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The impact of the racket on mobility performance in wheelchair tennis

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Abstract: *This study aimed to assess how the act of holding a tennis racket affected the manual propulsion of the wheelchair. The hypothesis was that the presence of the racket during acceleration and the change of direction of wheelchair players negatively affected the execution of shots. The research sample consisted of ten wheelchair tennis players. They completed four tests, which evaluated sprinting and manoeuvrability abilities in wheelchair tennis. The results of the paired sample t-test analysis showed the existence of a statistically significant difference in the tests performed with and without the use of the racket in wheelchair tennis players. All tests showed high ICCs (0.95–0.99) for the inter-trial reliability times. Higher level players, who should have a better and more efficient movement technique, due to their fitness and the way they use strength, are still able to overcome these difficulties more than lower-level players. The study also proposes a methodological approach to ensure that players with less experience could compete while guaranteeing sports inclusion.*
Keywords: *Sports inclusion, Wheelchair tennis, Adapted Physical Activity.*

Introduction

despite many difficulties, the practice of sporting activities for people with disabilities is now an established reality (Cassese & Raiola, 2017). The combination of sport and disability is representative of an approach that has collected the socio-cultural and scientific evolution of sports and physical-motor activity in a phenomenological key on the one hand, and of the vision of the disabled person in terms of biopsychosocial functioning on the other (D'Elia et al., 2020). The benefits of sporting activity and the importance of enhancing everyone's skills were highlighted, trying to overcome the prejudices that over time have limited sporting activity and the lives of people with disabilities (Cascone et al., 2020). Wheelchair tennis has over time become one of the most popular sports of the Paralympics, with international competitions taking place all over the world. It is a discipline that has many similarities to conventional tennis. It is very similar, in fact, both from a regulatory point of view but also from a technical and tactical level (Pisapia & D'Isanto, 2018). The measures of the field, the tools used, and the score do not vary. The only different rule is the double bounce of the ball. The wheelchair is considered part of the player's body, so all rules regarding the player's body also apply to the wheelchair (Cassese & Raiola, 2017). Sports coaches and scientists interested in this discipline are continually trying to improve current training methods and optimize specific training (Raiola, 2020). However, to ensure that training can reflect the needs of the sport and to try to find a link between adapted and conventional tennis, an understanding of the competitive and physiological sporting needs of the discipline is needed (Sindall et al., 2013). An important aspect of wheelchair sports is wheelchair mobility performance, defined as the skill of the wheelchair athlete on the field (Roy et al., 2006). This aspect seems to influence the performance of a disabled tennis player more than an able-bodied tennis player in the dynamics of movement, nullifying the possibility of sports inclusion (Di Palma et al., 2016). The dynamics of movement of wheelchair tennis are in fact specifically related to the push of the wheelchair while holding the tennis racket (Croft et al., 2010). The tennis racket is an important additional constraint of wheelchair tennis compared to other wheelchair sports, affecting mobility performance (Croft et al., 2010).

The presence of the racket seems to negatively affect the dynamics of the movement, especially for less experienced athletes (Goosey-Tolfrey & Moss, 2005). They have difficulty in being able to maintain the inertia of the wheelchair in going to hit the ball (Rietveld et al., 2019). This difficulty occurs at the time of preparation for the shot. The twisting action of the trunk and shoulders that is carried out in the preparation phase of the forehand is limited, therefore the players are able to accumulate energy in lesser quantities (Reid et al., 2007). This affects the effectiveness and precision of the shots, as well as the speed of impact and the production of power (Sánchez-Pay et al., 2016).

To better understand the needs of the racket in wheelchair tennis, several studies were carried out using an ergometer in laboratory tests (Di Palma et al., 2016, Invernizzi et al., 2020). These studies have provided important insights into the difficulty of coupling/uncoupling the racket/hand to the wheel, and therefore on speed and power production (Diaper & Goosey, 2009). Furthermore, holding the racket while pushing the wheelchair in addition to having a negative influence on the propulsion technique could also lead to injuries of the upper limbs (De Groot et al., 2017). This may be due to the longer time it takes to hold the racket and wheel simultaneously with the hand, which leads to greater power losses and consequently more power generated during the shorter push phase (DeGroot et al., 2017). In addition to laboratory tests, several validated field tests have also been designed to monitor the influence of the racket on the player's mobility performance (Invernizzi et al., 2020). Field tests are very important to perform and often preferred by coaches, as they involve play-related wheel skills, such as sprinting, turning or stopping (Reina et al., 2007). The aim of this study was to verify how the act of holding a racket affects the efficiency of the manual propulsion of the wheelchair. Possible differences in propulsion technique between pushing the wheelchair with and without a racket in hand were investigated. The hypothesis was that the presence of the racket during acceleration and the change of direction of wheelchair players negatively affected the execution of shots.

METHODS

ten wheelchair tennis players (age: 23 ± 0.3 years; height: 184.4 cm; body mass: 80.92 kg; training experience: 6 ± 0.3 years) participated in this study. The study involves the use of tests developed specifically for the needs of a wheelchair tennis match. These court tests were developed by the Royal Dutch Lawn Tennis Association (KNLTB) to evaluate the mobility performance of their players (Rietveld et al., 2019). They were the 20 m sprint test, the Spider test, the Butterfly sprint test and the Illinois test. Each participant took the test three times without a racket and three times with the racket with a 2-minute rest time between each repetition. All tests were analysed separately, mean times per test was calculated. In the 20m sprint test the participant was positioned in the centre of the field, behind the baseline, and had to perform a straight 20 m sprint, with markers placed at the starting point, at 5m, 10m and 20m (simulates the network advancement). In the Spider test and Butterfly sprint test, the athlete had to cover a course as quickly as possible (they simulated moving on the pitch during an exchange). Finally, the Illinois test was a speed-related agility test. In this last test, the player stood ready behind the starting line (cone 1). At the acoustic signal he had to run forward towards cone 2 located 10 m away from the starting line, and then suddenly turn back towards the starting line (cone 3) around which he had to turn, and then continue in slalom around others 3 cones positioned at 3.33 m from each other, to then go back, always in slalom up to cone 3. Here it makes a change of direction, turning around cone 3 and sprinting towards cone 4, reached which reverses the direction of travel to make the last sprint towards cone 5.

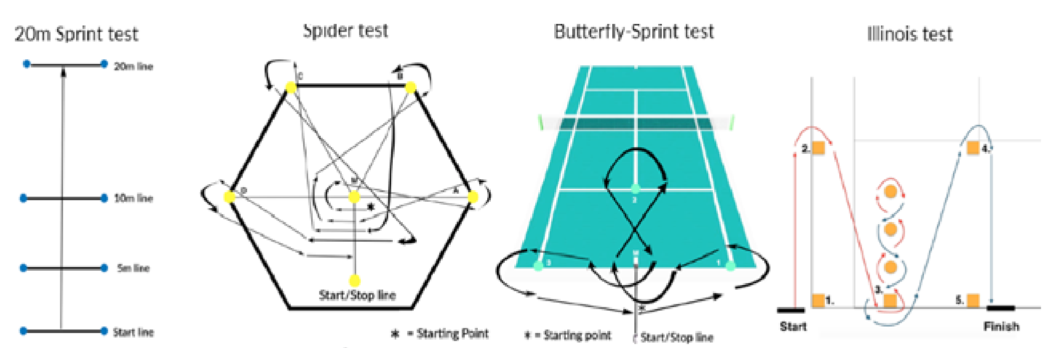

***Figure 1.** Outline of the tests carried out*

Each test was filmed with two GoPro Hero5 cameras positioned to analyse movements in the frontal plane and the sagittal plane and films were used for post-test assessment. The performance, expressed in seconds, was measured with a stopwatch.

Statistical analysis

A Shapiro-Wilks test revealed that values were normally distributed within each group and evaluation moment (P>0.05). Paired sample t-test was selected as the analytical method to check for the presence or absence of a significant difference between two data series. Specifically, the t-test allowed to compare the mean of the tests with and without a racket. Descriptive statistics were presented as estimated marginal mean ± standard error unless otherwise stated. Statistical significance was set at $P \leq 0.05$. For the relative reliability the intraclass correlations (ICC) and standard error of the mean (SEM) were calculated. Data analyses were performed using Statistical Package for Social Science software (IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY).

Results

Table 1. *Average time recorded in the execution of field tests with and without a racket.*

	With racket	Without racket	ICC (CI)	Std. Error Mean	t	p
20m sprint (s)	7.27 (0.29)	6.76 (0.92)	0.99 (0.96-0.99)	0.63	1.57	0.21
Spider test (s)	18.54 (2.14)	17.79 (2.10)	0.96 (0.89 -0.98)	0.33	2.72	0.24
Butterfly-sprint test (s)	17.15 (1.32)	16.87 (1.30)	0.95 (0.83-0.98)	0.38	0.77	0.44
Illinois test (s)	22.03 (2.61)	21.14 (2.46)	0.98 (0.92-0.99)	0.37	2.37	0.04

Discussion

the results showed that the use of the racket had a negative impact on the mobility of the players. This loss of speed with the use of the racket resulted in reaching the ball later and not being able to hit it correctly. Players took longer to cover distances of 5 and 10 meters when using the racket, but it was not like that at 20 meters. The data seem to indicate that the ability to accelerate from a static position was most affected using the racket in the first few meters. However, maintaining high speed levels did not appear to be significantly affected by racket use. This may be since once the initial inertia of the chair in a static position was overcome, the wheelchair itself made it easier to move when in motion. While higher-level players seem to perform specific movements more efficiently with or without the racket than lower-level players, the maximum speeds and peak speeds achieved are limited due to the racquet's presence. This may have been since higher level players had a better technique for pushing the wheelchair both with and without the racket.

With a view to sports inclusion, the use of facilitating tools in progression could work very well with both disabled and non-disabled athletes (Santopietro et al., 2020). Already in mini tennis various types of balls characterized by different colours are used:

- red ball (75% slower than a normal one and larger in diameter)
- orange ball (50% slower than a normal ball)
- green ball (or mid, 25% slower than a normal ball)
- yellow (or normal)

Specifically, the use of depressurized balls and reduced playing spaces produces four advantages:

- activation of the practice-success combination,
- activation of the practice-fun combination,
- interactivity between players in a short time
- correct learning of the technique.

These are the same goals that a beginner of any age wants to achieve when he enrols in a tennis course. Recent studies by the Australian Federtennis, concerning the differences in terms of teaching between the green ball (also called Mid) and the Yellow ball (normal) carried out on a sample of about 200 beginners from different countries, show that players who play tennis with Mid type make far fewer mistakes than those who practice it with the normal ball (Hewitt & Edwards, 2013). Furthermore, the Mid ball, traveling at a speed 25% lower than the standard one, gives wheelchair athletes more time to think about the choices to make, improving the game tactics much more quickly (Pisapia & D'Isanto, 2018). Furthermore, this type of ball, bouncing at a height less than 25% compared to the normal one, allows an optimal impact quality, contributing to a faster learning of the correct playing technique (Sánchez-Pay et al., 2015). The introduction of slower balls could allow a change in training methodology by making it easier for coaches to move from a prescriptive teaching methodology, with relatively static teaching situations and little play, to an active approach in which active tasks are based on the game (Richardson et al., 2017). Coaches could then provide relevant instructions and use the most appropriate type of ball to differentiate activity and ensure success. It is important that the experience for novice tennis players is not only active and fun, but also that it implies reasonable success from the very first lesson (Esposito et al., 2020). Beginner players who try their hand at slower balls find themselves moving 1 or 2 meters in different directions to reach the ball with a heart rate rapidly exceeding 140 beats per minute (Greenwood et al., 1990). They are doing interval training, having fun at the same time. It is important not only to introduce the game effectively, but also to adapt the game of tennis to the needs and skill levels of the players by organizing user-friendly play opportunities in combination with slower balls.

Conclusion

the use of the racket has a negative impact on the motion time and in the execution and effectiveness of the shots, although not in the same way in its different sections and depending on the level of the players. Higher level players, who should have a better and more efficient movement technique, due to their fitness and the way they use strength, are still able to overcome these difficulties more than lower-level players. For the purposes of sports inclusion, the introduction of measures such as the use of depressurized balls or a reduction in the height of the net could allow to limit the major difficulties encountered by tennis players in wheelchairs.

Announcement
We announce that the authors have equally contributed to this paper.

Conflict of interests
There is no conflict of interests among the authors themselves.

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