COMPARISON BETWEEN OUTCOMES OF A SPRINT TEST ON A WHEELCHAIR ERGOMETER AND ON-COURT AMONG WHEELCHAIR TENNIS PLAYERS

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The current study compared a wheelchair sprint in the laboratory (lab) on a wheelchair ergometer with a wheelchair sprint on-court in a group of experienced wheelchair tennis players. Nine wheelchair tennis players performed a 10m sprint in the lab, on a computerized wheelchair ergometer, and a 10m sprint on-court, equipped with inertial measurement units. Test duration, mean power output and mean velocity showed no differences between lab and field sprints, peak velocity was consistently higher in the field sprint. Despite methodological differences and experienced rolling resistance between the lab and field sprint, test duration, achieved power output and mean velocity did not differ. Field sprint testing is easier to conduct and provides valuable insights, and lab testing gives a broad additional array of in-depth biomechanical analyses.

KEYWORDS: Para-Athletes, Adaptive Sports, Ergometry, Inertial measurement units, Biomechanics.

INTRODUCTION: Wheelchair tennis demands linear accelerations and velocities of the wheelchair-athlete combination. This can be tested in either a standardized laboratory or natural field environment. Wheelchair sprint capacity can be assessed using a sprint test on a computer-controlled wheelchair ergometer (Janssen et al., 2022), or on court using a 10m straight sprint test (Rietveld et al., 2019). Laboratory (lab) testing offers researchers standardized conditions to collect detailed physiological, kinetic or kinematic data (de Klerk et al. 2020). On the other hand, field-testing on-court is easier to perform and is suggested to enhance external validity (Rietveld et al., 2019).

Lab and field sprints are considered to be complementary, allowing us to benefit from their respective strengths. Both lab and field sprints demand the same task, are of the same duration, take place in the player's own sports wheelchair, a racket is used in both tests, and high velocities are achieved. Besides similarities, differences also exist. Lab tests, using a wheelchair ergometer, limit the influence of trunk motion and involve minimal demands for small adjustments. Conversely, in the field, trunk motion is more important and it requires immediate self-correction to avoid errors like deviating from the straight line (M.P. van Dijk et al., 2024).

Similarities and differences lead to the question whether both testing environments together should be used in concert to evaluate wheelchair sprint performance. The current study compares a wheelchair sprint in the lab on a wheelchair ergometer with a wheelchair sprint on-court in a group of experienced wheelchair tennis players. It is hypothesized that strong correlations will be found between test duration, power output, peak and mean velocity of lab and field sprints. Because power output is a more objective measure, that takes into account the rolling resistance, it is expected to be a more robust measure, compared to velocity and test duration.

METHODS: This cross-sectional study included nine (5M/4F) experienced wheelchair tennis players, who had minimal two years of experience and trained (minimal) once per week. The players had an average age of 42 ± 18 years, average body mass of 81 ± 21 kg and played wheelchair tennis for an average of 13 ± 13 years.

Figure 1 Wheelchair tennis player on wheelchair ergometer

For lab testing, the computer-controlled Esseda wheelchair roller ergometer was used (Figure 1, Lode BV, Groningen, The Netherlands). This commercial wheelchair ergometer provides an accurate individual simulation of wheelchair propulsion, inertia and resistance, while allowing for accurate measurements of torque (Nm) and velocity (m/s) at 100 Hz (de Klerk et al. 2020). Power output (W) was subsequently calculated from the measured torque, wheel radius and wheel velocity (de Klerk, Vegter, Veeger, et al., 2020). Participants were asked to perform a 10s sprint test with racket, from where the first 10m were analysed.

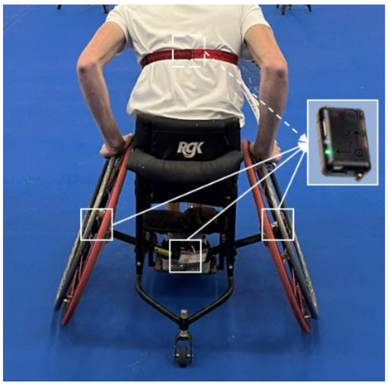

Figure 2 Placement of four IMUs on wheelchair tennis player

Regarding field testing, Inertial Measurement Units (IMU) were placed on the hub of both wheels, the frame of the wheelchair and the chest of the participant (Figure 2). Testing was performed on an acrylic hardcourt surface. The three-dimensional gyroscopes of the IMUs on the wheels and frame were used to calculate linear velocity over time. The IMU on the chest was used to calculate the orientation of the trunk with respect to the global earth frame, which was used to determine power output with more accuracy (M.P. van Dijk et al., 2024). Participants completed a 10m sprint test on-court, with racket (Rietveld et al., 2019). In order to be able to determine power output during the 10m sprint test, four coast down trails were performed to determine drag forces (de Klerk, Vegter, Leving, et al., 2020). Athletes were instructed to push the wheelchair with two pushes, place their hands on their knees, sit as still as possible and let the wheelchair decelerate naturally for a minimum of two seconds.

Lab and field testing were taken maximally one month apart. Outcome variables were the same between the lab and field tests: total time to reach 10m (s), average power output (sum of left and right in W), peak and mean velocity (average of left and right in m/s).

Mean and standard deviation of the results were reported. Due to the small sample size, a Wilcoxon signed-rank test was used to test for systematic differences between lab and field sprints. Spearman correlation coefficients between results from lab and field sprints were calculated and interpreted as low (< 0.3), medium (> 0.3 and < 0.5) or high (> 0.5).

RESULTS: For the lab tests, one participants had missing data for the 10s Sprint. In the field tests, power output of the 10m Sprint test is missing for four players. Test duration, average power output and mean velocity did not differ between lab and field sprints (Table 1, respectively $p = 0.46$, $p = 0.44$, $p = 0.31$). Peak velocity was 21 (18) % lower in the lab sprint, compared to the field sprint. Figure 3 shows a typical comparison of outcomes for the lab and

Table 1 Test outcomes for lab and field sprints, including the results of the independent t-test.

	N	Mean (SD)	*N*	Mean (SD)		Wilcoxon
Test duration (s)	*8*	5.1 (0.6)	*9*	4.9 (0.6)	3 (9)	0.46
Average power over 10m (W)	*8*	86 (49)	*6*	75 (31)	10 (22)	0.44
Peak velocity over 10m (m/s)	*8*	2.6 (0.4)	*9*	3.2 (0.6)	- 21 (18)	< 0.05 *
Mean velocity over 10m (m/s)	*8*	2.0 (0.2)	*9*	2.1 (0.2)	- 4 (10)	0.31

field sprint, with as main difference the velocity deceleration after every peak and on methodological level, the detailed instantaneous power output and asymmetry in the lab. Scatter plot and correlations between lab and field outcomes are reported in Figure 4. Power output showed the highest correlation (r=0.90, n=5). Peak velocity showed a correlation of 0.79 (n=8), and mean velocity and test duration both a correlation of 0.76 (n=8).

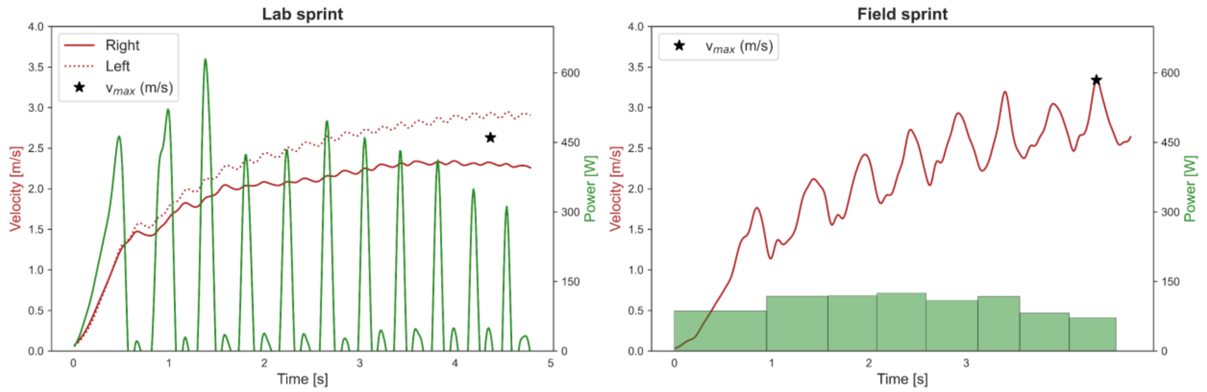

Figure 3 Typical example of a lab (left) and field (right) sprint. Power output is shown in green and is instantaneous for the lab sprint and cycle-averaged the field sprint. Velocity (m/s) is shown in red, the lab sprint shows the velocity separately for left and right, whereas the field sprint shows the average velocity. Peak velocity is annotated in both plots.

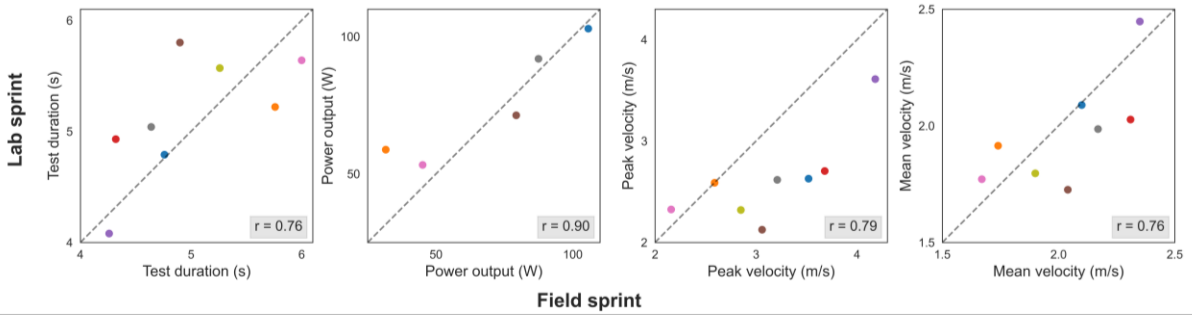

Figure 4 Comparison between lab and field test outcomes. Lab sprint results are displayed at the vertical axis, field results at the horizontal axis. Plots are annotated with the correlation coefficient and the line of identity (that indicates that achieved values in the lab and field are the same). Every color displayes one tennis player.

DISCUSSION: Lab and field sprinting differs in course of velocity, as well as in attained peak velocity. Conversely, no differences in test duration, power output and mean velocity were found in this group of experienced wheelchair tennis players.

As can be seen in Figure 3, graphs for sprint velocity between lab and field differ in amount of deceleration after every push. This is explained by the fact that the wheelchair in the lab is fixed to the wheelchair ergometer and allows no movement in relation with the trunk (de Klerk et al. 2020). In contrast, in the field, the wheelchair counteracts with the movement of the trunk, i.e., after the push the trunk has a backward acceleration with respect to the wheelchair (Marit P van Dijk et al., 2021). When measuring velocity with IMUs at the wheelchair, it will exaggerates the actual velocity of the total wheelchair-athlete combination, both in a positive and negative way. Moreover, rolling resistance is constant on the wheelchair ergometer and fluctuating in the field because the mass of the athlete shifts between the smaller front castor-wheels (that experience more rolling resistance) and the larger back wheels (M.P. van Dijk et al., 2024).

This difference of deceleration after every push did not lead to a significant difference in power output between the lab and field sprint (Table 1). Caution is warranted due to limited power output data (n=5). However, the Wilcoxon test did not show systematic differences between the average power output and because most players' values align around the line of identity (Figure 4), it is hypothesised that missing values of this group will also be around this line, but further research is warranted. In contrast, peak velocity was consistently higher in field sprints, compared to lab sprints, explained by the higher resistance coefficient on the wheelchair ergometer, compared to hard-court (0.012 vs 0.008) (Rietveld et al., 2021). While wheelchair tennis players play on different surfaces, power output might be a more consistent measure to use, that takes rolling resistance into account.

High correlations between the lab and field sprint imply that detailed biomechanical analyses from the lab can guide training to improve player's wheelchair mobility on-court. For example, the amount of peak and negative power output can be studied in detail in the lab and results can be used on-court. Moreover, field sprinting demands a straight-line trajectory that may mask left-right differences, lab sprints, without this requirement, exposes asymmetries more.

On the other hand, field testing is easier accessible, cheaper and faster to perform. Additionally, as the main goal is often to sprint in a straight line (shortest path between current location and desired location), field tests are more similar to match situations and should also be included in the test protocol. Despite the lower rolling resistance in the field, test duration was not faster (Table 1) in the field implying that field sprinting also may incorporate mobility skills, i.e., it requires immediate self-correction to avoid directional errors.

Taken together, both lab and field tests have unique advantages and can be used in concert or a choice, depending on the question, can be made. The current research has a limited amount of players and included only amateur players, from which the performance is less stable in comparison with more advanced athletes. Because lab and field tests were also taken maximal one month apart, this could induce some variation. Future research should additionally include more advanced athletes for (1) a more stable performance and (2) to increase the range of attained values.

CONCLUSION: Despite methodological differences and experienced rolling resistance between lab and field sprint tests, test duration, achieved power output and mean velocity did not differ. Field sprint testing is easier to conduct and provides valuable insights, and lab testing gives a broad additional array of in-depth biomechanical analyses.

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