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Wheelchair Basketball Exercise Intensity in Youth

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Abstract Children and youth with physical disabilities are at the greatest risk for inactivity, emphasizing the need for evidence-based activity options in recreation, rehabilitation, and post-rehabilitation settings. To determine if a wheelchair sport enabled youth participants to sustain moderate to vigorous physical activity (MVPA), the primary purpose of this study was to document exercise intensity of wheelchair basketball (WBB) among youth. The secondary purpose was to examine the influence of age, disability type, and training condition on intensity. Thirty-four youth with physical disabilities (M_{Age} = 15.73 ± 2.57 yrs; $M_{Playing\ \mathrm{Experience}}$ = 4.32 ± 2.77 yrs) participated in three wheelchair basketball training sessions that included tactical drills (M = 113 min), and scrimmage (M = 57 min) training conditions. Percentage of maximum heart rate (HR_{Max}), mean accelerometer vector counts per minute, and rate of perceived exertion (RPE) were assessed across 3 practices and collapsed into one training intensity score for each variable. Mean HR_{Max} was 66±8% and mean accelerator vector counts were 6,055±1439 per minute, indicating that participants sustained MVPA during WBB training. Perceived effort, however, was distinct from the actual physical demand as mean RPE was 3.1±1.5. Age did not influence intensity scores but players who had a congenital or acquired spinal cord injury and were participating in scrimmage activity demonstrated higher exercise intensity. These findings support the ability of youth WBB players to sustain MVPA. This activity can be recommended as an evidence-based initiative in sport, rehabilitation or post-rehabilitation settings.

Keywords: *disability sport, physical disability, exercise prescription, fitness, heart rate*

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1. Introduction

The need to implement evidence-based physical activity initiatives is an emerging issue in disability and health [1]. Persons with disabilities, especially those with physical disabilities, are far less likely than those without to participate in healthy lifestyle behaviors such as health-enhancing exercise [2,3]. As a result, individuals with physical disabilities such as cerebral palsy, muscular dystrophy, and spinal cord injury are more likely to experience poorer health outcomes and are at increased chronic disease risk [4,5]. Because activity behaviors in adulthood can track from childhood, establishing effective physical activity patterns in youth rehabilitation and post-rehabilitation settings is a must [6].

Current activity guidelines recommend 60 minutes of daily moderate- to vigorous-intensity physical activity (MVPA) that includes bone and muscle-strengthening activities [7,8]. Benefits that result from this behavior among youth, regardless of ability level, include improved health-related physical fitness and reduced risk of chronic disease (including obesity) [7]. Regular MVPA is also linked to social and academic benefits such as greater academic learning time (as measured using on task time), improved socialization, and improved mood or reduced risk of depression [9,10]. Unfortunately, as few as 20% of all children meet the recommended amounts of MVPA with an even smaller percentage meeting this standard among youth with disabilities [8]. For people with a physical disability, accessibility is often uncertain. A number of barriers, such as lack of accessibility in built/physical environments (e.g., public buildings and spaces in both urban and rural settings), lack of accessible equipment, and insufficient program opportunities, impede activity participation [6,11]. As a result, persons with physical disabilities are at the greatest risk for inactivity [2], emphasizing the need for evidence-based activity options in rehabilitation and post-rehabilitation settings [1,9].

1.1. Wheelchair Sport as Exercise

Wheelchair sport may be a viable activity option for children and youth with physical disabilities [12,13]. Wheelchair sport is becoming part of mainstream sports programming through both community recreation and grassroots efforts, enabling youth to access sport teams and leagues [14]. Wheelchair sport is also offered in accessible facilities, that differ from many public buildings and spaces reducing the number of physical and environmental barriers for manual wheelchair users. Finally, multiple benefits from wheelchair sport have been documented among adults with disabilities in both rehabilitation and post-rehabilitation settings including improved aerobic fitness, muscular strength, lipid profile, affect, and reduced risk of chronic disease [5,11,15,16,17].

The research problem for the current study is that exercise intensities of many wheelchair sports are unknown. Butte and colleagues [18] have made tremendous strides identifying appropriate physical activity intensities for youth but wheelchair sport estimates are still lacking. The energy cost of activities cannot simply be extrapolated from adults as the developmental changes in children and youth affect energy expenditure [19]. To determine if wheelchair sport is an evidence-based physical activity option for youth, we must first determine if players sustain recommend intensity for good health, or stated differently, determine if individuals are able to achieve and sustain MVPA during participation.

Youth wheelchair basketball (WBB) is a viable starting point to explore activity intensity because it is one of the most popular wheelchair sports [20,21] and is one of the most vigorous sports for adults with disabilities [22,23,24]. Therefore, the primary purpose of this study was to determine the intensity of WBB in youth. Our hypothesis, based on the intensity documented during adult WBB, was that players would sustain MVPA during WBB participation. Additionally, it is clear that developmental differences affect exercise intensity in youth [18] and that type of disability [25,26] and training condition [21,27,28] affect exercise intensity in adults. Therefore, the secondary purposes of this study were to examine the influence of age group, disability type, and training condition on exercise intensity.

2. Materials and Methods

2.1. Participants

Participants were recruited from five teams across a metropolitan city in the Southeast United States. Eligibility criteria for participation in these wheelchair basketball programs included participants who (1) had a primary disability that was physical, (2) were able to travel unassisted, with devices or manual wheelchairs, and (3) were able to compete in a manual wheelchair. Inclusion criteria for the study required at least one season of wheelchair basketball experience with their current coach to ensure minimum skill proficiency. Participants (N = 34; 23 males, 11 females) ranged in age from 13 to 21 years (M = 15.73 ± 2.57) and had up to 10 years of playing experience with the same coach (M = 4.32 ± 2.77 yrs). Athletes represented four racial groups: Caucasian (n=15), African American/Black (n =14), Hispanic (n=4) and Multiracial (n=1). Three participants were unable to wear a heart rate monitor due to latex allergies and one participant did not have accelerometer data. Consent and assent were provided by participants and parents, respectively, and IRB approval was obtained.

Targeted basketball programs were open to school-aged students with disabilities in grades 1-12 which, in the United States, provide school-based services through the age of 21 [29]. Teams were cross disability and co-ed. Medical forms submitted to the sport organizations from which participants were recruited documented participant disability. An equal number of participants had a spinal cord injury (thoracic or lumbar level) inclusive of spina bifida (n=17; congenital or acquired) as non-spinal cord injury (n=17; amputation, arthrogryposis, cerebral palsy or other). Specific level and completeness of spinal cord injury, severity of disability, and sport classification were not collected for several reasons. First, trainings were conducted at the community or school district level; therefore, all school-age participants within a school district who met the eligibility criteria outlined above were eligible to participate regardless of severity level. Second, medical documentation required for sport participation included evidence of a physical disability but not level of impairment. Third, classification is not used for junior division prep teams consistent with the policies of the National Wheelchair Basketball Association (https://www.nwba.org/juniorclassification).

2.2. Instruments

Percentage of HR_{Max} and ratings of perceived exertion (RPE) have both been used extensively in WBB to monitor exercise intensity [3,30,31]. These intensity variables are complementary in wheelchair basketball players and provide distinct, meaningful information [30,32]. To assess percentage of HR_{Max}, Cardiosport Go digital heart rate monitors (Healthcare Technology Ltd.; Hampshire, United Kingdom) were used to monitor HR across data collection sessions. This device records training time and scores can be downloaded to determine HR values across varied conditions (e.g., average drill HR, average scrimmage HR, etc.). Additionally, because HR can be affected by impairment, we also assessed exercise intensity as average physical activity counts recorded through an accelerometer (actigraph wGT3X). We chose this instrument as a complimentary tool to assess WBB intensity because strong relationships (r = 0.93 to 0.95) have been reported between energy expenditure (VO_2) and wrist-worn accelerometer counts during manual wheelchair pushing [33].

The Wheelchair Perceived Exertion Scale (WHEEL) was used to assess RPE [34]. The WHEEL scale was created to serve as a criterion measure of exertion in persons who use wheelchairs for activities of daily living (including wheelchair sport) and was developed specifically for individuals with lower extremity impairments who use assistive devices who may not have experience with a standard bicycle, walking or stepping to better relate to personal feelings of exertion through pictures specifically designed for them [34]. The WHEEL is a pictorial assessment of perceived exertion with verbal descriptors based on the child OMNI rating of perceived exertion scale. Pictures reflect a person in a sport wheelchair pushing up an incline. The WHEEL scale can measure either differentiated (e.g, arm fatigue) or undifferentiated (overall body) ratings of perceived exertion. Given a lack of evidence for the use of differentiated or undifferentiated RPE in persons with a physical disability [34] and the lack of exposure of youth with disabilities to evaluating RPE, an undifferentiated rating of perceived exertion was used in the present study.

Participants viewed the WHEEL scale and indicated the level of exertion they felt at the given checkpoint. Participants pointed to the RPE on the WHEEL or identified a verbal response. The WHEEL scale has demonstrated concurrent and construct validity when evaluated with the Borg 6-20 Scale, demonstrating a moderate significant linear correlation between HR and WHEEL RPE and between VO_2 and WHEEL RPE [34].

2.3. Procedures

Teams trained once a week for 90 to 120 minutes. To maximize generalizability of findings and external validity of the design, coaches were solely responsible for planning their own training program and no restrictions were made relative to training condition (e.g., tactical drills, scrimmage) or time spent in different conditions. We felt collecting data in ecologically valid settings would yield the most ecologically valid measure of WBB intensity. After-school training was selected as more players had the opportunity to participate compared to gameplay when some may have limited playing minutes. Data were collected at wheelchair basketball training sessions (i.e., team practices) for three consecutive weeks. Data collection over multiple training periods reflects recent work in WBB intensity studies [25,28,30,31] and provides a much more stable estimate of activity intensity than earlier literature for one practice or game exposure [21,23,26,35,36]. Participants missing a practice were tested the following week upon their return, as this would have been their individual consecutive week of attendance. As such, there were no missing samples.

The Cardiosport receiver was attached to the rear of the wheelchair frame to avoid getting caught in the wheels and to minimize participants using HR readings to modify natural exercise intentions. The heart rate monitor and transmitter was placed on players' chest a minimum of 10 minutes prior to the start of practice to facilitate familiarization with the device. Practice start and end times were recorded and HR was recorded continuously for the length of each training session. The accelerometer was placed on the upper arm at the same time as the HR monitors were placed on players chests.

Continuous HR data were collected every 5 seconds across the following conditions: dynamic warm-up (e.g., wheelchair pushing drills with and without a ball); tactical skill practice (e.g., offense and defense, setting picks), and scrimmage. Research assistants logged condition times, time-outs, rest breaks, and total practice time manually. At the conclusion of training, accelerometer and HR data were downloaded to determine exercise intensity. The equation 208 - (0.07 * age) was used to estimate HR_{Max} because it is more accurate than traditional formulas (e.g., 220-age), has been validated in youth with and without a disability, and is not affected by age, gender, or level of activity [37,38]. Average exercise intensity was computed for the training day and for each training condition. Accelerometer data were also downloaded to determine average vector counts per minute across the entire training session.

Evaluation of RPE in children is based on an assumption that children have an understanding and memory of what it feels like to exercise to a state of maximal exhaustion. Young children, particularly those with physical impairments, may never have experienced this state and have no understanding of how it feels [40]. To address this potential limitation, RPE was collected over three trainings sessions to enable participants to gain skill in understanding their effort. Familiarization with the RPE rating scale took place at rest on the first training day when the chest transmitter was positioned on each player. Rating of perceived exertion was assessed prior to the start, at transition breaks following each training condition, and at the end of each training session. The pictorial representation of exertion levels translates into a number representing level of exertion increasing incrementally on a scale from 0 (not at all tired) to 10 (very, very tired). A score of 10 is akin to wheeling across the finish line at a race, with a rating of 6 likened to the exertion felt if one were running late and was pushing the wheelchair quickly to get to the bus stop [34]. The various levels of RPE from 1-10 were explained using verbal descriptors along with numeric anchors each time participants completed the scale. Players pointed to their RPE on the WHEEL scale with scores manually recorded. Players were assured there were no right or wrong perceptions, that their responses would be kept confidential and not shared with coaches, and not judged by the research investigators.

2.4. Analyses

To determine the intensity of WBB in youth, we computed descriptive statistics to express training intensity as: 1) percentage of maximum heart rate, 2) average accelerometer vector counts per minute, and 3) RPE. Based on the models of Yanci and Iturricastillo (28,30), data collected across multiple training sessions were collapsed into one training intensity measure for each assessment. We then examined intensity by condition for the instruments that allowed visual inspection by time (i.e., HR and RPE). The criteria for MVPA were ≥ 64% of HR_{Max}, average vector counts ≥ 3,500 per minute, and RPE ≥ 5 [41]. No studies have compared methods of estimating exercise intensity in youth with disabilities. These relative exercise intensity classifications, however, have been commonly used in practice, result in improvements in cardiorespiratory fitness and thus are recommended for use for the current study [41]. All three variables met assumptions for normality (Shapiro-Wilk) as skewness and kurtosis were not present.

To examine the influence of age, impairment type, and training condition on intensity, we first used step-wise regression to examine the collective influence of age and disability type on intensity. We then used ANOVA to determine if significant mean differences on exercise intensity existed between training conditions (i.e., dynamic warm-up, tactical drills, and scrimmage). Each of these analyses were conducted for each expression of intensity (i.e., %HR_{Max}, vector counts, RPE). The step-wise model was chosen because it allowed us to examine the collective influence of independent variables on intensity. Follow-up independent groups ANOVA and Cohen's *d* were used to examine independent effects of entered variables.

3. Results

Participants completed both tactical drills (M = 113 min), and scrimmage (M = 57 min) training conditions. Our hypothesis, based on the anticipated energy demand necessary to move a manual wheelchair repeatedly over moderate long distances, was that players would sustain moderate- or vigorous-intensity during WBB training. This hypothesis was supported as mean HR_{Max} was 66±8% and mean accelerator vector counts were 6,055±1439 per minute, indicating that participants sustained MVPA during WBB training. Perceived effort, however, was distinct from the actual physical demand as mean RPE was 3.1±1.5. This value is associated with light-intensity rather than moderate-intensity activity. This distinction reflects that affective assessments of intensity (RPE) may differ from objectively-measured measures (%HR_{Max}, accelerometer counts) during WBB sport. Very few participants were exposed to dynamic warm-up activities and these data were excluded from review; however, exercise intensity is reported across other training conditions in Table 1.

The secondary purpose of this study was to examine the influence of age, disability type, and training condition on exercise intensity. Regression models showed that disability type, but not age, explained a significant amount of variability in WBB intensity expressed as %HR_{Max} (R = .72) but not when expressed as accelerometer counts or RPE (i.e., no variables were significant predictors). Participants with acquired or congenital SCI demonstrated a significantly higher %HR_{Max} (71±5%) compared to participants without SCI (61±6%; F = 26.21, p = .000). Almost all participants with SCI used a manual wheelchair for everyday activities so we examined the effect of this potentially confounding variable on intensity but there were no differences between participants who did and did not use manual chairs outside of sport on %HR_{Max}. Further examination of data, however, revealed that players with cerebral palsy and amputations had lower intensity scores when expressed as a percentage of HR but not when expressed as RPE or accelerometer counts. This finding is explored in the discussion. Finally, repeated measures ANOVA demonstrated significant increases in %HR_{Max} (F = 13.58, p = .001) and RPE (F = 22.73, p = .000) from tactical drill to scrimmage conditions (Table 1).

Table 1. Mean Exercise Intensity by Training Condition

	Tactical Drills	*Scrimmage*	*Total Training*
% HR_{Max}	64.3 ± 9.3	71.0 ± 8.7*	66.2 ± 7.5
RPE	2.6 ± 1.6	4.5 ± 1.7*	4.5 ± 1.7
Accelerometer Counts per Minute			6,055 ± 1,439

*Statistically different from Tactical Drill Condition.

Table 2. Mean Exercise Intensity by Disability Group

	% HR_{Max}	*Accelerometer*
Amputee (n = 5)	62 ± 7	5,732 ± 1,473
Cerebral Palsy (n = 7)	59 ± 8	6,777 ± 1,681
Spina Bifida (n = 13)	71 ± 5	5,670 ± 980
Spinal Cord Injury (n = 4)	72 ± 1	6,014 ± 1,208

Note. Participants with other physical impairments (n = 5) were not included in this table.

4. Discussion

The primary purpose of this study was to determine the intensity of WBB in youth. This evidence-based study supports the ability of youth to sustain moderate to vigorous physical activity (MVPA) during WBB training. As such, practitioners and therapists can use and recommend WBB as a meaningful physical activity intervention. Regular MVPA helps youth improve cardiorespiratory fitness, decrease levels of body fatness, improve cognitive skills, and improve affect [8]. In the able-bodied population, sports are positively related to physical activity in youth and the current study supports the usage of WBB as a physical activity promotion initiative.

Exercise intensity documented during adult WBB has either been moderate [23,42] or vigorous [21,28,36,43]. Multiple authors have reported that heart rate intensity in WBB is related to skill level with greater skill yielding higher heart rates [21,28]. The fact that youth were able to demonstrate a meaningful exercise intensity during WBB, despite the limited skill level, should give coaches, program directors, and therapists more confidence when recommending WBB as a youth sport, recreation, rehabilitation, or post-rehabilitation option. The majority of wheelchair basketball research has been conducted on players competing at the national or international level. Because youth wheelchair sport is typically offered through grassroots programs that serve both competitive and non-competitive athletes [6,44], it is not surprising that current findings did not duplicate game-based intensity of national- and international-level competition. Regardless, the ability of school- and community-based sport to sustain MVPA associated with meaningful health benefits supports the use of wheelchair basketball as an evidence-based activity initiative. It should also be recognized that current findings may underestimate actual gameplay intensity as we assessed intensity during after-school training rather than actual competitions.

An inhibiting factor to sustaining high intensity in youth WBB could be the base level of fitness needed for the competitive game. Multiple researchers have stressed the importance of aerobic fitness specific to this sport [22,23,45]. Above average fitness is essential to performance of adult wheelchair basketball because only 20-30% of gameplay is anaerobic in nature [22,23,32,36,45]. Wheelchair basketball training requires high-intensity training and youth athletes may not have developed the aerobic or anaerobic endurance capacity needed to sustain highly vigorous-intensity during training. However, the fact that the game is predominantly aerobic with high-intensity sprints included is a good model for youth to increase their aerobic fitness over time.

5. Influence of Age, Disability Type, and Training Condition

The secondary purpose of this study was to examine the influence of age, disability type, and training condition on exercise intensity. Tremendous strides identifying exercise intensity for youth have been made over the past decade and the compendium of activity intensities reported by Butte and colleagues [18] indicate that ambulatory physical activity intensity is age dependent. As youth age, multiple factors such as physical development and movement efficiency contribute to higher intensity with advancing age. Although intensity estimates for youth disability sport are not available in the compendium, results from the current study do not support the trend that age affects WBB intensity. Based on step-wise regression, age was not related to training intensity expressed as $\%HR_{Max}$, accelerometer counts, or RPE. Even when examining the independent effect of compendium-based age groups on intensity (10-12 years, 13-15 years, 16-18 years, > 18 years), there were no statistical differences across groups. Players in all compendium age groups demonstrated the ability to sustain MVPA during WBB training. In short, unlike ambulatory sport, other individual characteristics affected exercise intensity more than age in the current study.

Limited research has examined the effect of impairment type on WBB intensity. In the current study, disability type influenced exercise intensity when expressed as $\%HR_{Max}$ but not when expressed as accelerometer counts or RPE. Players with SCI, inclusive of those with spina bifida, demonstrated significantly higher $\%HR_{Max}$ scores than those without SCI. In particular, participants with amputations and cerebral palsy demonstrated noticeably lower $\%HR_{Max}$ scores compared to players with some form of SCI (Table 2). This outcome was surprising as absolute heart rate is typically lower in adult athletes with SCI during WBB [26] but relative training intensity seems to be similar [25]. The higher HR intensity among youth with SCI during WBB, despite similar activity demand as expressed by accelerometer counts, is unexplained and requires further investigation.

It is important to note that persons with physical disabilities are most likely to engage in light-intensity exercise on their own [46]. The ability of participants to sustain MVPA across multiple WBB training sessions demonstrates its potential effectiveness as an activity promotion initiative. For players unable to sustain moderate-intensity exercise during WBB, light-intensity activity is related to a number of important benefits for persons with physical impairments including improved strength, improved wheelchair propulsion efficiency, improved functional capacity or ability to complete everyday tasks, and improved life satisfaction [47,48]. Additionally, sport for persons with physical impairments, regardless of intensity, has been shown to be essential for optimizing health and performance [45,46]. It seems clear that wheelchair basketball affords youth with physical disabilities an effective and accessible opportunity to positively affect individual health through regular participation, regardless of impairment type.

Finally, WBB intensity varied by condition. Consistent with other sports, scrimmage activities required a greater sustained effort than tactical sport-specific drills. This variation in training intensity has been demonstrated in a number of sports including wheelchair basketball [27,31], wheelchair rugby [49], wheelchair soccer [47,50], and wheelchair tennis [51]. Sport-specific drills typically consist of intermittent, rather than continuous, activity and rest time for instruction. The fact that exercise intensity increased from tactical drills to scrimmage activity in the current study reinforces the ability of this sport to provide a training stimulus that is modifiable. Because the training stimulus can be manipulated, coaches, program directors, and therapists can intentionally use WBB to manipulate effort and associated adaptations.

We chose to add a subjective measure of intensity, RPE, to support our objective intensity measures because they are not predictive of one another in wheelchair basketball, possibly due to the inherent intermittent nature of the sport [52]. RPE is indicative of time to exhaustion in persons with and without paraplegia and increases as exhaustion nears, regardless of available active muscle mass [53]. The low RPE in the current study reflect players' ability to continue training despite the intensity demand of the activity (i.e., $\%HR_{Max}$, accelerometer counts). RPE was very stable over time in the current study and was responsive to intensity differences in the changing training conditions (tactical drills, scrimmage). Previous research has also shown that HR remains fairly stable during WBB which was consistent with current findings [52].

Typically, manual wheelchair users demonstrate lower intensities in sport than able-bodied athletes, most likely because the motor patterns are better ingrained and movement is more efficient in regular wheelchair users. In the current study, however, participants who used their manual chair to complete ADLs demonstrated similar exercise intensities, regardless how it was expressed, compared to players who primarily used a manual chair for sport only. Findings confirmed that dependence on a manual wheelchair outside of sport did not prevent participants from sustaining MVPA during WBB. Inefficient movement can inhibit one's ability to reach higher energy demands, therefore, future research should examine the ability of novice participants to reach and sustain MVPA during training and/or gameplay. Further research is needed in this area.

6. Limitations and Future Directions

Several limitations of field research studies are worth noting. Significant differences in the structure of basketball practices across different teams was evident. Because we wanted to maximize external validity of findings, we did not dictate to coaches the training schedule. Teams varied in their amount of time in tactical and scrimmage conditions thus impacting the frequency with which HR, accelerometer and RPE ratings were ascertained during training. Some teams took fewer breaks than others making the number of measurements and the period between recordings of HR and RPE different across teams. Future research might consider standardizing a practice with a consistent training plan for all teams with built-in transitions and breaks for comparative data collection. Second, it is possible that coaches may have made minor adjustments to their practice structure to alter intensity to demonstrate their effectiveness as a coach but, subjectively speaking, players and coaches appeared to pay little attention to HR or RPE measurements as neither asked for reports of HR during, or at the end of, practice. The number of athletes attending a practice also may have influenced intensity of training. Teams differed in attendance patterns with some teams maintaining a full roster at each practice while others had four athletes at a given practice. In some cases, volunteers and/or coaches participated to enable players to engage in tactical drills or full scrimmage at an intensity level on par with teams with a full roster. The integration of non-WBB players absolutely could affect training intensity. The real-word conditions of WBB training dictated our decision to collect data over multiple sessions in order to get one fairly stable intensity over time, reducing the impact of altered playing conditions at each practice. Additionally, the interpretation of the data may be limited as it does not consider the unique impact of level and completeness of spinal cord injury on HR. However, from a research to practice perspective, the practical value of the findings, regardless of the impact of the level of any SCI, is of importance to coaches and practitioners working to improve the health and well-being of youth with physical disabilities through sport. Last, future research could consider functional evaluation of basketball skill as a surrogate to a players' level where disability classification is not available.

In conclusion, the purpose of this study was to document the exercise intensity of wheelchair basketball to determine if it is an evidence-based physical activity option. Participants sustained MVPA over three wheelchair basketball practices. Age did not affect intensity measures but disability type and training condition did. Results from this study support wheelchair basketball as an evidence-based physical activity, recreation, rehabilitation or post-rehabilitation option for youth.

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Statement of Competing Interests

The authors have no competing interests.

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