athletes representing the Group A had the highest contribution in zone 2 of heart rate (25%) and the lowest in zone 5 (15%). Athletes from the Group B worked in similar contributions in zones from 2 to 5 (20-22 %) and lowest contribution in zone 1 (15%) (figure 1).

Table 2. Heart rate and sprints achieved by wheelchair basketball athletes representing the Group A and B during matches

Parameter	Group A (1.0-2.5 points)		Group B (3.0-4.5 points)		Total		p	ES
	$\bar{x}$ ± sd	min-max	$\bar{x}$ ± sd	min-max	$\bar{x}$ ± sd	min-max		
HR_{av} [beats/min]	120.9 ± 4.0	115 - 127	136.2 ± 8.3	121 - 149	128.5 ± 8.9	115 - 149	0.001	2.35
$\%HR_{av}$ [%]	67.2 ± 3.3	63 - 73	74.7 ± 5.4	65 - 83	70.1 ± 5.4	63 - 83	0.001	1.64
HR_{peak} [beats/min]	174.4 ± 7.1	160 - 183	183.4 ± 4.5	177 - 192	178.8 ± 6.5	160 - 192	0.001	1.78
Sprints [n]	80.1 ± 21.2	55 - 120	53.2 ± 16.3	33 - 80	66.5 ± 21.3	33 - 120	0.002	1.42
HRR [beats/min]	113.7 ± 7.5	102 - 125	123.9 ± 4.9	117 - 132	119.2 ± 6.8	102 - 132	0.002	1.45
%HRR [%]	55.3 ± 2.9	51 - 60	62.4 ± 6.5	52 - 73	58.9 ± 5.6	51 - 73	0.004	1.40

$\bar{x}$ – mean; sd – standard deviation; HR – heart rate; HRav – average heart rate; %HRav - percentage of average heart rate; HRpeak – maximal heart rate in a game; HRR - heart rate reserve; %HRR - percentage of heart rate reserve

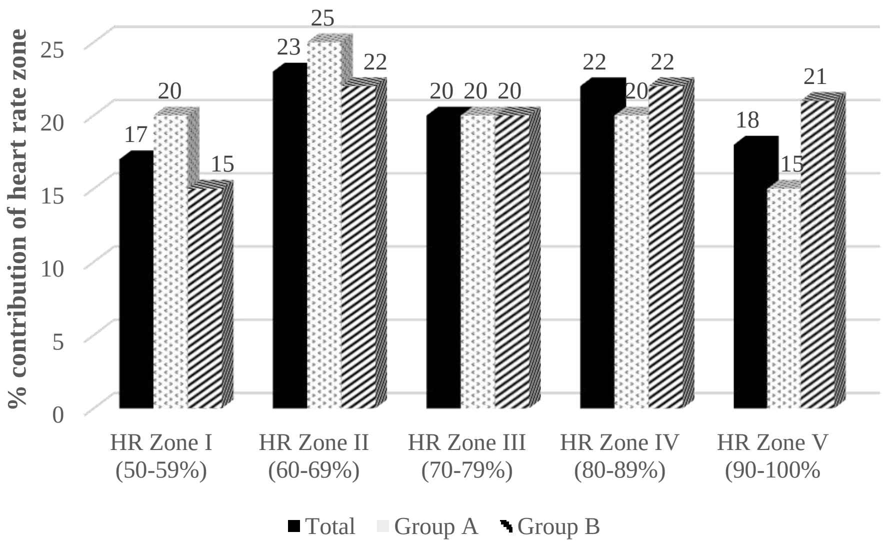

Figure 1. Athletes' physiological response during wheelchair basketball game – percentage contribution of five heart rate zones

DISCUSSION

The aim of this study was to analyze the physiological response of wheelchair basketball athletes in game situations based on heart rate zones and number of sprints in relation to functional classification and disability. The physiological responses (HR; HR_{peak}, HR_{av}, $\%HR_{av}$, HRR, %HRR) which were analyzed during WB games were significantly higher for athletes with higher functional classification (Group B, athletes between 3.0-4.5 points). However, comparing how long these players were in each HR zone during a game, it turned out that they spent more time in lower level HR zones (I-II). The opposite situation was noticed for athletes with lower functional classification (Group A, athletes between 1.0-2.5 points). This observation (the difference between A and B Group athletes) is evidence that the current classification system divides WB athletes appropriately in terms of their functional abilities, and, in this case, different physiological responses during a game. That is why, authors of this study supposed that lower HR results could correlate with the type of impairment – all individuals from the Group A had spinal cord injury. In a similar study, Iturricastillo et al. (2016c) observed values of absolute HR (current HR_{peak}) and relative HR results in small-sided WB games between athletes with and without spinal cord injury. They noticed that lower absolute HR was achieved by athletes with spinal cord injury but no differences were obtained in relative HR results between Groups [12].

What is important to underline discussing about HR assessment before the match HR data analysis, in the current study, the valid aerobic test on the armcrank ergometer proposed by Molik et al. (2017) [9] was used to assess HRpeak. Iturricastillo et al. (2016c) assessed absolute HR in a field test - the 10m Yo-Yo intermittent recovery test level 1 (YYIR1) [13, 12]. Iturricastillo et al. (2016c) and Molik et al. (2017) used valid and reliable but different HRpeak assessment methods. In consequence, we decided to use Molik's et al. (2017) approach [9] in our study.

Also, Perez et al. (2007) completed research exploring the physiological response in WB. They underlined that the higher the players functional potential, the higher %HRR attained. Moreover, they concluded that physiological demands in a team sport competition and in adapted sports such as WB, should be related to HR and %HRR of athletes, personal characteristics like age, weight, gender, and especially to players' functional classification [7]. It would be helpful to find perceived exertion (RPE responses) of players with and without spinal cord injury, to be more subjective and detailed in future analyses [13].

On the other hand, West and Krassioukov (2017) found a different relationship. They analyzed autonomic cardiovascular function of 14 WB players in relation to the WB classification system. Their study showed that the current sports classification system used in WB does not accurately reflect cardiovascular function and thus, places some athletes at a distinct disadvantage/advantage within their respective sport class (there are not clear differences in cardiovascular function between athletes from different sports class in WB) [14]. The current analysis showed that further investigation is needed to describe relationship between physiological response during wheelchair basketball matches and athletes' functional classification. There is a need to continue this course of study.

In the present study, HRav values for both groups were relatively low (128.5 beats/min). Perez et al. (2007) noted similar results for Spanish elite athletes (132.1 beats/min) [7]. However, Croft et al. (2010) showed HRav value as 163 beats/min calculated for a whole WB game and HRav as 154 beats/min during basketball active playing time (without breaks and stops) [15]. Also, dos Santos et al. (2017) noted HRav values as 163 beats/min for two basketball athletes. In the current study, all HR parameters were monitored during an entire game (with breaks between quarters, etc.) [16]. That is why physiological profiles were different compared to other studies.

Our analysis confirmed previous investigations of Perez et al (2007). In the present study, %HRR was noted as 58.9 while Perez et al. (2007) showed %HRR as 58.4. These authors also showed higher all HR values for players with higher functional classifications compared to players with lower functional classifications [7].

The number of sprints which performed by wheelchair basketball athletes in a game, was another factor considered in this study. Results showed that athletes with lower functional classification (Group A) did significantly more sprints in a game than athletes with higher functional classification (Group B). We argue that the difference is due to athletes between 1.0-2.5 points having a different tactical role than athletes between 3.0-4.5 points. They tend to mark opponents more closely (stop in front of the opponent) and play more of a defensive role than an offensive role. They stop the wheelchair more often, e.g. when shooting, and when they maneuver the wheelchair between other players. When the Group A players want to start moving they have to push the wheelchair very dynamically and quickly (their acceleration is higher). Group B players typically move most of the time during the match, and they do not need to push the wheelchair so dynamically to start the movement, because their trunk control is significantly better, and they are apt not stop in shooting action. They maneuver the wheelchair faster between opponents, and they maintain the speed of their wheelchair. That is why athletes with lower functional classification did significantly more sprints in this study than athletes with higher functional classification.

In the current study the differences in %HRR between athletes were observed. The difference in %HHR was higher among athletes from the Group B and showed that these players were playing with higher intensity in analyzed matches compared to players with spinal cord injury, i.e. Group A (%HHR was 62.4 versus 55.3). Moreover, all analyzes of heart rate zones confirmed that athletes from the Group A spent the least amount of time in the fifth zone (HR zone V - 90-100%), and athletes from the Group B worked the least amount of time in the first zone (HR zone I - 50-59%). We perceived that the lower values of all HR results were achieved in this study compared to Croft et al. (2010) and dos Santos et al. (2017), because time outs and all breaks were considered in the current study's calculations [15, 16]. Perhaps, considering only the active part of the game would indicate higher level of intensity of the athletes.

Limitation of the current study and recommendation for future studies

In this study active time and inactive time during a match were included. In the future studies, athletes' active time of play should be compared to total time (active and inactive time). Half-time and quarter intermissions, time outs in each match, etc. should be cut from the main analysis. The physiological response should be also compared to each athletes' functional class, not only between two Groups. Future analyzes should considerate a match score (winning and losing) and the order of games (the final game vs the first game), as well as athletes' perceived exertion like other authors have advised [13]. It would be interesting to measure the average distance which athletes travel during a match.

CONCLUSIONS

The current study confirmed differential specificity of a WB game, i.e. all players were found in all five HR zones with different contribution (from 50% to 100% of $HR_{peak,}$ where 50% of HR_{peak} is close to resting HR (HR_{rest})). It was observed that there are significant differences in the physiological response (all HR parameters) between WB athletes representing different functional levels. This knowledge is needed to plan the system of preseason conditioning exercises for each WB athlete. Further research studies are needed in this field to understand the physiological response of WB athletes during games more fully.

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