Research Paper

METABOLIC RESPONSES AND ENERGY EXPENDITURE DURING A BASKETBALL MATCH IN PLAYERS WITH SPINAL CORD INJURY.

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Abstract

Wheelchair basketball is one of the most popular sports for people with Spinal Cord Injuries (SCI). **Objective**. The aim of the present study was to assess metabolic responses and energy expenditure during a wheelchair basketball match in players with SCI. **Method**. Ten wheelchair male basketball players(n=10)aged 18-34 years, participated in one match per week over a 10-week period (10 matches in total), with one player being assessed in each match. Aportable gas analyzer (SensorMedics 2900c, SensorMedics Corporation, USA) was adapted to the player throughout the 40-min match, to record oxygen consumption (one per game), while blood samples were drawn for blood lactate determination. **Results**. A remarkable increase in oxygen consumption was observed, compared to the initial values, with the largest increase occurring in the 3rd period of the match. At the same time, the total energy expenditure of the match increased about 12 times up, compared to the values before the start of the match. During the 4th period, recorded the greatest increase in lactic acid, in all athletes. Correspondingly the heart rate showed a small increase at the 4th period of the match. **Conclusion.** Participation in wheelchair basketball matchplay results in substantial increase in energy expenditure, while both glycolytic and oxidative pathway are highly taxed to meet the energy requirements.

Keywords: SCI, wheelchair basketball game, metabolic demands.

Introduction

Spinal Cord Injuries (SCI), like other types of disability, reduce dramatically the individual's participation in physical activities and/or exercise programs, and as such might lead to deterioration of physical abilities and muscle mass, while increasing the risk for obesity cardiovascular diseases (Baumann, Kahn,, Grimm, Spungen, 1999). In addition, individuals with SCI display lower resting energy expenditure compared to their healthy counterparts, due to diminished muscle mass and a highly active sympathetic nervous system (Hoetal., 2007). It has been reported that, during exercise, individuals with SCI display lower energy expenditure by 15% - 70%, as compared to their healthy counterparts (Pelly et al., 2018). Moreover, these individuals are at high risk for metabolic and cardiovascular diseases (Baumann et al., 1999), That represent major causes of death in young people with functional disabilities (Baumann et al., 1999). Beyond physiological consequences, psychological ones are also evident in individuals with SCI, such as increased levels of anxiety and depression, which prevent this population from adhering to daily life activities and employment (Scivoletto et al., 1997).

Participation in wheelchair basketball might serve as an efficient countermeasure against the deleterious consequences driven by SCI, as it is a physical activity that incorporates physical exercise and entertainment. During a basketball match, athletes execute a

combination of multidirectional movements, such as sprinting, sudden braking and shuffling at variable velocities (Molik et al., 2010). Both glycolytic and oxidative pathways are highly activated to meet the energy requirements (McInnes et al., 1995; Crisafulli et al., 2002; Balčiūnas et.al 2006). Abel et al. (2008), reported that wheelchair basketball players display a basal metabolic rate of ~65 kcal/h, while in healthy population the average values range from 80 to 90 kcal/h. Schmidt and colleagues (1998), compared the response to a maximal ergometer test as well as to a basketball game between female wheelchair basketball players and non athletes with spinal cord injury, and found that the former were characterized by larger heart dimensions (620.3 ± 9.6 ml $\cdot$ kg^{-1}) than the latter (477.4 ± 8.2 ml $\cdot$ kg^{-1}), but did not exceed the heart rate of able-bodied non-exercising subjects. In addition, female basketball players displayed greater maximum work capacity (59.9 versus 45.5 W) higher maximum oxygen consumption (33.7 versus 18.3 ml$\cdot$min$^{-1}\cdot$ kg^{-1}) and higher concentration of blood lactate (9.1 versus 5.47 mmol$\cdot$l^{-1}) compared to non-athletes with SCI, although no differences observed amongst groups in terms of heart rate and aerobic threshold work (Schmidt et al., 1998).

To the best of our knowledge, only two studies have examined so far the energy expenditure during sports participation in these individuals (Burke et al., 1986; Abel et al., 2008). Furthermore, there are currently no data on the effect of exercise on resting metabolic rate during (4 periods) the post-exercise period. Therefore, the aim of the present study was to assess the metabolic responses and energy expenditure during a wheelchair basketball game in male athletes with SCI.

Method

Participants were ten (10) wheelchair male basketball players, who participated in the official Greek championship of FHWBPA (Federation of Hellenic Wheelchair Basketball Players Associations) and were members of this association. Their age was 18-34 years, and all of them had SCI from T6 to O3 vertebra (paraplegia with no control of lower limb movement). The participation criteria that the participants had to meet were the following: i) they were male volunteers, ii) athletes had paraplegia/quadriplegia and were confined to a wheelchair (at least for 2 years) unable to perform any form of movement without the wheelchair, iii) none of the athletes should suffer from any viral disability (eg polio) or neurological disorder (eg cerebral palsy), v) they could stop their medication for a week, vi) to be active athletes of a club participating in the league and to train 4 times a week and play an official match, and their training age was at least 1 year, vii) In the last trimester they had not been sick and had not suffered any infection.

Initially, all participants underwent a baseline assessment of their (i) anthropometric characteristics (i.e. body height, body weight and body fat), (ii) maximal oxygen uptake (VO_2peak) with arm ergometer and (iii) daily dietary intake. Following baseline assessment, they participated in one match per week over a 10-week period (10 matches in total). One player was assessed in each match. A portable gas analyzer device (SensorMedics 2900c, SensorMedics Corporation, USA) was adapted to the player to measure oxygen consumption breathe by breathe, whose values were recorded every 5 minutes, during the game. Blood sampling was performed for blood lactate estimation during the match. All the athletes, 6 hours before the match, consumed the last meal according to the nutrition form we had distributed to them, while during the race, all they could consume were small amounts of water, mandatory. Energy expenditure were estimated indirectly from oxygen consumption

values, after first being converted to METs and then to kcal/min. All procedures were in accordance with the declaration of Helsinki (Washington, United States, October 2002).

Somatometric characteristics

During baseline testing, body weight was measured to the nearest millikilogram (0.001 kg) using an electronic scale platform (Yongkang Fenghua Weighing Apparatus Co.,Ltd).Body height was measured to the nearest half centimeter (0.5 cm) using a telescopic stadiometer (Seca 224, UK). The measurement of height was done in a supine position, with the subjects lying on the statiometer and their soles touching a vertical wall (Oke, K. & Udoh, D., 2013). Body mass index were calculated as mass (kg) per height (m) squared.

Table 1. Means ± SD and individual wheelchair basketball players' characteristics

Exper. group	Age (years)	Weight (Kg)	Height (m)	BMI (Kg · m^2)	SCI level	Clas.	Train Age (years)
n=1	27	72,213	1,85	21,04	T8	2	9
n=2	33	75,658	1,8	23,15	T6	1	6
n=3	34	78,22	1,79	24,34	T12	2,5	6
n=4	28	93,596	1,89	26,04	T10	2	9
n=5	31	65,149	1,9	18,01	T6-T7	1	3
n=6	34	83,713	1,88	23,48	T7	1	10
n=7	33	89,975	1,87	25,74	T9	2	4
n=8	18	79,345	1,8	24,38	O3	3	3
n=9	29	81,687	1,81	23,12	T3	1	5
n=10	26	77,245	1,80	24,59	T11	2,5	7
Mean±SD	34±8	79,7±9,2	1,84±0,04	23,2±2,8			6,2±2,8

Peak oxygen uptake

Peak oxygen uptake was assessed on a Sci Fit Pro 1000 arm cycle ergometer (Sinties Scientific Inc., Tulsa, OK) using an automatic gas analyzer (SensorMedics 2900c, SensorMedics Corporation, USA) according to the Froelicher's protocol (Froelicher, 2006). Athletes were in a seated position in their own wheelchair at such a distance from the axis of rotation of the cranks that the elbows were slightly before full extension. The exercise protocol was consisted of a) a 6-min warm-up period, b) braking with a constant load of 30 W for 4 min, c) a progressive increase in load per minute ranging from 5 W to 20 W (5 to 13 for quadriplegics and 10 to 20 for paraplegics). During the last 30 seconds of each minute, heart rate (HR), mean VO_2, Respiratory Exchange Ratio (RER) and Rating of Perceived Exertion (RPE) were recorded. The flow meter was calibrated by injecting 3 liters of air using a special syringe. In order to establish that the peak oxygen uptake (VO_2peak) recording had been achieved, at least one of the following criteria had to be met: a) the values in the Respiratory Exchange Ratio (RER) value ≥ 1.10, b) or the subject to exceed the 15th grade RPE ≥ 15 (Borg scale6-20).

Table 2. Means ± SD physiological values,VO2peak, RER of each player.

Exper. group	VO2peak mL/kg/min	RER	HR
n=1	42,3	0.99	187
n=2	28,4	0.96	180
n=3	40,2	1.01	178
n=4	37,6	0.90	179
n=5	25,4	0.91	177
n=6	29,1	0.97	181
n=7	35,4	0.93	182
n=8	33,1	1.07	184
n=9	36,4	0,98	180
n=10	34,7	0,93	179
Mean±SD	34,2±5,3	0,95±0,03	180±3

Blood lactate

Capillary blood samples (25 μL) were collected from the finger to assess basal blood lactate concentration;Sampling was performed before the match and at the end of each 10-min period. Concentration of blood lactate was measured spectrometrically, according to an enzymatic method by Sigma Diagnostics (St. Louis, Missouri, USA). Spectrophotometer Hitachi u-2900 double beam spectrophotometer was used for the measurement.

Statistical analysis

Purpose of the present study was to evaluate the energy demands of a single wheelchair basketball game. No statistical analysis and comparisons were performed. Data presented as mean standard deviation per quarter and total game time. In each game only one player was evaluated in terms of oxygen consumption and energy expenditure.

Results

Oxygen consumption during the match increased by 243% compared to resting values, demonstrating its peak during the 3rd 10-min period (24,49 ± 1,53 ml/kg/min). Likewise, total energy expenditure increased by 1200%, with the highest values observed in the 3rd 10-min period (91,3 ± 14,8 kcal/per). Blood lactate increased by 193%, with the highest value at the 4thperiod. During the game, the average heart rate beyond the periods, increased about 108%.

Table 3. Metabolic demands during participation in a wheelchair basketball game.

Variables	Before match	1st period	2nd period	3rd period	4th period	F, p
Oxygen consumption (ml/kg/min)	7,14±0,86	22,63±1,46	22,68±1,99	24,49±1,53	21,10±0,95	104.2, 0.000
Energy expenditure (kcal)	26,3±3,8	84,9±17,6	85±13,1	91,3±14,8	79,5±11,5	107.4, 0.000
Lactic acid (mmo/l)	1,64±0,15	3,61±0,58	4,77±1,04	4,55±1,04	4,80±1,22	28.12, 0.000
MeanHR (b/min)	71,2±2,69	140,2±4,31	138,2±5,35	148,4±3,27	138±5,57	199.5, 0.000
HRmax (b/min)	71,2±2,69	149,9±10,2	148,7±15,65	154,5±8,68	150,2±10,14	1.68, 0.2

Discussion

The purpose of this study were to determine the energy expenditure and metabolic demands during a wheelchair basketball match in individuals with SCI. Resting mean HR for the participants in our study was 71,2±2,69 (b/min), with the greatest mean value being observed at the 3rd period (148,4±3,27 b/min) and the peak HR value being at 154,5±8,68 (b/min), which is also observed at the 3rd period. In the study by Bernardi et al. (2010), during an official wheelchair basketball match, average HR values were recorded, which ranged between 148 and 163 b•min¯1 for athletes with SCI, in absolute values, while its peaks were 174.6±11 b •min¯1, when the first 2 quarters of the game were analyzed, while in the study by Croft et al. (2010), during the recording throughout the game the HR peaks ranged at 190.6±12 b•min¯1, values which show that the matches we performed were of a high demands level. In the study by Abel et al. (2008),the average heart rate was 118,5 ± 23,1 b·min¯¹, in contrast to the present research the average heart rate at 141.3±5.2 b•min¯¹. However, we should take into account that for people with SCI, the heart rate is regulated by the autonomic innervation of the heart, as a result, some disabilities may lead to a bias in HR responses due to a partial loss of sympathetic cardiac control.

The mean VO2peak of our participants, after the protocol we applied to the arm cycle ergometer, were estimated at 34,2±5,3 mL/kg/min with HR at 180,7±2,9 bpm and RER at 0,95±0,03, values that come in agreement with the Rotstein et al. (1994), measured by arm cycle ergometry, at wheelchair basketball players, ranged between 16.58 ml/kg/min and 36.24 ml/kg/min with a mean of 23.1 ml/kg/min and Torhaug et al. (2016), 27.3±3.2 mL·kg¯¹·min¯¹ at individuals with SCI, indicating the high level of aerobic capacity of the athletes in accordance with the international literature. Blood lactate was another metabolic indicator that showed that our game was of a high level. At the present research the mean lactic acid concentration was 4.43 ± 0.6 mmol•l ¯¹,presenting an increase of the order of 192% in relation to the initial values. In the study by Abel et al. (2008),who performed a basic metabolism assessment in the laboratory and a field test to wheelchair basketball players, the mean lactate

concentration was 2.09±0.7 mmol•l^{-1}in , which indicates that the match we performed was of high metabolic demand.

It is evident that people with SCI are characterized by lower resting energy expenditure compared to their healthy counterparts, that might be attributed to skeletal muscle atrophy, amongst other factors (Price, 2010). As a consequence, they also display lower energy expenditure during exercise. Actually, it has been estimated that energy expenditure during activities such as team sports or explosive power sports like tennis, is lower by 35-70% in athletes with SCI compared to healthy athletes (Price, 2010). In the study by Abel et al. (2008), who performed a basal metabolic assessment in the laboratory and a field test measuring respiratory parameters in wheelchair tennis, basketball and rugby players, found that the mean energy expenditure of the whole group was 316.4 ±89.6 kcal•h^{-1}, with the basketball players having the highest mean of 374.8 ± 127.1 kcal•h^{-1}, values that coincide with the values of the present study, where the total energy expenditure of the athletes on average was 314,8±54,2kcal•h^{-1}. For all the above differences we will have to include the methodological differences, the intensity of the exercise as well as the different forms of disability, play a decisive role in the recording of the indicators.

Conclusions

In conclusion, our results indicate that participation in a wheelchair basketball match induces remarkable metabolic responses and energy expenditure, with increased contribution of both glycolytic and oxidative pathways to energy supply. Therefore, participation in sports is of paramount significance for these individuals, as a strategy to prevent or treat obesity and cardiovascular diseases associated with SCI.

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