# Assessment of wheelchair basketball training intensity using heart rate in physically disable people

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## Abstract

Objective: To verify the intensity of wheelchair basketball (WB) in people with disabilities (PWD) during 8 weeks intervention. Methods: Longitudinal experimental study of 13 male WB in PWD was assessed and HR, mean heart rate ($HR_{Mean}$) were monitored for the calculation of minimum heart rate ($HR_{Min}$). %THR were based on the $HR_{peak}$. These were then analyzed for possible correlation with the type, level and time of injury, as well as the anthropometric values obtained through bio-impedance. Results: After statistical analysis, of the independent variables, the percentage body fat ($p < 0.01$), intracellular and extracellular water were found to be positively correlated ($p < 0.05$) with %THR. The dependent variables, functional classification, level and type of lesion and BMI were not significant ($p > 0.05$) when correlated with $HR_{peak}$. Conclusions: The majority of the participants´ % THR was above 60% of the $HR_{peak}$ thus indicating that the intervention aided in the promotion of cardiovascular health, besides the mentioned benefits of hydration levels and % body fat of each individual. The present study could serve as a scientific base for the physical educationist alike, and the likes, particularly regarding the use of wheelchair basketball in the rehabilitation or physical fitness workout for PWD.

Keywords: Intracellular and extracellular water; Body fat; Heart rate; Training; Intensity.

## Introduction

The regular practice of wheelchair basketball for PWD promotes benefits in movement speed, agility, skill, strength and endurance in the field with improved physical performance[1]. In addition, also promotes social interaction between practitioners and contributes positively in psychological aspects and in improving quality of life[2,3]. The wheelchair basketball stimulates both the aerobic and anaerobic energy systems, as it has short periods of high intensity, interspersed with brief periods of recovery during a game[4].

According to the American College of Sports Medicine[5], heart rate is a key element during physical activity practices that is used as an estimate of training intensity. Due to the acuity of the total fitness, and to the potential risks and adherence problems associated with high intensity activities, mild to moderate intensity activity with longer duration is recommended for the non-athlete adult. An individual with a low level of fitness can achieve a significant training effect with a % training heart rate (%THR) in the range of 60 to 90% of peak heart rate ($HR_{peak}$)[5].

The heart rate is a parameter used in the monitoring of the heartbeat, to measure the intensity limit of an exercise, to assess the state of fatigue and to quantify the internal training loads in games and training sessions in intermittent team sports, like the wheelchair basketball[6]. Exercise with moderate intensity ranging from 40-60% of $HR_{peak}$ increases blood high-density lipoprotein (HDL) levels, a factor associated with reduced cardiovascular diseases[7]. Studies have shown that medium and high intensity exercises can positively influence in the improvement of the cardiovascular health status of people with physical disabilities[8]. Aerobic training allows the practitioner to recover quickly between the high intensity peaks of an activity related to the higher overall intensity of the game. This afford assessment of heart rate and intensity threshold during training through the heart rate monitor, and therefore classification into training zones can be achieved 60, 70 or 80% $HR_{peak}$)[9,10].

Few studies have correlated intracellular and extracellular values, as well as % body fat with specific training protocols for people with physical disabilities, which in fact makes it an important tool for quality of life and in the development of adequate preventive measures in this population[11]. As regards the improvement of the competitive performance and the physical capacities of athletes of various sports, it is of interest to the physical trainer to evaluate the body composition by analyzing the weight, height, skin folds, circumferences, body mass index (BMI), and % body fat, % lean mass, intracellular and extracellular water. These will allow the trainer to correlate the results obtained with not only the training intensity and performance of the athletes but also serve as criteria related to health and exercise[12].

Thus, the present study aimed to verify the intensity of the training sessions in wheelchair basketball in people with physical disabilities by monitoring their heart rate and evaluating the correlation between anthropometric indicators, to know if the players reached favorable training intensity to provide an ideal stimulus to the aerobic resistance needed in games.

# Methods

### *Study type*

The present study is a longitudinal experimental study that is part of a twelve-month macro project (January to December 2019). In this segment of the research, PWD who engaged in wheelchair basketball were physically assessed and submitted to a training protocol, the intensity of which was individually monitored. This is done to preserve the health of the participants, as well as to improve physical performance, and this lasted for eight weeks (October to November 2019).

### *Participants*

The study included 13 people with physical disabilities who are wheelchair basketball players, residents of Cuiabá, Mato Grosso state of Brazil (FIGURE 1). All were male with a mean age of 36 ± 8.9 years. Information concerning characteristics of the disabled male wheelchair basketball players, who participated in the study, were captured using a previously validated questionnaire 13. These includes the type of lesion, the level of the lesion, age in years, and their participation in sport. Functional classification was performed by level of injury according to the International Wheelchair Basketball Federation[14] (TABLE 1).

### *The study location*

The wheelchair basketball sports activity was performed at Aecim Tocantins Gymnasium located in Cuiabá, Mato Grosso, Brazil.

### *Study design*

The training protocol used in the present work was adapted from the Brazilian government manual on "Wheelchair Basketball: Guidance Manual for Physical Education Teachers"[15]. This study was carried out for eight consecutive weeks (from October to November) during the twelve-month macro project intervention. The wheelchair basketball training for PWD was done twice a week, in a 2-hour sessions from 19:00 to 21:00.

As part of the study design, assessments were done at pre and post intervention. However, the numbers of participants that consistently showed up for all the assessments are too small (n=5) for significant data analysis. We therefore presented in the present study, assessments that were made after the intervention.

TABLE 1 - Characteristics of wheelchair basketball players, disabled, male, resident in Cuiabá-MT, Brazil.

| P | Type of Lesion | Level | Age (years) | Classification IWBF* | Time of Lesion (years) | Sport practice |
|---|---|---|---|---|---|---|
| P1 | Spinal cord injury | T11 | 26 | 2.0 | 5 | Y |
| P2 | Polio | Plegia (MID) | 40 | 4.0 | + 20 | Y |
| P3 | Spinal cord injury | L2 | 24 | 3.0 | + 20 | N |
| P4 | Polio | Plegia (MIE) | 41 | 4.0 | + 20 | Y |
| P5 | Spinal cord injury | T7 | 23 | 3.0 | 5 | Y |
| P6 | Myelitis | T11 | 22 | 3.5 | 5 | Y |
| P7 | Viral Disease (poliomyelitis) | Triparesis | 42 | 1.0 | + 20 | Y |
| P8 | Spinal cord injury | L3 | 41 | 2.0 | + 20 | N |
| P9 | Viral Disease (poliomyelitis) | Paraplegia | 46 | 2.0 | + 20 | Y |
| P10 | Spinal cord injury | T12 | 44 | 2.0 | + 20 | Y |
| P11 | Viral Disease (poliomyelitis) | Monoplegia | 42 | 4.0 | + 20 | N |
| P12 | Viral Disease (poliomyelitis) | Paraplegia | 41 | 1.0 | + 20 | Y |
| P13 | Suzaki Syndrome | Paraparesis | 41 | 1.0 | 10 | Y |

*IWBF: International Wheelchair Basketball Federation; P: Participants; RLL: Right Lower Limb; LLL: Left Lower Limb; BMI: Body Mass Index.

### *Inclusion Criteria*

Participants were included according to the physical capacity, preservation and mobility of the upper limbs, as well as good intellectual understanding and medical certificate for the sport, after assessing their clinical health for the sport research.

### *Exclusion Criteria*

Participants, who are not fit to practice the sports or who possess no affinity with the sports, with less than 18 months of injury and with medical impediment to practicing physical exercise were excluded from the study.

### *Body composition measures*

#### *Anthropometry Measurements*

All anthropometric assessments were performed using standardized techniques[5]. Body mass (kg) was measured with the Micheletti brand (500 kg, 120 x 120 cm) electronic wheelchair scale, Micheletti®, São Paulo, Brazil. Participants' weight was assessed in a standardized way by standing on the scale with their own chair, and body mass was previously computed and subtracted from the measured chair mass.

Height was measured in a standardized manner for all volunteers and made in the supine position on a stretcher using a Personal Caprice Sanny® portable stadiometer (Sanny®, São Paulo, Brazil), with a measuring range of 0 to 210 cm and accuracy of 1 mm. This step took place under the supervision of physical education professionals, members of TIMES research group located at the Faculty of Physical Education, Federal University of Mato Grosso (FEF/UFMT).

### *Bioelectrical impedance analysis (BIA)*

The weight (kg) and height (cm) values were entered in the InBody S10 single-frequency tetrapolar bioelectrical impedance analysis (BIA) (InBody®, Seoul, Korea) device (50 kHz) to determine body composition. BIA is widely applied in body composition and health system measurements, commonly used in individuals, paraplegia and surgical patients[16]. The measurements were performed after 4 hours of fasting, with the participant in supine position with four electrodes placed on the surface of the medial and lateral malleolus of the right and left ankles and in the middle and thumb fingers of the right and left hands. The body mass analysis was divided into five segments, two for the upper limbs, two for the lower limbs and one for the trunk, presenting body fat percentage (%), skeletal muscle mass (%), intracellular, extracellular body water and body mass index ($kg/m^2$)[17] (TABLE 2).

TABLE 2 - Characteristics of body mass index, % fat, % skeletal muscle mass, and intracellular and extracellular body water of wheelchair basketball participants for people with disabilities, resident in Cuiaba -MT, Brazil.

| | | | | Body water | |
|---|---|---|---|---|---|
| | BMI | % Fat | % SMM | Intracellular | Extracellular |
| P1 | 22.2 | 35,1 | 24.5 | 20.3* | 14.8** |
| P2 | 26.3 | 30.5 | 30.7 | 25.1* | 16.0** |
| P3 | 24.2 | 34.9 | 28.9 | 23.7* | 17.1 |
| P4 | 23.5 | 36.4 | 19.4 | 16.4* | 10.8** |
| P5 | 20.3 | 8.4 | 34.5 | 28.0 | 11.7** |
| P6 | 24.4 | 37.1 | 27.7 | 21.3* | 14.9** |
| P7 | 20.9 | 38.3 | 17.0 | 14.6* | 10.0** |
| P8 | 33.7 | 51.4 | 24.7 | 20.5* | 14.7** |
| P9 | 30.3 | 15.2 | 55.0 | 13.2* | 8.7** |
| P10 | 35.8 | 53.3 | 23.5 | 19.6* | 13.9** |
| P11 | 31.8 | 31.6 | 38.3 | 30.9 | 18.9 |
| P12 | 29.6 | 55.3 | 15.7 | 13.6* | 9.8** |
| P13 | 24.2 | 21.1 | 34.5 | 28.0 | 17.7 |
| X | 26.7 | 34.5 | 28.8 | 21.1 | 13.7 |
| SD | 4.8 | 13.4 | 10.1 | 5.5 | 3.2 |

P: Participants; BMI: Body Mass Index; % Fat: Fat Percentage; % SMM: Percentage Skeletal Muscle Mass; X = average, SD = standard deviation. *percentage of intracellular water less than normal; **percentage of extracellular water less than normal.

### *Heart rate*

The HR of the 13 participants was monitored in a 2-hour training sessions twice a week (Mondays and Wednesdays) under a standardized WB training protocol. Participants received their polar heart rate sensor straps attached to a chest strap prior to the start of the session, and withdrawn at the end of the workout, each with their respective identified strap, according to Polar Team System® (PolarTeamPro®, Kempele, Finland), a tool for measuring team exercise and heart rate data. The system consists of an Interface Recharger Unit (IRU), in particular team transmitters and control software - Polar Precision Performance 3.0, which transmits average heart rate ($HR_{mean}$) and maximum training heart rate ($HR_{peak}$) data by software, this monitoring was carried out in a period of 8 weeks.

This method was previously reported by Iturricastillo et al.[18] by calculating the practitioner's $HR_{peak}$ minus their age ($HR_{peak}$-age), and the result classifies the %THR of the practitioners, from this stage the data were extracted to tabulate the average results of eight weeks of monitoring[18] (TABLE 3).

TABLE 3 - Statistical analysis of constant% body fat, intracellular and extracellular water on the dependent variable % THR basketball in wheelchairs in the physically disable people, male residents of Cuiabá-MT, Brazil.

| Variables | β^ | SE(β^) | t-student | p-value | Significancy |
|---|---|---|---|---|---|
| Constants | 21.748 | 17.538 | 1.240 | 0.246 | n.s. |
| %fat | 0.897 | 0.247 | 3.623 | 0.006 | ** |
| Intracellular water | 2.577 | 0.963 | 2.677 | 0.025 | * |
| Extracellular Water | -3.110 | 1.225 | -2.540 | 0.032 | * |

Note: n.s.= not significant; * = significant 5%; ** = significant 1%.

### *Statistical analysis*

The assumption of normality was verified using the Shapiro-Wilk test. For data tabulation, mean ± standard deviation values were used. To establish relationship between the variables obtained in the training sessions for the nonparametric data, the Spearman's correlation was employed, and for the parametric data, the Pearson's test with significance level established at $p < 0.05$.

To select the independent variables to identify the influence on the % THR variable using the linear regression model, the back selection method was considered, with the independent variables being: age, classification, time of injury, if practices sport, the weight, height, BMI, minimum heart rate, $HR_{mean}$, $HR_{peak}$, systolic, diastolic, oxygen content and Eborg. For this purpose, an input probability value of $p < 0.05$ and an output probability value of $p < 0.05$ were considered.

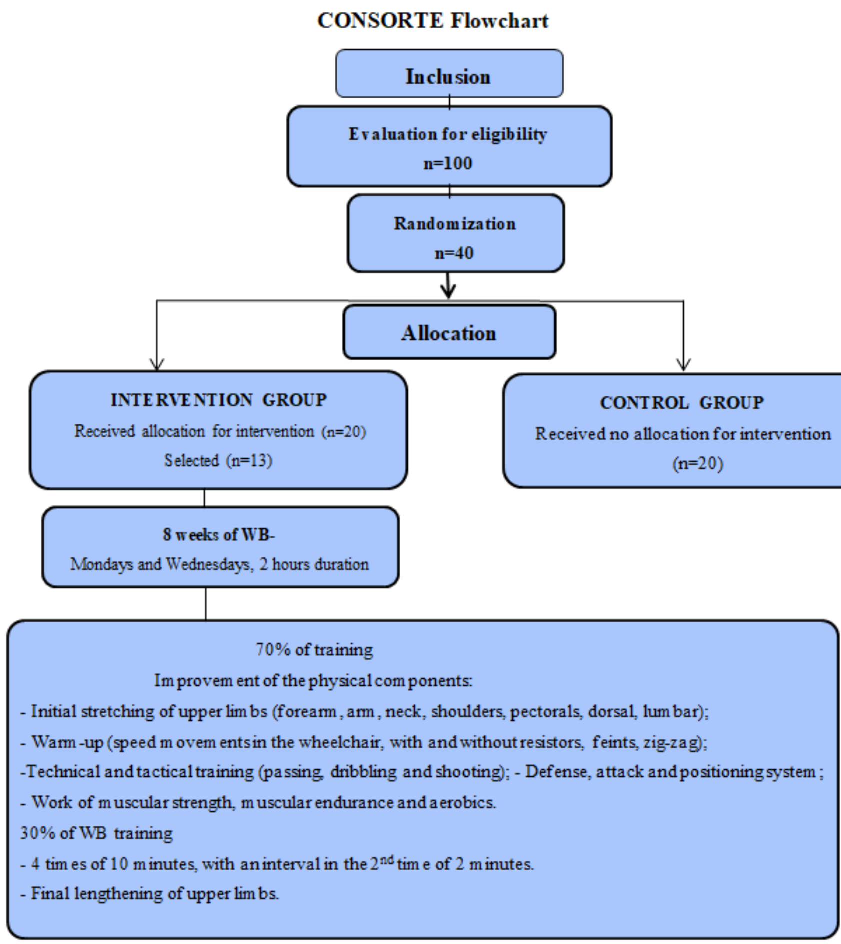


FIGURE 1 - Standardization from Consolidated Standards of Reporting Trials.

# Results

Regarding the injury types, 46% (n = 6) presented spinal cord trauma (SPT); and 54% (n = 7) poliomyelitis sequelae with injury level between lumbar 2 (L2) and thoracic 12 (T12). According to IWF classification, 23% (n = 3) of the total players were rated at 4.0; 7% (n = 1) presented 3.5; 15% (n = 2) at 3.0; 30% (n = 4) at 2.0 and 23% (n = 3) at point 1.0.

Regarding the time of lesion, 69% (n = 9) of the participants have been with the lesion over 20 years; 7% (n = 1) at 10 years and 23% (n = 3) at 5 years. Of these, 76% (n = 10) practiced physical activities, while 23% (n = 3) did not engage in any activity.

### *Bioelectrical Impedance Analysis (BIA)*

The results of the body mass evaluation of the 13 participants using BIA demonstrated that the following percentage body fat (%): one each (7.69%) were within the normal (10.0 ~ 20.0) and below normal range, while the other eleven (11, 84.61%) were above normal range. In relation to the percentage lean mass within the normal (33.2 ~ 40.6), below normal and above normal ranges were three (23.07%), nine (69.23%) and one (7.7%) respectively. The intracellular body water content within the normal range (26.8 ~ 32.8 L), and less than normal were three (23.07%) and ten (76.92%), respectively. The extracellular body water within the normal range (16.5 ~ 20.1 L) and lower values were three (23.07%) and 10 (76.92%), respectively. In the calculation of BMI, PWDs that were within the normal range of 18.5 ~ 25.0 kg / $m^2$ (n = 7), while (n = 6) were with values above normal.

### *Heart rate*

The $HR_{mean}$ and $HR_{peak}$ values were monitored using the Polar Team System® (Polar TeamPro®, Kempele, Finland) to calculate the % THR of WB practitioners, over 8 weeks. The average results were extracted (TABLE 4), showing four % THR zones, I - 50-59% (n = 2), II - 60-69% (n = 6), III - 70-79% (n = 4) and IV 80- 89% (n = 1) (FIGURE 2).

TABLE 4 - Average results collected over 8 weeks of the intensity values of wheelchair basketball training for people with disabilities, male, residing in the Baixada Cuiabana-MT, Brazil.

| P | $HR_{Mean}$ Bpm | $HR_{peak}$ Bpm | % THR |
|---|---|---|---|
| **P1** | 126 | 194 | 65 |
| **P2** | 128 | 180 | 71 |
| **P3** | 127 | 196 | 65 |
| **P4** | 121 | 179 | 67 |
| **P5** | 134 | 197 | 68 |
| **P6** | 120 | 198 | 60 |
| **P7** | 95 | 178 | 53 |
| **P8** | 145 | 179 | 81 |
| **P9** | 138 | 174 | 79 |
| **P10** | 131 | 176 | 74 |
| **P11** | 115 | 178 | 65 |
| **P12** | 132 | 179 | 74 |
| **P13** | 91 | 179 | 51 |
| **X** | 123,08 | 182,75 | 67,33 |
| **SD** | 16.24 | 8.75 | 9.35 |

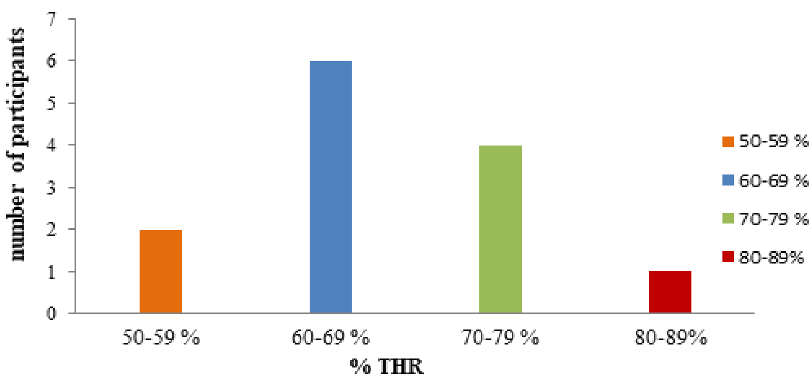


FIGURE 2 - Percentage training heart rate (% THR) of people with disabilities after application of wheelchair basketball training protocol.

## Discussion

The result demonstrated that 60% of the participants were able to attained % THR considered favorable for training. Besides, statistically significant positive correlation was observed between the % THR, the percentage body fat, the intracellular and extracellular water content. This is possibly related to the reduced fluid consumption, or excessive sweat and urine water loss in this population. In addition, it also implies that the methodology applied in the intervention during the eight weeks of training was capable of promoting a sufficient training threshold for PWD that are reflected in the high HR, $HR_{mean}$ and $HR_{peak}$[19].

HR-related studies in WB are linked to national, international, professional and elite athletes competing in Paralympic Championships and Games[20]. HR is a common parameter used to estimate training intensity. To improve $VO_2$Max, the recommend minimum training intensity threshold should be approximately 60% of $HR_{peak}$[20]. In this sense, HR is an indicator of exercise intensity in PWD and may contribute to the understanding of the game dynamics as well as the cardiac stress imposed on WB players according to disability or functional class and can be used to plan training sessions[20].

Therefore, to assess the intensity of WB training in PWD in the present study, we monitored HR during the training sessions of the 13 PWD who practiced WB. Overall (n=11) the % THR of the PWD was greater than 60% of their $HR_{peak}$ demonstrating that the WB' training protocol used was ideal as it strongly suggested that WB is a demanding team game. Although, the game involves small efforts such as rowing and dynamic propelling, passes, turnovers, shots and passes, all the same, it resulted in high HR, $HR_{mean}$ and HRpeak[19].

Croft et al.[21] reported that percentage THR zones need to be calculated individually for each player considering their $HR_{peak}$, especially that high intensity training sessions may be more beneficial for WB players as well as better preparing players for the games. In addition, dos Santos et al.[22] reported that less trained players would experience more physiological stress in a competitive game with many repeated sprints with HR in different training zones. Therefore, in this study we applied a WB training protocol that developed stimuli of intensity similar to a competitive game to assess % THR.

It is known that physical activity with higher demands on intensity decreases the % body fat, and consequently the BMI[23]. Some studies suggest physical activity for PWD on wheelchair in order to provide an increase in their energy expenditure, as well as a decrease in percentage body fat to attain a positive influence on the metabolic profile of this population[24,25]. The results of the physical evaluation showed that 54% of the participants had a normal BMI, while 77% had a higher than normal fat percentage. Based on these findings, it is clear that there are challenges among this study participants who are PWDs on wheelchairs, and who have suffered spinal cord injury, in maintaining adequate levels of % body fat, as well as BMI within the normal values[26]. It is obvious therefore, that the knowledge of the body composition of each individual practitioner is necessary to plan a tailored-made training plan for physical conditioning[27].

According to Matias et al.[28], intense physical activities associated with loss of sweat and dehydration may be related to changes in the amount of intracellular and extracellular water, as well as the impairment of sportsmen's physical performance[16]. In addition, while over hydration is quite uncommon in athletes, physiological dehydration processes can be induced by high-intensity physical activity, leading to hypotonia and isotonic or hypertonic dehydration[29]. Hypo-hydration can produce a decrease in blood volume, which reduces systolic volume and, in turn, evokes a higher heart rate to maintain cardiac output, demonstrating that hydration is a major factor that must be incorporated into the habits of all athletes or non-athletes[6]. Among the 13 study participants, 10 presented low intracellular and extracellular water levels. This result is possibly related to the reduced fluid consumption, or excessive sweat and urine water loss in this population.

Providing this information will allow the development of recommendations for the monitoring of HR in WB, to avoid large inter-individual variations within the group and lack of standardization of HR in relation % THR. This will enable in a better fashion the basketball coaches, fitness professionals and sports scientists to make informed decisions about implementing HR monitoring practices to verify the intensity, frequency, methodology and volume of WB training in order to generate positive effects on various cardiovascular conditions. In this sense, it will be possible to improve the physical performance of PWD[30].

There are differences in physiological responses among WB players having different classifications and functional levels. Based on this, the IWBF controls the classification and game rules of WB and employs a classification system based on the functional abilities of PWD, as they are performing different roles within the WB game[18,31]. In the present study, although the players, had different functions within the game, they did not present difficulties in mobility and performance of their tasks, therefore, the variables regarding functional classification, level, type and time of injury evaluated were not statistically significantly different in correlation with % THR.

Some limitations were found in the study that could serve to clarify specific points regarding the specificity, training and functional classification in WB. The difficulty in finding similar data that describe the monitoring of WB players' HR who underwent intervention-using WB at 8 weeks of training. On the other hand, this is a predicate of the present study in offering data that were not found to be similar. Another point is the comparison of the % THR on $HR_{peak}$ data collection in a single moment of evaluation during the intervention. We suggest further investigation of the influence of $VO_{2max}$ and cardiac reserve rate, in addition to game-specific skills tests in comparison to the time of injury and BMI of PWD.

It is worth highlighting the importance of applications of HR monitoring and HRpeak of each individual using appropriate technologies to achieve an internal response on % THR, and responding adequately in relation to the external load administered, functional classification, level and type of injury. This is important so that future coaches can quantify the best load, the volume, frequency and intensity of training for PWD who practice WB.

## Conclusion

The WB training showed a favorable result on the intensity assessed by monitoring heart rate, suggesting that the methodology applied in the respective training was able to promote a sufficient training threshold in this group of people. Therefore, it is necessary to propose specific exercise protocols, as well as to determine % THR, hydration levels and % body fat of each individual practitioner. This is important, as it will enable future coaches in determining what is the best training load, volume, frequency and intensity of training that can best meet the needs and demands of the PWD who are WB practitioners.

## Resumo

Avaliação da intensidade do treinamento de basquete em cadeira de rodas por monitoramento da frequência cardíaca em pessoas com deficiência física.

Objetivo: Verificar a intensidade do basquete em cadeira de rodas (BCR) em pessoas com deficiência (PCD) durante 8 semanas de intervenção. Métodos: Estudo experimental longitudinal com 13 PCD foi avaliado o monitoramento da FC, freqüência cardíaca média ($FC_{Méd}$) para cálculo da frequência cardíaca mínima ($FC_{Min}$) e % frequência cardíaca de treinamento (% FCT) foram baseados na $FC_{pico}$. Estes foram então analisados para possível correlação com o tipo, nível e tempo da lesão, bem como os valores antropométricos obtidos por bioimpedância. Resultados: Após análise estatística, nas variáveis independentes verificou-se que o percentual de gordura corporal ($p <0,01$), água intracelular e extracelular foram correlacionado positivamente ($p <0,05$) com % FCT. As variáveis dependentes, classificação funcional, nível e tipo de lesão e IMC não foram significativas ($p> 0,05$) quando correlacionadas com a $FC_{pico}$. Conclusões: A maioria dos participantes obteve a % FCT acima de 60% da $FC_{pico}$ e indicando que a intervenção auxiliou na promoção da saúde cardiovascular, além dos benefícios mencionados dos níveis de hidratação e % gordura corporal de cada indivíduo. O presente estudo pode servir de base científica para o educador físico e afins, principalmente no que diz respeito ao uso do basquete em cadeira de rodas na reabilitação ou treino de aptidão física para PCD.


Palavras-chave: Água intracelular e extracelular; Corpo gordo; Frequência cardíaca; Treinamento; Intensidade.

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