Northumbria Research Link

Citation: Khudair, Mohammed, van Biesen, Debbie, Pérez-Tejero, Javier and Hettinga, Florentina (2021) The importance of pacing in basketball players with intellectual impairment: Input for evidence-based classification. *Journal of Sports Sciences*, 39 (Sup1). pp. 116-124. ISSN 0264-0414

Published by: Taylor & Francis

URL: <https://doi.org/10.1080/02640414.2021.1881303>
<<https://doi.org/10.1080/02640414.2021.1881303>>

This version was downloaded from Northumbria Research Link:
<http://nrl.northumbria.ac.uk/id/eprint/45419/>

Northumbria University has developed Northumbria Research Link (NRL) to enable users to access the University's research output. Copyright © and moral rights for items on NRL are retained by the individual author(s) and/or other copyright owners. Single copies of full items can be reproduced, displayed or performed, and given to third parties in any format or medium for personal research or study, educational, or not-for-profit purposes without prior permission or charge, provided the authors, title and full bibliographic details are given, as well as a hyperlink and/or URL to the original metadata page. The content must not be changed in any way. Full items must not be sold commercially in any format or medium without formal permission of the copyright holder. The full policy is available online: <http://nrl.northumbria.ac.uk/policies.html>

This document may differ from the final, published version of the research and has been made available online in accordance with publisher policies. To read and/or cite from the published version of the research, please visit the publisher's website (a subscription may be required.)

The importance of pacing in basketball players with intellectual impairment:

Input for evidence-based classification

M. Khudair¹, D. van Biesen², J. Pérez-Tejero³, F.J. Hettinga^{4*}

*Corresponding author

¹Mohammed Khudair, Department of Sport, Exercise & Rehabilitation, Faculty of Health and Life Sciences, Northumbria University, Room 258, Northumberland Building, Newcastle Upon Tyne, NE1 8ST, United Kingdom, T: +46 (0)760 290828 E: m.khudair@northumbria.ac.uk

²Debbie Van Biesen, PhD, Research Group for Adapted Physical Activity and Psychomotor Rehabilitation, Department of Rehabilitation Sciences, Faculty of Kinesiology and Rehabilitation Sciences, KU Leuven, Tervuursevest 101 – box 1500, 3001 Heverlee, T: +32 16 37 65 12 E: debbie.vanbiesen@kuleuven.be, www.idealproject.org

³Prof. Javier Pérez-Tejero, PhD, Faculty of Physical Activity & Sport Sciences, Technical University of Madrid, Spain.

Martín Fierro, 7, 28040, Madrid, Spain. T: +34 910677882 E: j.perez@upm.es

⁴Prof Dr Florentina J Hettinga, PhD, Department of Sport, Exercise & Rehabilitation, Faculty of Health and Life Sciences, Northumbria University, Room 238, Northumberland Building, Newcastle Upon Tyne, NE1 8ST, United Kingdom, T: +44 (0)191 227 3989 E: florentina.hettinga@northumbria.ac.uk (corresponding author)

M. Khudair, D. van Biesen, J Perez, F.J. Hettinga. The importance of pacing in basketball players with intellectual impairment: Input for evidence-based classification. *JSS (in press)*

22

23

24 **Abstract**

25 Pacing places a high demand on intellectual functioning and has been found useful for classification of
26 athletes with intellectual impairments (II). This may also be true in open-loop sports like basketball. The
27 aim of the current study was to investigate the pacing behaviour of basketball players with and without
28 II. Using time-motion analysis, the activity of elite basketball players with II (n=37) and amateur players
29 without II (n=34) was coded into four movement categories over eight periods of each game: standing,
30 walking, running and jumping. Following two-way ANOVA, an effect of group showed differences between
31 groups in duration and frequency of the movement categories within each period of the games.
32 Additionally, an effect of time suggested that players in both groups paced their performances. However,
33 no interaction was found, indicating that pacing may not be different between groups. In conclusion, the
34 results suggest that due to the dynamic nature of basketball, the included players paced more intuitively
35 by responding to environmental cues and using less deliberate planning. The players with II demonstrated
36 slower games, which may be due to an impaired ability to make quick moment-to-moment deliberate
37 decisions. These skills should be further studied in the context of evidence-based classification.

38 Keywords: Disability, cognition, decision-making, team sports, regulation of energy expenditure.

39 Word count: 5465 words

40 References: APA-style 7th

41

42 **Introduction**

It is important for athletes to regulate the exercise intensity in athletic performances in order to avoid the effect of early fatigue and, at the same time, avoid underperforming. This is also known as pacing – the goal-directed regulation of exercise intensity throughout an exercise bout (Smits et al., 2014). The decision-making process for either increasing or reducing exercise intensity in order to adapt to the environment is dependent on cognitive abilities (Brick et al., 2016; Smits et al., 2014). Athletes with intellectual impairment (II), unlike athletes without II (non-II), have limitations in intellectual functioning and adaptive behaviour (Gilderthorp et al., 2018) and due to the lower levels of cognitive abilities and executive functioning, they may find it particularly difficult to pace athletic performances (Van Biesen et al., 2016b). It has been highlighted in previous research that there is a need for research on athletes with II that provides input for the creation of evidence based classification systems for II-sports (Tweedy et al., 2016). In describing the process of creating evidence-based classification systems, Tweedy et al. (2016) called for the development of sport-specific measures of determinants of performance that are impacted by the impairment. Pacing has been investigated in middle-distance runners with and without II, which has shown significant differences in pacing between the groups, highlighting the impact of the impairment on pacing abilities and providing input for classification of runners with II in athletics (Van Biesen et al., 2016a).

In an open-loop team sport like basketball, the above may be especially true. An open-loop sport, as opposed to a closed-loop sport, is one where athletes are required to react in a dynamically changing, unpredictable and externally-paced environment (Wang et al., 2013). Therefore, pacing is more externally regulated as players frequently respond and adapt to environmental changes imposed by the events of the game, as well as by teammates and opponents (Waldron & Highton, 2014). In addition, basketball is a high-intensity intermittent sport, where players frequently perform short bursts at high intensity (Read et al., 2014). In order to maintain the ability to perform high-intensity bursts throughout a 40-minute basketball game, it is important for players to regulate the frequency and duration of these bursts, thereby

67 deciding on how and when to invest their energy throughout the game (Waldron & Highton, 2014). As
68 this is a cognitively demanding task, it may be impacted by II and differences in pacing behaviour may
69 exist between players with and without II.

70 Previous research, which for the most part has studied closed-loop individual sports, has shown that in
71 order to pace their performance, athletes make use of pre-planned pacing strategies that are based on
72 knowledge of the likely demands of the game, experience and the goals concerning their performance
73 (Edwards & Polman, 2013). However, athletes do not always pace their performances according to their
74 pre-planned pacing strategies (Van Biesen et al., 2017). In addition to their pre-planned pacing strategies,
75 they respond to their internal states, i.e. physiological states like fatigue, and psychological states like
76 motivation and emotions; and environmental cues like events of the game, opponents, teammates and
77 spectators (Konings et al., 2016; Tucker, 2009; Van Biesen et al., 2016a). In athletes with II, Van Biesen et
78 al. (2017) compared the ability to maintain a pre-planned pacing strategy in 400 m running trials between
79 elite runners with and without II. They found that runners with II deviated more from the pre-planned
80 pacing strategy compared to the runners without II in both the first 200 m of the race, where they received
81 external guidance and during the remaining 200 m of the race, where they did not receive any external
82 guidance. Thus, runners with II showed difficulties in maintaining the pre-planned pacing strategy, both
83 when they received external guidance and when they were to self-regulate the intensity. In another study,
84 Van Biesen et al. (2016a) investigated the pacing behaviour of elite middle distance runners (400 m and
85 1500 m) with and without II. They found that the runners with II paced their races differently compared
86 to the runners without II and the optimal pacing strategy of a world record holder. Although these findings
87 are derived from research in a closed-loop sport, they explain, to some extent, the lower performance
88 level of runners with II compared to runners without II and may be true in open-loop team sports as well
89 as these findings relate to the shortfalls in intellectual functioning in athletes with II (Gilderthorp et al.,
90 2018).

Research in II basketball has demonstrated the negative impact of II on different basketball performance aspects. For example, Pinilla (2016) studied the key game related statistics for team success by analysing the 13 games (63 players) at the 2013 INAS (now VIRTUS) World Basketball Championships in Ankara, Turkey. They found that assists and successful 2-point attempts were discriminant variables to success in II basketball competitions, as in non-II basketball. However, defensive rebounds discriminated in competitions for non-II but not for II. In addition, steals and offensive rebounds were only discriminant in competitions for II, which increases the number of ball possessions per game. Relevancy of assists reflected the importance of teamwork in both competitions for non-II and II. However, the lower shooting efficiency of players with II suggests possible limitations on decision making capacity or offensive tactics. Consequently, second opportunities to score, following offensive rebounds and opportunities to score under low defensive pressure in fast-breaks after a steal seem to take relevance to increase successful 2-point attempts in players with II (Pérez-Tejero et al., 2015). In all playing positions, players with II presented more unsuccessful 2-point attempts and a lower shooting percentage in all kinds of shots (Pinilla et al., 2017). Similar findings in game-related statistics have been found in elite basketball players without II. It was found that players who are able to maintain high defensive pressure throughout a game, and thereby able to maintain a higher pace than their opponents, were also able to recover the ball more often, creating additional scoring opportunities from turn-overs, steals and defensive rebounds (Sampaio et al., 2010).

Adding to these findings, it is particularly important to further our understanding of how athletes with II adapt to and behave in a dynamic environment such as basketball competition, where the environmental demands are amplified. The environmental demands make pacing-related decision making difficult as it depends on cognitive skills (Smits et al., 2014). The studies that investigated the pacing behaviour of players without II in high-intensity intermittent team sports have shown that the prominent pacing behaviour that is seen in matches is slow-positive, indicating a gradual decline of high-intensity running

over the course of a match, with 10-20% from the first to the second half and 20-30% from the first quartile of the match to the last quartile (Waldron & Highton, 2014). As these findings suggest fatigue, it has been found that players in high-intensity intermittent team sports increase the length of recovery duration between high-intensity bursts towards the latter parts of the game in order to recover, which helps maintain the ability to perform the high-intensity bursts (Black & Gabbett, 2014; Edwards & Noakes, 2009). This way, the athletes are able to regulate their efforts in the moment in anticipation of fatigue as part of a larger pacing strategy aimed at successfully completing the game without physiological failure (Edwards & Noakes, 2009). Additionally, differences between groups of playing position in activity have been established in previous studies on basketball players without II. Ben Abdelkrim et al. (2007) found differences in percent time spent in high intensity activity between under-19 players without II in different playing positions. This relates to the different task demands on players in the different playing positions, mainly relating to the differences in distances covered over the course of a game (Ben Abdelkrim et al., 2010). The above has been further operationalized by Edwards and Noakes (2009) who proposed a three-level model of the individual pacing behaviour in high-intensity intermittent team sports describing the regulation of intensity at three different levels. On the first level of pacing (macro-pacing), the players plan the pacing strategy ahead of a game based on past experiences and anticipated demands of the upcoming game to allow completion of the game without reaching physiological (and psychological) failure. The second level of pacing (meso-pacing) relates to an inter-half adjustment of the macro-pacing strategy, where players adjust the initial pacing strategy to current physiological and psychological states in relation to game demands. The third level of pacing (micro-pacing) is made up of in-the-moment adjustments of the pace, where the players decide on maintaining or reducing the intensity in order to maintain the ability to complete sprints (Edwards & Noakes, 2009). Thus, it has been established that athletes in high-intensity intermittent team sports engage in pacing to achieve the best possible performance. However, to date, no research has investigated the pacing behaviour of athletes with II in

basketball, or any high-intensity intermittent II team sport. Therefore, investigating the pacing behaviour of athletes with II in a sport such as basketball may shed light on much needed factors influencing the adaptability and performance of athletes with II.

In order to further our understanding of the pacing behaviour of athletes with II in a high-intensity intermittent team sport, the aim of the current study was to investigate the pacing behaviour of basketball players with and without II. The hypotheses were: (1) Players with II show a larger decline in the frequency and duration of running/jumping bouts over the course of the game compared with players without II. This difference will be found between the main II and non-II groups as well as for the different playing positions. (2) Players with II will show both an increase in recovery duration and a reduced frequency of running/jumping bouts earlier in a match compared to players without II. (3) Players with II show lower overall frequency and duration of high-intensity activities, i.e. running and jumping, and higher overall duration and frequency of low-intensity activities, i.e. standing and walking.

Materials and methods

In order to investigate the pacing behaviour of basketball players with and without II, videos of official basketball games for II and non-II players, respectively, were used. Two games from the 2013 INAS World Basketball Championships in Ankara, Turkey (final game and the game for 3rd place), including four teams (n=37), constituted the II group. The present study was approved by the KU-Leuven ethical committee (ref: [s57643](#)) and it was supported by INAS and IPC. The 2017 and 2018 finals of the Dutch Promotion Division league, including four teams (N=34), constituted the non-II group. The Dutch Promotion division is an amateur league in which players match the training volume of the players with II, which is 3/5 training sessions per week, and therefore the two groups were considered comparable. Ethical approval for the use of the publicly available matches of the Dutch Promotion Division was obtained from the local ethical committee at Northumbria University (ref: 21126). Thus, the complete sample of players was divided into

two main groups, II and non-II. Therefore, each of the two main groups was further divided into three playing position groups: guards, centers and forwards.

Using time-motion analysis provides the time spent in different movement categories, i.e. different intensities, which provides information on players' distribution of energy during the game (McInnes et al., 1995; Narazaki et al., 2009). The games were recorded with one camera from the midline of the court and panned to follow the players as they moved across the court. The games were coded by one investigator using Solomon Coder Version: beta 19.08.02, which is software used to code specific behaviour from video footage in real time (Péter, 2019). Four movement categories were coded that represent levels of intensity: standing, walking, running and jumping (Narazaki et al., 2009). The four categories were coded according to types of locomotion as follows; standing: both feet in contact with the floor without moving, walking: moving in any direction with one foot touching the floor at all times and no flight phases, running: moving in any direction with both single and double support, including a flight phase in each stride, jumping; moving vertically or horizontally with both feet released from the floor (Narazaki et al., 2009). The videos were coded with a temporal resolution of 0.02 seconds to match the frame rate of the video and later reduced to a temporal resolution of 1 second. This was to reduce the data to one movement category per second and allow the calculation of duration and frequency of each movement category. If multiple movements were performed within a 1-second window, each 1-second window included the most performed movement (Narazaki et al., 2009). The time in which the ball was considered "dead" was excluded from the data used for the statistical analyses (FIBA, 2018). The ball was considered dead during free throws and the time between consecutive free throws; during the time from when an official blows the whistle until the ball is thrown in and becomes at the disposal of the players; during the time from when the shot clock sounds after one team's possession time is over until the ball is thrown in and becomes at the disposal of the players; and after the game clock sounds the end of the quarter or overtime (FIBA, 2018). Each played quarter was divided into two periods of equal length, yielding 8 periods per

game (Black & Gabbett, 2014). As all players were substituted during the games, the pacing behaviour of each player was analysed for the duration of their playing time and the periods that they played during the games.

For test-re-test reliability, one full quarter was coded by the same investigator on two occasions with three weeks between the occasions for two players, one with II and one without II. Second-by-second data was used to calculate the intraclass correlation coefficient (ICC) separately for the players in a two-way mixed model of single-rater type and absolute agreement definition (Koo & Li, 2016). ICC for both players were considered excellent: for the player with II ICC=0.91 (CI 95%: 0.90-0.92) and the player without II ICC=0.93 (CI95%: 0.92-0.94).

Statistical analysis

The data reduction and analysis were performed in R (R Core Team, 2019). The second-by-second activity was reduced to running, jumping, walking and standing frequency (n/min) and duration (s/min), dividing the number of actions by the number of minutes played within each period, and further combined into running and jumping frequency (RJF), walking and standing frequency (WSF), running and jumping duration (RJD) and walking and standing duration (WSD; Black & Gabbett, 2014). The sample was stratified by Group (II and non-II), playing Position (center, forward and guard) and Match outcome (winning and losing). In addition, the eight-level factor Period was included to represent the eight time points across the games.

In order to investigate the differences in the pacing behaviour between the players with and without II across the 8 periods, two-way (2x2) repeated measures analysis of variance (ANOVA) was performed to analyse the effect of Group using RJF, WSF, RJD and WSD as dependent variables, respectively. Period was used as the within-subjects factor, and Group (II and non-II) as the between-subjects factor. Similarly, three-way repeated measures ANOVA was performed to analyse the effects of playing position, using RJF,

WSF, RJD and WSD as dependent variables, Period as the within-subjects factor, Group as the first between-subjects factor, and Position as the second between-subjects factor. Partial Eta squared was calculated for effect sizes to indicate the proportion of within- and between-subjects variations in movement categories with magnitudes set to small = 0.01, medium = 0.06 and large = 0.14 (Cohen, 1988). For both two-way and three-way ANOVA, Bonferroni was used as the method for post hoc correction. In the case of violation of the assumption of sphericity, according to Mauchly's test of Sphericity, the Greenhouse Geisser correction was used for interpretation of the results. Other tested assumptions were, Levene's test of homogeneity of variance and the normality of the residuals according to Shapiro-Wilk's test. The level of significance was set to $\alpha = 0.05$.

Results

The two-way repeated measures ANOVA showed significant main effects of Period and Group for RJF, RJD and WSD, showing that the non-II group maintained a higher frequency and duration of running and jumping and lower duration of walking and standing than the II group throughout the games, and that both groups varied in RJF, RJD and WSD over the eight periods. No main effects were found for WSF, suggesting no differences between the groups in WSF, and none of the groups varied in WSF throughout the games (Table 1). No significant interaction effects were found for either of these variables, suggesting that the distribution of the RJF, WSF, RJD and WSD may not be significantly different between the II and non-II groups. Table 1 shows the results of the two-way ANOVA for the four dependent variables. For the post-hoc analysis of the two-way ANOVA, see Figure 1.

Figure 1 near here

Table 1 near here

Results of the three-way repeated measures ANOVA for Period, Group and Position (Table 2) showed a main effect of Group for RJF, where the non-II group maintained an overall higher RJF than the II group.

Centers maintained a lower frequency than guards and forwards in the II group, whereas the reverse, but smaller, differences were found in the non-II group. No interaction effect was found for RJF, suggesting that the distribution of RJF over the eight periods was not significantly different between the II and non-II groups. For WSF, no main effects or interaction effects were found, suggesting that the II and non-II groups and the groups of playing positions maintained similar WSF and distributed WSF similarly across the eight periods. For RJD and WSD, main effects were found Period, Group and Position, showing that the non-II group maintained higher RJD and lower WSD than the II-group across the eight periods. The centers maintained lower RJD than guards and forwards, respectively, in both the II and non-II groups across the eight periods. The same, but reverse, results were found for WSD. The results showed no interaction effects for RJD and WSD, suggesting that the II and non-II groups as well as the groups of playing positions distributed RJD and WSD similarly over the eight periods, within playing positions, between playing positions and between II and non-II. Table 2 shows the results of the three-way ANOVA for the four dependent variables. For the post-hoc analysis of the three-way ANOVA, see Figure 2.

Figure 2 near here

Table 2 near here

Discussion

The current study investigated the pacing behaviour of elite basketball players with and without II. It was hypothesized that the players with II would show a larger decline in the frequency and duration of running/jumping bouts and a larger decline in walking/standing duration and frequency over the course of the game compared with players without II. This difference was hypothesized to be found between players of different playing positions as well. It was also hypothesized that players with II would show lower overall frequency and duration of high-intensity activities, i.e. running and jumping, and higher overall duration and frequency of low-intensity activities, i.e. standing and walking. The results did not

support the first two hypotheses as the players with and without II did not show differences in the distribution of intensity across the 8 periods of the games. However, the third hypothesis was supported by the results, showing that the players with and without II differed in the overall intensity throughout the games.

Based on the main effects found for Group, the results of the current study show that athletes with II maintained a lower overall frequency and duration of high intensity activity (i.e. running and jumping) and a higher overall frequency and duration of low intensity activity (i.e. standing and walking) than players without II throughout the games. In the current study, the non-II group comprised the finalists of the Dutch Promotion Division league that were considered to perform a similar training volume as the elite II players. The lower intensity maintained throughout the games in the players with II may be representative of lower fitness levels compared to the players without II, which is in line with previous research on the pacing behaviour of elite runners with and without II that show differences in performance between the two groups, relating to a lower fitness level in athletes with II (Van Biesen et al., 2016a). However, Van De Vliet et al. (2006) found that elite athletes with II exhibit equal fitness levels to physically active non-athletes without II, which may be representative of the training frequency and volume performed by both groups. Therefore, a lower fitness level may not entirely explain the difference in overall intensity found in the current study. Van De Vliet et al. (2006) found that athletes with II tend to show lower performance levels than their non-II counterparts, especially in cognitively demanding sports. This may be related to game comprehension. Therefore, the finding that players with II played at an overall lower intensity may be related to cognitive factors. Findings of previous studies on game related statistics (Pérez-Tejero et al., 2015; Pinilla et al., 2016) and decision making in basketball specific field tests (Pinilla et al., 2016) point to intellectual functioning as a discriminant between players with and without II. For example, Pinilla et al. (2016) revealed limitations in players with II in solving different real standardized basketball situations using a field test designed ad hoc on a sample of 38 elite II-players who participated in the 2015 INAS

Global Games and 38 Spanish national-level basketball players without II. They found that decision time, number of dribbles and situations in which they succeeded were the variables that best discriminated between players with and without II. No differences were found in number of correct decisions made. Related to these findings, the slower game exhibited by the players with II relates to efficiency of movement. One previous study on elite and semi-elite basketball players without II found that the more experienced elite players performed fewer accelerations/decelerations than the less experienced players (Trapero et al., 2019). It may be that players with II are less decisive in their actions and perform energy consuming manoeuvres that may not contribute to success but lead to increased fatigue, which may ultimately result in a slower game. The differences found between players in intellectual functioning in these studies may therefore explain an overall slower game in players with II.

Based on the main effect of Period within each group (II and non-II), the results show that the players in both groups regulated the intensity of their performances throughout the games. However, based on the lack of interaction effects between the II and non-II groups, the results suggest that group pacing may not be different between the two groups, i.e. the distribution of the movement categories over the eight periods of the games. The hypothesis was based on previous literature in elite runners with and without II, which showed differences between the groups in the distribution of intensity throughout their performances as well as the level of performance (Van Biesen et al., 2017; Van Biesen et al., 2016a). This research was carried out in running, which is a closed-loop sport, where the environmental influence is minimal, which might be a crucial difference with the open-loop sport basketball, where environmental factors largely determine a player's actions. Research has highlighted the role of environmental cues in pacing-related decision-making processes in closed-loop sports in non-II populations. It was found that the introduction of opponents alters pacing behaviour of non-II cyclists through environmental cues by way of opponent behaviour (Konings et al., 2016). Thus the role of the environment on pacing is important. Micklewright et al. (2017) argued that the decision-making process for pacing is

multidimensional by nature as it does not solely depend on intrapersonal factors but also external factors such as the cues provided by the environment. Pacing can, in addition, be based on either deliberate decision making, which uses pre-planned pacing strategies or make use of rationally combined information in the moment, or intuitive decision making, which is a quick short-cut response to cues and affordances presented by the environment (Micklewright et al., 2017). Basketball is a highly dynamic environment, in which players continually perceive cues in the environment and respond to them (Waldron & Highton, 2014). The lack of differences in pacing between players with and without II in the current study may relate to the fact that intuitive decision-making is dominant over deliberate decision-making in basketball. As such, this implies that a different cognitive skillset compared to closed-loop sports may be required in the basketball environment, where pacing depends more on tactical elements than on strategic planning skills, which may be important to investigate in future research on classification of basketball players with II. Relating to the three-level pacing model by Edwards and Noakes (2009), the players adapt their pre-planned macro-pacing strategies during the game both between periods of the game using deliberate decision making (meso-pacing) and using intuitive decision-making for in-the-moment adjustments (micro-pacing). Based on literature, it could be suggested that planning skills related to the regulation of exercise intensity are difficult for athletes with II (Van Biesen et al., 2016a), but when pacing depends on more intuitively responding to the environment as is required in basketball, this skill might be less impaired.

In this line, a recent investigation using a basketball-specific decision making test found significant lower decision-making speed and accuracy in a sample of international level senior basketball players with II in comparison with four groups of players without II (under 14, 16, 18 years old and senior), situating the performance of the players with II below the performance of the players without II in the youngest age category (Pinilla et al., submitted). As demonstrated in previous studies, individual and team performances studied through game related statistics (Pérez-Tejero et al., 2015; Pinilla, Pérez-Tejero, Van

Biesen, et al., 2016) and decision making in basketball specific field tests (Pinilla et al., 2016) and computerized tests (Pinilla et al., submitted) are different in basketball players with II compared to players without II. However still, the cognitive abilities involved directly in II basketball performance need to be identified along with their (possible) relationship with the ability to regulate their own pace themselves during competition.

In addition to the environmental influence on pacing in team-sports, wherein the moment-to-moment changes in movement patterns (i.e. micro pacing) are regulated as a response to the environment and their current physiological and psychological states, they also pace to serve their role in the bigger pacing strategy of the team during the game. Athletes in open-loop team sports can be substituted during the game, as opposed to closed-loop sports where there are no breaks during the race/game (Edwards & Noakes, 2009; Waldron & Highton, 2014). Substitutions allow the athlete to rest before being substituted back into the game and, in cases of limited substitutions, they allow the coach to make strategic substitutions of fatigued players, which may be possible to plan ahead of the game (i.e. macro-pacing). This is especially true for a sport like basketball, in which unlimited substitutions are allowed (FIBA, 2018). Player substitutions have shown a positive effect on basketball performance in terms of game-related statistics, i.e. defensive efficiency, offensive rebounding, steals and scoring efficiency (Clay & Clay, 2014; Gómez et al., 2017). However, as found by Gómez et al. (2017), the effects of substitution were mostly pronounced in the first and third quarters of the games and are contextual as they are related to the dynamic nature of basketball. Additionally, substitutions are partly in the control of the coach, which implies that pacing in basketball is not only regulated by the players, but also by the coach who oversees the team-pacing strategy. As found in other sports, player substitutions have an impact on the pacing behaviour of players as those who play short durations are at a lower risk of fatigue when maintaining a high intensity. This was confirmed by Black and Gabbett (2014) who found that substituted rugby league players were able to maintain an overall higher intensity than whole-game players. Thus, substitutions

allow the overall team effort to be maintained throughout the game and further regulate the pace so that players are able to respond to play-by-play events with the required effort (Edwards & Noakes, 2009; Waldron & Highton, 2014).

Further research is needed to understand the pacing behaviour of basketball players without II at different levels of competition as well as the factors that influence pacing from the perspective of decision-making in basketball, being a highly dynamic environment. In addition, further research is needed to understand decision making in athletes with II as it shows to be a key factor in performance of basketball players with II. Van De Vliet et al. (2006) mention in their study on physical profiles of athletes with II that athletes with II have difficulties improving their performance as a result of difficulties in game comprehension. The latter two points point toward research on the specific cognitive skills required by the sport of basketball, which can be useful for classification of basketball players with II. Apart from the role of decision making in pacing in basketball, further research is needed to address the effect of player substitutions on pacing behaviour of basketball players.

Finally, the current study encountered a limitation that may have influenced the results. Four movement categories were chosen each to represent four levels of intensity, which, for the purpose of analysing pacing behaviour, is more relevant than including a large number of movement categories within each level of intensity as in some studies on the activity and physiological profiles of basketball players (Ben Abdelkrim et al., 2010; McInnes et al., 1995). However, the differences in overall intensity and the distribution of intensity between players with and without II may have been more pronounced by further distinguishing between levels of running, i.e. jogging and sprinting instead of running. Another limitation in the current study is related to substitutions. As players were substituted at different time points during the games, the time played by each player varied. The length of the playing time is in the control of the coach and may be planned ahead of the game or in response to events during the game. This may be especially true in II-basketball. As found in previous research, the duration of the playing time has an

influence on the pacing behaviour of players in high-intensity intermittent team sports (Ferraz et al., 2018). Future studies may take this into consideration by adjusting for playing time, although this may over-/underestimate the pace at later stages during the games. Another suggestion is to include game-related statistics such as ball possessions to help control for variations in playing time in the form of number of plays (Pinilla et al., 2017). Finally, the lack of additional demographic information about the players was considered a limitation of the study. Especially for players with II, information regarding measures of IQ, types of additional physical and medical issues may have allowed a more in-depth analysis and shed light on limitations in the population. Also, a comparison between the groups taking into account aspects such as length, level of experience and specific information regarding training may have allowed for a more informed match up.

Conclusion

The results of the current study show that basketball players with II demonstrate a lower duration and frequency in high-intensity activities and a higher duration and frequency in low-intensity activities than players without II. This partly points to the differences in physical fitness between the two groups and partly to the differences in intellectual functioning between the groups, which may result in the overall slower game for the players with II. In addition, the distribution of duration of frequency in all movement categories did not differ significantly between the players with and without II, implying that the pacing behaviour of the two groups may not differ. This is different compared to literature on closed-loop sports where pacing was found to be impaired in athletes with II. This might suggest that because of the highly dynamic nature of basketball, adequate pacing is not so much about deliberate planning skills but more about the ability to intuitively respond to environmental cues and the need for players with and without II to regulate the pace as part of a team. These intuitive decision-making skills might be relatively less impaired in the athletes with II. However, players with II demonstrated slower games, which may be a result of an impaired ability to make fast moment-to-moment deliberate decisions, a crucial element of

399 basketball. These deliberate decision-making skills in particular would need to be further studied in the
400 context of evidence-based classification.

401

402 **Acknowledgments**

403 The current study was carried out in conjunction with the “Intellectual Disability, and Equal opportunities
404 for Active and Long-term participation in Sport” (IDEAL) project consortium.

405

406 **Disclosure statement**

407 The authors report no conflict of interest.

408

References

- Ben Abdelkrim, N, Castagna, C., Jabri, I., Battikh, T., El Fazaa, S., & El Ati, J. (2010). Activity profile and physiological requirements of junior elite basketball players in relation to aerobic–anaerobic fitness. *Jornal of Strength and Conditioning Research*, 24(9), 2330–2342.
- Ben Abdelkrim, N, Chaouachi, A., Chamari, K., Chtara, M., & Castagna, C. (2010). Positional role and competitive-level men’s basketball players. *Journal of Strength and Conditioning Research*, 24(5), 1346–1355.
- Ben Abdelkrim, Nidhal, El Fazaa, S., & El Ati, J. (2007). Time-motion analysis and physiological data of elite under-19-year-old basketball players during competition. *British Journal of Sports Medicine*, 41(2), 69–75. <https://doi.org/10.1136/bjsm.2006.032318>
- Black, G., & Gabbett, T. (2014). Match intensity and pacing strategies in rugby league: An examination of whole-game and interchanged players, and winning and losing teams. *Journal of Strength and Conditioning Research*, 28(6), 1507–1516.
- Brick, N. E., MacIntyre, T. E., & Campbell, M. J. (2016). Thinking and action: A cognitive perspective on self-regulation during endurance performance. *Frontiers in Physiology*, 7(APR), 1–7. <https://doi.org/10.3389/fphys.2016.00159>
- Clay, D. C., & Clay, K. E. (2014). Player rotation, on-court performance and game outcomes in ncaa men’s basketball. *International Journal of Performance Analysis in Sport*, 14(2), 606–619. <https://doi.org/10.1080/24748668.2014.11868746>
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum Associates Inc.
- Edwards, A. M., & Polman, R. C. J. (2013). Pacing and awareness: Brain regulation of physical activity.

431 *Sports Medicine*, 43(11), 1057–1064. <https://doi.org/10.1007/s40279-013-0091-4>

432 Edwards, A., & Noakes, T. (2009). Dehydration: cause of fatigue or sign of pacing in elite soccer? *Sports*
 433 *Medicine*, 39(1), 1–13.
 434 <http://search.ebscohost.com/login.aspx?direct=true&db=rzh&AN=105644313&site=ehost-live>

435 2018 Official Basketball Rules Basketball Rules & Basketball Equipment, 98 (2018).
 436 <http://www.fiba.basketball/documents/official-basketball-rules.pdf>

437 Ferraz, R., Goncalves, B., Coutinho, D., Sampaio, J., & Marinho, D. A. (2018). Pacing behaviour of players
 438 in team sports: Influence of match status manipulation and task duration knowledge. *PLoS ONE*,
 439 13(2), 1–12.

440 Gilderthorp, R., Burns, J. H., & Jones, F. (2018). Classification and intellectual disabilities: An investigation
 441 of the factors that predict the performance of athletes with intellectual disability. *Journal of Clinical*
 442 *Sport Psychology*, 12(3), 285–301. <https://doi.org/10.1123/jcsp.2017-0018>

443 Gómez, M. Á., Silva, R., Lorenzo, A., Kreivyte, R., & Sampaio, J. (2017). Exploring the effects of
 444 substituting basketball players in high-level teams. *Journal of Sports Sciences*, 35(3), 247–254.
 445 <https://doi.org/10.1080/02640414.2016.1161217>

446 Konings, M. J., Schoenmakers, P. P. J. M., Walker, A. J., & Hettinga, F. J. (2016). The behavior of an
 447 opponent alters pacing decisions in 4-km cycling time trials. *Physiology and Behavior*, 158, 1–5.
 448 <https://doi.org/10.1016/j.physbeh.2016.02.023>

449 Koo, T. K., & Li, M. Y. (2016). A Guideline of Selecting and Reporting Intraclass Correlation Coefficients
 450 for Reliability Research. *Journal of Chiropractic Medicine*, 15(2), 155–163.
 451 <https://doi.org/10.1016/j.jcm.2016.02.012>

452 McInnes, S. E., Carlson, J. S., Jones, C. J., & McKenna, M. J. (1995). The physiological load imposed on

453 basketball players during competition. *Journal of Sports Sciences*, 13(5), 387–397.
 454 <https://doi.org/10.1080/02640419508732254>

455 Micklewright, D., Kegerreis, S., Raglin, J., & Hettinga, F. (2017). Will the Conscious–Subconscious Pacing
 456 Quagmire Help Elucidate the Mechanisms of Self-Paced Exercise? New Opportunities in Dual
 457 Process Theory and Process Tracing Methods. *Sports Medicine*, 47(7), 1231–1239.
 458 <https://doi.org/10.1007/s40279-016-0642-6>

459 Narazaki, K., Berg, K., Stergiou, N., & Chen, B. (2009). Physiological demands of competitive basketball.
 460 *Scandinavian Journal of Medicine and Science in Sports*, 19(3), 425–432.
 461 <https://doi.org/10.1111/j.1600-0838.2008.00789.x>

462 Pérez-Tejero, J., Pinilla, J., & Vanlandewijck, Y. (2015). *Performance profile at the basketball world*
 463 *championship (Ankara 2013) for people with intellectual disabilities: Implications for eligibility*
 464 *system*. 10(2), 187–192.

465 Péter, A. (2019). *Solomon coder, Version: beta 19.08.02*. <https://solomon.andraspeter.com/>

466 Pinilla, J., Pérez-Tejero, J., Van Biesen, D., Polo, I., Janssens, L., & Vanlandewijck, Y. C. (n.d.). *Cognitive*
 467 *development and decision making in basketball: a comparison between players with and without*
 468 *intellectual impairment and across different age-categories*.

469 Pinilla, Javier, Pérez-Tejero, J., Sampedro, J., Refoyo, I., Lorenzo, A., Lorenzo, J., Van Biesen, D., &
 470 Vanlandewijck, Y. (2016). Influence of intellectual impairment (II) on basketball players' capacity to
 471 solve a game situation: Towards evidence-based classification systems in II-basketball. *Psychology,*
 472 *Society and Education*, 8(2), 121–134. <https://doi.org/10.25115/psye.v8i2.453>

473 Pinilla, Javier, Pérez-Tejero, J., & Van Biesen, D. (2017). Basketball game related statistics that
 474 discriminate between players with intellectual impairment and able-bodied players. *Revista de*

475 *Psicologia Del Deporte*, 26(1), 113–119.

476 Pinilla, Javier, Pérez-Tejero, J., Van Biesen, D., & Vanlandewijck, Y. (2016). Effect of intellectual
477 impairment on basketball game-related statistics. *Collegium Antropologicum*, 40(4), 279–284.

478 R Core Team. (2019). *R: A language and environment for statistical computing*. R Foundation for
479 Statistical Computing. <https://www.r-project.org/>

480 Read, P., Hughes, J., Stewart, P., Chavda, S., Bishop, C., Edwards, M., & Turner, A. (2014). A needs
481 analysis and field-based testing battery for basketball. *Strength and Conditioning Journal*, 36(3),
482 13–20.

483 Sampaio, J., Lago, C., & Drinkwater, E. J. (2010). Explanations for the United States of America's
484 dominance in basketball at the Beijing Olympic Games (2008). *Journal of Sports Sciences*, 28(2),
485 147–152. <https://doi.org/10.1080/02640410903380486>

486 Smits, B. L. M., Pepping, G. J., & Hettinga, F. J. (2014). Pacing and decision making in sport and exercise:
487 The roles of perception and action in the regulation of exercise intensity. *Sports Medicine*, 44(6),
488 763–775.

489 Trapero, J., Sosa, C., Zhang, S., Portes, R., Gómez-Ruano, M. Á., Bonal, J., Jiménez, S. L., & Lorenzo, A.
490 (2019). Comparison of the movement characteristics based on position-specific between semi-elite
491 and elite basketball players. *Revista de Psicología Del Deporte*, 28(3), 140–145.

492 Tucker, R. (2009). The anticipatory regulation of performance: The physiological basis for pacing
493 strategies and the development of a perception-based model for exercise performance. *British*
494 *Journal of Sports Medicine*, 43(6), 392–400. <https://doi.org/10.1136/bjsm.2008.050799>

495 Tweedy, S. M., Mann, D., & Vanlandewijck, Y. C. (2016). Research needs for the development of
496 evidence-based systems of classification for physical, vision, and intellectual impairments. In Y. C.

497 Vanlandewijck & W. R. Thompson (Eds.), *Training and Coaching the Paralympic Athlete: Handbook*
 498 *of Sports Medicine and Science*.

499 Van Biesen, D., Hettinga, F. J., McCulloch, K., & Vanlandewijck, Y. (2016). Pacing profiles in competitive
 500 track races: Regulation of exercise intensity is related to cognitive ability. *Frontiers in Physiology*,
 501 7(DEC), 1–10. <https://doi.org/10.3389/fphys.2016.00624>

502 Van Biesen, D., Hettinga, F. J., McCulloch, K., & Vanlandewijck, Y. C. (2017). Pacing Ability in Elite
 503 Runners with Intellectual Impairment. *Medicine and Science in Sports and Exercise*, 49(3), 588–594.
 504 <https://doi.org/10.1249/MSS.0000000000001115>

505 Van Biesen, D., Mactavish, J., McCulloch, K., Lenaerts, L., & Vanlandewijck, Y. C. (2016). Cognitive profile
 506 of young well-trained athletes with intellectual disabilities. *Research in Developmental Disabilities*,
 507 53–54, 377–390. <https://doi.org/10.1016/j.ridd.2016.03.004>

508 Van De Vliet, P., Rintala, P., Fröjd, K., Verellen, J., Van Houtte, S., Daly, D. J., & Vanlandewijck, Y. C.
 509 (2006). Physical fitness profile of elite athletes with intellectual disability. *Scandinavian Journal of*
 510 *Medicine and Science in Sports*, 16(6), 417–425. <https://doi.org/10.1111/j.1600-0838.2006.00539.x>

511 Waldron, M., & Highton, J. (2014). Fatigue and pacing in high-intensity intermittent team sport: An
 512 update. *Sports Medicine*, 44(12), 1645–1658. <https://doi.org/10.1007/s40279-014-0230-6>

513 Wang, C. H., Chang, C. C., Liang, Y. M., Shih, C. M., Chiu, W. S., Tseng, P., Hung, D. L., Tzeng, O. J. L.,
 514 Muggleton, N. G., & Juan, C. H. (2013). Open vs. Closed Skill Sports and the Modulation of
 515 Inhibitory Control. *PLoS ONE*, 8(2), 4–13. <https://doi.org/10.1371/journal.pone.0055773>

516

517

Table 1. Result of the two-way ANOVA of the difference in the movement categories (Running and jumping frequency (RJF), Walking and standing frequency (WSF), Running and jumping duration (RJD) & Walking and standing duration (WSD)) between players with and without II over the eight periods of the games.

^s Greenhouse-Geisser adjustment for sphericity; * Significant at $\alpha = 0.05$; ** Significant at $\alpha = 0.01$; *** Significant at $\alpha = 0.001$

	DF (n, d)	F	P	η_p^2
RJF				
Group	1, 40	21.71	<0.001***	0.352
Period	7, 280	4.701	<0.001***	0.105
Group * Period	7, 280	1.068	0.384	0.026
WSF				
Group	1, 40	1.3	0.244	0.034
Period	7, 280	1.905	0.069	0.045
Group * Period	7, 280	0.522	0.818	0.013
RJD				
Group	1, 40	9.077	0.004**	0.185
Period ^s	7, 213.24	8.976	<0.001***	0.183
Group * Period ^s	7, 213.24	1.832	0.103	0.044
WSD				
Group	1, 40	9.077	0.004**	0.185
Period ^s	7, 280	8.976	<0.001***	0.183
Group * Period ^s	7, 280	1.832	0.103	0.044
^s Greenhouse-Geisser adjustment for sphericity;				
* Significant at $\alpha = 0.05$; ** Significant at $\alpha = 0.01$; *** Significant at $\alpha = 0.001$				

Table 2. Result of the three-way ANOVA of the difference in the movement categories (Running and jumping frequency (RJF), Walking and standing frequency (WSF), Running and jumping duration (RJD) & Walking and standing duration (WSD)) between players with and without II and between groups of playing position over the eight periods of the games.

^s = Greenhouse-Geisser adjustment for sphericity; * = Significant at $\alpha = 0.05$; ** = Significant at $\alpha = 0.01$; *** = Significant at $\alpha = 0.001$

	DF (n, d)	F	p	η_p^2
RJF				
Group	1, 24	12.109	0.002**	0.335
Position	2, 24	0.508	0.608	0.041
Period	7, 168	1.378	0.218	0.054
Group * Position	2, 24	0.75	0.483	0.059
Group * Period	7, 168	1.105	0.362	0.044
Position * Period	14, 168	0.916	0.543	0.071
Group * Position * Period	14, 168	0.564	0.89	0.045
WSF				
Group	1, 36	2.154	0.151	0.056
Position	2, 36	1.625	0.211	0.083
Period ^s	7, 198.5	2.862	0.013	0.074
Group * Position	2, 36	0.878	0.424	0.047
Group * Period ^s	7, 198.5	0.548	0.757	0.015
Position * Period ^s	7, 198.5	1.47	0.145	0.075
Group * Position * Period ^s	7, 198.5	0.835	0.605	0.044
RJD				
Group	1, 36	11.391	0.002**	0.24
Position	2, 36	5.412	0.009**	0.231
Period	7, 252	7.747	<0.001***	0.177
Group * Position	2, 36	0.891	0.419	0.047
Group * Period	7, 252	1.624	0.129	0.043
Position * Period	14, 252	0.947	0.508	0.05
Group * Position * Period	14, 252	0.911	0.548	0.048
WSD				
Group	1, 36	11.391	0.002**	0.24
Position	2, 36	5.412	0.009**	0.231
Period	7, 252	7.747	<0.001***	0.177
Group * Position	2, 36	0.891	0.419	0.047
Group * Period	7, 252	1.624	0.129	0.043
Position * Period	14, 252	0.947	0.508	0.05
Group * Position * Period	14, 252	0.911	0.548	0.048

^s = Greenhouse-Geisser adjustment for sphericity;

* = Significant at $\alpha = 0.05$; ** = Significant at $\alpha = 0.01$; *** = Significant at $\alpha = 0.001$

Figure 1

Figure 2

Figure 2. The distribution of the combined movement categories (Running and jumping frequency (RJF), Walking and standing frequency (WSF), Running and jumping duration (RJD) & Walking and standing duration (WSD)) across the eight periods of the games for basketball players with and without II. * = Significant for Group (II vs non-II) at $\alpha = 0.05$; ** = Significant for Group (II vs non-II) at $\alpha = 0.01$; *** = Significant for Group (II vs non-II) at $\alpha = 0.001$;

Figure 2. The distribution of the combined movement categories (Running and jumping frequency (RJF), Walking and standing frequency (WSF), Running and jumping duration (RJD) & Walking and standing duration (WSD)) across the eight periods of the games for basketball players with and without II of different playing positions (center, forward & guard). Statistical significance indicates significant difference in the movement categories between players in the II and non-II groups in the same playing position. * = Significant for Group (II vs non-II) at $\alpha = 0.05$; ** = Significant for Group (II vs non-II) at $\alpha = 0.01$; *** = Significant for Group (II vs non-II) at $\alpha = 0.001$.