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Perceived Exertion in Small Sided-Games Internal Load Quantification in Wheelchair Basketball Players

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Abstract

The present study seeks to analyse the physiological responses, differential perceived exertion and perceived load of wheelchair basketball (WB) players during a small sided games (SSG) and to analyse the existence or not of differences studied variables according to whether or not they have a spinal cord injury and the age of the players. This study makes a total of 128 observations of a single format SSG (4 vs. 4 players with a duration of 4 min). The players with a spinal cord injury obtain a lower mean heart rate (HR_{Mean}) and a lower peak HR (HR_{Peak}) in the SSG than players without a spinal cord injury ($p < 0.001$; ES = 0.9 to 1.1; large). However, players with a spinal cord injury show higher respiratory (RPE_{res}) and muscular (RPE_{mus}) perceived exertion than players without a spinal cord injury as well as record a higher respiratory (RPE_{res} TL) and muscular (RPE_{mus} TL) load ($p < 0.001$; ES = -0.7 to -0.8, moderate-large). Related to age groups, the results obtained demonstrate that players < 30 years old obtain higher HR_{Mean}, HR_{Peak}, tympanic temperature ($p < 0.001$; ES = -1.1; high), RPE res, RPE_{mus}, RPE_{res} TL and RPE_{mus} TL ($p < 0.001$; ES = -0.7 to -0.9; moderate-large) than players > 30 years in the SSG. The impairment (whether they have a spinal cord injury or not) and the age of the players can affect the internal load in a SSG and the perceived exertion method can provide additional information about the load, especially among players with a spinal cord injury.

Keywords: heart rate, temperature, internal load, intensity, physiological response

Introduction

The specific demands presented by wheel-chair basketball (WB) competitions (Aitor Iturricastillo et al., 2018; Marszałek et al., 2019) from the physical, physiological, technical and tactical point of view, lead coaches to develop training tasks that cause positive effects in all dimensions that influence performance. Thus, one of the tasks commonly used by basketball coaches to provoke physical adaptations and specific abilities in players is the small-sided game (SSG) (Taylor, 2004). The SSG are training tasks that are similar to competition and are played using modified areas and rules and with fewer players on the court (Castagna, Impellizzeri, Chaouachi, Ben Abdelkrim, & Manzi, 2011). In spite of the many scientific investigations carried out on different team sports including basketball (Ade, Harley, & Bradley, 2014; A Delextrat & Martínez, 2014; Gómez, Paulis, & Blanco-Villaseñor, 2012; Halouani, Chtourou, Gabbett, Chaouachi, & Chamari, 2014; Harrison, Gill, Kinugasa, & Kilding, 2013), to the best of our knowledge, there are only a limited number of studies that analyse the physiological responses of WB players in different types of SSG (Aitor Iturricastillo, Granados, Los Arcos, & Yanci, 2017; A Iturricastillo, Yanci, Los Arcos, & Granados, 2016; Mason, van der Slikke, Hutchinson, Berger, & Goosey-Tolfrey, 2018; J Yanci, Iturricastillo, & Granados, 2014), so that the obtention of more information on the responses of WB players in SSG could have interesting practical applications.

Among all the physiological variables, heart rate (HR) monitoring has been the most commonly used to ascertain the intensity of training tasks in many sports (Hill-Haas, Dawson, Impellizzeri, & Coutts, 2011; Jeukendrup, 2003) and also in WB (Aitor Iturricastillo et al., 2017; Aitor Iturricastillo, Granados, & Yanci, 2016; Aitor Iturricastillo, Yanci, Granados, & Goosey-Tolfrey, 2016; Marszałek et al., 2019; Mason et al., 2018). Several studies describe that it is an indicator of exercise intensity (Drust, Reilly, & Cable, 2000; Esposito et al., 2004). However, some studies question it's validity in athletes with a disability, especially in the case of players with a spinal cord injury (Jacobs et al., 1997; Lewis, Nash, Hamm, Martins, & Groah, 2007). Previous research shows that athletes with a spinal cord injury can present alterations in their capacity to increase HR, mainly due to impaired control of the sympathetic/parasympathetic nervous system (Goosey-Tolfrey & Leicht, 2013). This aspect highlights the need to

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know if, in common training tasks in WB like SSG, the HR of these players differs from those who do not have a spinal cord injury and if other methods of quantification of the internal load, like the subjective rating of exertion and perceived workload proposed and used in WB (Aitor Iturricastillo et al., 2018; Aitor Iturricastillo, Cristina Granados, et al., 2016) can provide complementary information on the responses of WB players to SSG. Moreover, it is common in WB teams to have players of very different ages, from younger to much older players (Granados et al., 2015; Aitor Iturricastillo, Cristina Granados, et al., 2016; Javier Yanci, Iturricastillo, Lozano, & Granados, 2015), therefore, it will also be interesting to discover if the age of the players influences internal load in training tasks.

Therefore, the objectives of the present study are, on the one hand, to analyse the physiological response, and differential perceived exertion and workload in WB players during SSG, and on the other to investigate the existence or not of differences in the variables studied as a function of whether they had a spinal cord injury, and their ages.

Methodology

Participants

An analysis is made on the basis of 128 observations in a single format SSG (4 *vs.* 4 players) with a duration of 4 minutes. The observations are divided according to whether the participating players have a spinal cord injury or not (spinal cord injury group, n = 6 players, 48 observations; non-spinal injury group, n = 7 players, 80 observations) and according to the age group (< 30 years, n = 5 players, 58 observations, > 30 years, n = 8, 70 observations). The range of observations made per player ranges from 4 to 20. The SSG are played by 13 players who belong to a team from the First Division of the Spanish WB League. They all have more than 5 years' experience in this sports modality and have a licence from the Spanish Federation for Sports for people with a Physical Disability and the corresponding functional classification from the Wheelchair Basketball Federation (IWBF). The procedures adhere to the guidelines set down by the Declaration of Helsinki (2008) updated in Fortaleza (2013).

Procedure

The study has been carried out over five consecutive weeks during the competitive period in which all the SSG tasks that used the same format are monitored (4 *vs.* 4, a duration of 4 min, played on their own training court and in an area of 28 x 15 m) (Aitor Iturricastillo et al., 2017; A Iturricastillo et al., 2016). This task is chosen as it is commonly used by the coach in team training sessions, so that all the players know the SSG analysed. All the SSG tasks included in the study are carried out in some of the team's training sessions in the evenings (20-21h). The same instructions are given to the players in all the tasks and the IWBF rules are applied (IWBF, 2014). In all the SSG tasks analysed, the two teams are formed according to the coaching staff's criteria, with equality in the total score for functional classification and sports level.

Measurements

HR monitoring: HR is monitored every 1s in all the players in all the SSG played (Polar Team Sport System®, Polar Electro Oy, Finland) (Aitor Iturricastillo et al., 2017; A Iturricastillo et al., 2016) obtaining peak heart rate (HR_{peak}) and mean heart rate (HR_{mean}) for each player in each SSG played. Internal load has also calculated using the Edwards ($Load_{Edwards}$) and Stagno ($Load_{Stagno}$) methods, (Edwards, 1993; A Iturricastillo et al., 2016; Stagno, Thatcher, & Van Someren, 2007) as well as the time spent in each intensity zone as a percentage of HR_{peak} reached in the SSG. The HR zones are defined according to the criteria previously established in basketball (Anne Delextrat & Kraiem, 2013) and used in WB players (Aitor Iturricastillo, Cristina Granados, et al., 2016) as follows: low (<75% of HR_{peak}), moderate (75-85% of HR_{peak}), high (85-95% of HR_{peak}) and maximum (>95% of HR_{peak}).

Tympanic temperature: tympanic temperature is measured immediately after the end of the SSG with a thermometer (ThermoScan® IRT 4520 5, Braun GmbH, Kronberg, Germany Alemania), following the protocol stipulated by Hamilton, Marcos, and Secic (2013), previously used in WB players (J Yanci et al., 2014).

Subjective perceived exertion and differentiated perceived load: Immediately after each SSG ended, every player rates their perceived exertion in the task without the presence of other players and without knowing the values declared by them. They are all familiarised with the perceived exertion scale as it is used in all the training sessions and games during the season. The participants give differentiated replies for respiratory (RPE_{resp}) and muscular perceived exertion (RPE_{mus}) (Aitor Iturricastillo, Cristina Granados, et al., 2016; Paulson, Bishop, Leicht, & Goosey-Tolfrey, 2013). In order to calculate the perceived respiratory ($Load_{resp}$) and muscular ($Load_{mus}$) loads for the task, the value of $Load_{resp}$ and $Load_{mus}$ are multiplied by the duration (minutes) of the task (Foster et al., 2001; Aitor Iturricastillo, Javier Yanci, et al., 2016).

Statistical Analysis of The Data

The results are presented as mean ± standard deviation (SD). Student's t-test for independent samples is used to gauge the differences existing in the variables analysed

among the different groups (presence or absence of spinal cord injury and age group). Effect size (ES) is calculated following the proposal by Cohen (1988). Effect sizes of less than 0.2, between 0.2 and 0.49, between 0.5 and 0.79 or greater than 0.8 are considered trivial, low, moderate or high, respectively. The statistical analysis is performed using the Statistical Package for Social Sciences (SPSS Inc, version 24.0 Chicago, IL, USA). Statistical significance is set at $p < 0.05$.

Results

Table 1 presents the results corresponding to the variables of HR, tympanic temperature and rating of perceived exertion recorded by all the players participating in the study in all the observations of SSG.

Table 1

Results corresponding to the variables of heart rate, tympanic temperature and rating of perceived exertion recorded by all the players participating in the study in all the observations of SSG (n = 128 observations).

	Min.	Max.	Mean	SD
Heart rate				
HR_{mean} (bpm)	124.0	177.0	156.4	12.0
HR_{peak} (bpm)	130.0	193.0	169.4	12.1
$Load_{Stagno}$ (AU)	6.2	20.0	13.8	3.4
$Load_{Edwards}$ (AU)	12.4	19.9	16.9	1.8
$HR_{<75\%}$ (min)	0.0	2.2	0.3	0.3
$HR_{75\text{-}85\%}$ (min)	0.0	3.8	1.1	1.0
$HR_{85\text{-}95\%}$ (min)	0.0	3.7	1.8	1.0
$HR_{>95\%}$ (min)	0.0	3.6	0.8	1.1
Tympanic temperature				
Temp (ºC)	35.2	37.9	36.9	0.6
Rating of perceived exertion				
RPE_{res}	1.0	9.0	6.2	1.8
RPE_{mus}	1.0	9.5	6.3	2.1
$Load_{res}$ (AU)	4.0	36.0	24.8	7.3
$Load_{mus}$ (AU)	4.0	38.0	25.2	8.5

Min. = minimum, Max. = maximum, SD = standard deviation, HR_{mean} = mean heart rate, HR_{peak} = peak heart rate, HR = heart rate, Temp = temperature, RPE_{res} = Subjective rating of perceived respiratory exertion, RPE_{mus} = Subjective rating of perceived muscular exertion, $Load_{res}$ = perceived respiratory load, $Load_{mus}$ = perceived muscular load, AU = Arbitrary units.

Table 2 present the results obtained in all the observations of the SSG in the groups of players with or without a spinal cord injury. The players with a spinal cord injury record lower HR_{mean} and HR_{peak} in the SSG than those without a spinal cord injury ($p < 0.001$; ES = 0.9 to 1.1, high).

Although no significant differences are observed between players with and without a spinal cord injury in the rest of the HR values or in tympanic temperature, the players with a spinal cord injury record higher RPE_{res} and RPE_{mus} than the players without a spinal cord injury and obtain a greater $Load_{res}$ and $Load_{mus}$ ($p < 0.001$; ES = -0.7 to-0.8, moderate to high).

Table 2

Results obtained in all the observations of the SSG according to functional group (Group with a spinal cord injury, n = 48 observations; Group without a spinal cord injury, n = 80 observations).

	Spinal cord injury	Mean	SD	ES	*P value*
Heart rate					
HR_{mean} (bpm)	Yes	149.9	13.5		
	No	160.4	9.0	0.9	< 0.001**
HR_{peak} (bpm)	Yes	161.9	13.9		
	No	173.9	8.2	1.1	< 0.001**
$Load_{Stagno}$ (AU)	Yes	13.5	3.0		
	No	14.0	3.6	0.1	0.428
$Load_{Edwards}$ (AU)	Yes	16.8	1.6		
	No	16.9	1.9	0.0	0.859
$HR_{<75\%}$ (min)	Yes	0.2	0.2		
	No	0.3	0.4	0.3	0.099
$HR_{75\text{-}85\%}$ (min)	Yes	1.2	1.1		
	No	1.1	1.0	-0.1	0.440
$HR_{85\text{-}95\%}$ (min)	Yes	2.0	1.0		
	No	1.7	0.9	-0.3	0.114
$HR_{>95\%}$ (min)	Yes	0.6	0.8		
	No	0.9	1.2	0.3	0.133
Tympanic temperature					
Temp (ºC)	Yes	36.9	0.6		
	No	36.8	0.7	-0.1	0.678
Rating of perceived exertion					
RPE_{res}	Yes	6.9	1.4		
	No	5.8	1.9	-0.7	< 0.001**
RPE_{mus}	Yes	7.2	1.1		
	No	5.8	2.4	-0.8	< 0.001**
$Load_{res}$ (AU)	Yes	27.8	5.5		
	No	23.1	7.6	-0.7	< 0.001**
$Load_{mus}$ (AU)	Yes	28.6	4.5		
	No	23.1	9.6	-0.8	< 0.001**

SD = standard deviation, HR_{mean} = mean heart rate, HR_{peak} = peak heart rate, HR = heart rate, Temp = temperature, RPE_{res} = rating of perceived respiratory exertion, RPE_{mus} = rating of perceived muscular exertion, $Load_{res}$ = perceived respiratory load, $Load_{mus}$ = perceived muscular load. ** $p < 0.01$ very significant differences between groups. AU = Arbitrary units.

The players < 30 years record a greater HR_{mean} and HR_{peak}

in the SSG than the players > 30 years ($p < 0.001$, TE = -1.1, high) (Table 3). Significant differences are not observed between the age groups in the results obtained in the SSG for the rest of the HR variables. The players < 30 record a higher tympanic temperature than the players > 30 years ($p < 0.001$; TE = -1.1, high). The players < 30 years record a greater RPE_{res} and RPE_{mus} than the players > 30 years and a greater $Load_{res}$ and $Load_{mus}$ ($p < 0.001$, TE = -0.7 to -0.9, moderate to high).

Table 3

Results obtained in all the observations of the SSG according to age (< 30 years, n = 58 observations; > 30 years, n = 70 observations).

	Age group	Mean	SD	ES	*P value*
Heart rate					
HR_{mean} (bpm)	< 30 years	163.7	9.1		
	>30 years	152.1	11.4	-1.1	< 0.001**
HR_{peak} (bpm)	< 30 years	176.5	9.9		
	>30 years	165.1	11.4	-1.1	< 0.001**
$Load_{Stagno}$ (AU)	< 30 years	13.3	3.4		
	>30 years	14.2	3.3	0.3	0.141
$Load_{Edwards}$ (AU)	< 30 years	16.5	1.7		
	>30 years	17.1	1.8	0.3	0.096
$HR_{<75\%}$ (min)	< 30 years	0.2	0.3		
	>30 years	0.3	0.4	0.2	0.421
$HR_{75\text{-}85\%}$ (min)	< 30 years	1.3	1.1		
	>30 years	1.0	0.9	-0.3	0.066
$HR_{85\text{-}95\%}$ (min)	< 30 years	1.9	0.9		
	>30 years	1.8	1.0	-0.1	0.601
$HR_{>95\%}$ (min)	< 30 years	0.5	0.8		
	>30 years	0.9	1.2	0.4	0.060
Tympanic temperature					
Temp (ºC)	< 30 years	37.2	0.3		
	>30 years	36.7	0.7	-1.1	< 0.001**
Rating of perceived exertion					
RPE_{res}	< 30 years	6.9	1.3		
	>30 years	5.8	1.9	-0.7	< 0.001**
RPE_{mus}	< 30 years	7.3	1.2		
	>30 years	5.7	2.3	-0.9	< 0.001**
$Load_{res}$ (AU)	< 30 years	27.7	5.3		
	>30 years	23.1	7.7	-0.7	< 0.001**
$Load_{mus}$ (AU)	< 30 years	29.1	4.9		
	>30 years	22.9	9.3	-0.9	< 0.001**

SD = standard deviation, HR_{mean} = mean heart rate, HR_{peak} = peak heart rate, HR = heart rate, Temp = temperature, RPE_{res} = rating of perceived respiratory exertion, RPE_{mus} = rating of perceived muscular exertion, $Load_{res}$ = perceived respiratory load, $Load_{mus}$ = perceived muscular load. ** $p <$ 0.01 very significant differences between groups. AU = Arbitrary units

Discussion

The objectives of the present study have been, on the one hand, to analyse the physiological response (HR_{mean}, HR_{peak}, $Load_{Stagno}$, Load Edwards, time spent in the different intensity zones and body temperature) and effort (RPE_{res}, RPE_{mus}) and differential perceived load ($Load_{res}$ and $Load_{mus}$) in WB players during SSG tasks (4 vs. 4 of 4 min duration), and on the other, to analyse the existence or not of differences in the variables studied according to the presence of a spinal cord injury and the age of the players. The findings of the investigation show that in spite of there not being differences between the players with or without a spinal cord injury nor in the players < 30 years and > 30 years in LoadStagno, LoadEdwards, and the time spent in the intensity zones, there were significant differences in HRmean, HRpeak, RPEres, RPEmus, Loadres and Loadmus between players with or without a spinal cord injury and between players < 30 years and > 30 years.

Despite the fact that in the last few years studies have been conducted to analyse the differences in the responses of WB players in different tasks and competitions according to their impairment (Aitor Iturricastillo, Cristina Granados, et al., 2016; Aitor Iturricastillo, Javier Yanci, et al., 2016; A Iturricastillo et al., 2016; Marszałek et al., 2019), only a few investigations have studied if this physiological response and rating of perceived exertion in tasks commonly used by coaches (like SSG) depends on the presence or absence of a spinal cord injury (A Iturricastillo et al., 2016) This aspect may have special relevance regarding the control of training loads, as it has been reported that those who have a spinal cord injury may show altered HR responses (Goosey-Tolfrey & Leicht, 2013). The results of the present study show that the players with a spinal cord injury record a lower HR_{mean} and HR_{peak} in the SSG than those who did not have a spinal cord injury ($p < 0.001$; ES = 0.9 to 1.1; high). However, significant differences are not observed among the players with a spinal cord injury and those without in the results obtained in the SSG regarding the rest of the HR values or the tympanic temperature, in spite of the fact that, regarding this last parameter, people with a spinal cord injury have a lesser capacity to regulate core temperature due to impaired vasomotor and sudomotor activity below the level of the injury (Trbovich, Ortega, Schroeder, & Fredrickson, 2014). These results partially coincide with those obtained by (Aitor Iturricastillo, Cristina Granados, et al., 2016) as these authors observe that players with a spinal cord injury also record a lower HRmean (149.85±13.49 bpm *vs.* 160.39±8.95 bpm) and a lower HR_{peak} (161.85±13.88 bpm vs. 173.89±8.2 bpm) than players without a spinal cord injury in SSG. However, they highlight that when the values of HR are relativized according to HR_{peak}, these differences disappear. Therefore, although the WB players with a spinal cord injury can have an impaired capacity to increase HR which means they cannot reach a high HRpeak, it may be that this does not affect their relative values of HR as is observed in the present study and in a number of previous

investigations (Aitor Iturricastillo, Cristina Granados, et al., 2016; Aitor Iturricastillo, Javier Yanci, et al., 2016), implying that these relative values may be of greater interest to coaches when quantifying training. Although HRmean and HRpeak in players with a spinal cord injury are lower, they record a higher RPE $_{res}$ and RPE $_{mus}$ and declare higher values of Loadres and Loadmus than the players without a spinal cord injury ($p < 0.001$; ES = -0.7 to -0.8; moderate to high). The fact that the ratings of perceived exertion and the differentiated perceived load are higher in the players with a spinal cord injury, suggesting that the effort made could be higher than that of the players without such an injury. The high-intensity intermittent nature and other characteristics of SSG with muscle stress generated by the stops and changes of direction may have influenced the perceived exertion of the players with a spinal cord injury given that they may have a lower work capacity, and normally have a smaller muscle mass (Goosey-Tolfrey & Leicht, 2013). It may, therefore, be necessary to not only monitor HR but also use other subjective methods like rated perceived exertion and perceived load to obtain a more precise assessment of their responses during SSG.

It is common for WB teams to have players of different ages. The teams are usually formed by young players (18 – 20 years) and experienced players of 40 to 60 years (Granados et al., 2015; Aitor Iturricastillo, Cristina Granados, et al., 2016; A Iturricastillo et al., 2016; Tejero-González, 2016; Javier Yanci, Granados, et al., 2015; Javier Yanci, Iturricastillo, et al., 2015). Up until now, to the authors' knowledge, no study has analysed whether the age of the players could condition the HR responses and subjective rating of perceived exertion of WB players in SSG. The results obtained in the present study show that players <30 record a higher HR $_{mean}$ and HR $_{peak}$ than players >30 years. Similarly, the players <30 years also record a higher tympanic temperature, a greater RPE $_{res}$ and RPE $_{mus}$ and a higher Loadres and Loadmus than the players > 30 years. This aspect highlights that the same training task, like SSG, may present different stimuli to players of different ages in WB. Given that the present study does not analyse the players' external load, it is not possible to know if the players from both age groups made a similar physical effort and yet the physiological response is different, or in contrast, if the physical response is different and thus also the physiological response. Studies carried out in other sports disciplines show that the more experienced and older players tend to make less physical effort,given that they are able to better interpret play, have superior sports competitiveness and are able to economise their efforts more because they interpret the game and position themselves more effectively (Clemente, Castillo, & Los Arcos, 2020). In this regard, in future studies it could be interesting to discover if this phenomenon is also present in WB players, so that it would be suitable to quantify the external load of the players in SSG.

Conclusion

The main conclusion of the study is that both, the type of impairment (presence or absence of a spinal cord injury) and the age of the players (<30 years and >30 years) can affect the internal load in a SSG. The players with a spinal cord injury, in spite of recording a lower HR $_{mean}$ and HR $_{peak}$ in the SSG than the players without a spinal cord injury, report a higher RPE $_{res}$ and RPE $_{mus}$ and greater values of Load $_{res}$ and Load $_{mus}$ than the players without a spinal cord injury. Bearing in mind that those players with a spinal cord injury may have an impaired capacity for increasing HR, it may be necessary to monitor the responses of WB players, not solely using HR, but also other subjective methods like differentiated RPE, in order to conduct a more precise assessment of their responses during SSG.

The results obtained in the present study show that the players <30 years record a higher HR $_{mean}$ and HR $_{peak}$, a higher tympanic temperature, a greater RPEres and RPE $_{mus}$, and a higher Load $_{res}$ and Load $_{mus}$ than the players of >30 years in the SSG. This highlights that the same training tasks, like SSG, may present different stimuli to players of different ages in WB.

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