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Title of the Article

Velocity and power-load association of bench press exercise in wheelchair basketball players and their relationships with field-test performance

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Abstract

Purpose: This study analyzes the relationship between mean propulsive velocity (MPV) of the bar and relative load (%1RM) in the bench press exercise, as well as determining the relationship of power variables (i.e. Mean Power (MP), Mean Propulsive Power (MPP) and Peak Power (PP)) in change of direction ability (CODA), linear sprint and RSA performance.

Methods: Nine Spanish First Division wheelchair basketball (WB) players participated in the study. All participants performed an isoinertial bench press (BP) test in free execution mode, 505 change of direction ability test (505 CODA), linear sprint test (20 m), and Repeated Sprint Ability Test (RSA).

Results: A nearly perfect and inverse relationship was observed for the BP exercise between the %1RM and MPV ($r = -.97$; $R^2 = .945$; $P < 0.001$). The maximum loads for MP, MPP and PP were obtained between 48.1 – 59.4% of the 1RM. However, no significant correlations were observed between strength and wheelchair performance.

Conclusions: WB players with different functional impairments showed a nearly perfect and inverse relationship for the BP exercise between the %1RM and MPV, thus the MPV could be used to estimate the %1RM. This finding has important practical applications for velocity-based resistance training in which coaches would be able to prescribe and monitor training load. Conversely, the absence of association between BP performance and field tests might be due to other factors such as wheelchair-user interface, trunk muscular activity or propulsion technique apart from strength variables.

Keywords: *wheelchair sport, upper limb strength, resistance training, field tests.*

Introduction

Despite the growing interest in Paralympic sport, specifically in wheelchair sports, relatively little is known about physical performance in wheelchair basketball (WB) players.[1,2,3] WB is an intermittent activity demanding simultaneously several skills for wheelchair maneuvering (i.e. propulsion, starting/stopping and changing direction of the wheelchair) and ball handling (i.e. shooting, passing, dribbling or rebounding).[4] Thus, the key components of wheelchair court-sport performance, such as WB, are the athlete profile, competition environment, equipment and physical capacity[5] in order to face WB game requirements. Due to the importance of physical fitness in WB, many studies have analyzed different physical tests to determine, among other aspects, the neuromuscular capacity of WB players.[1,2,3] These studies have used sprint tests, change of direction ability (CODA) tests and field strength tests (i.e. handgrip, maximal pass or medicine ball throw),[2,6] but few studies have analyzed neuromuscular capacity using direct methods and standardized tests.[7,8,9] In this way, having standardized and simple tests to measure the neuromuscular capacities in WB players could help coaches to use them at any time of the season in order to assess the physical fitness of the players and the evolution of these abilities.

Wheelchair sports, including WB, depend on the ability to generate strength and power with the upper extremities,[9] which especially influence wheelchair handling and propulsion.[10] Although in conventional team sports, upper limb strength capacity has been widely determined by means of the bench press (BP),[11,12] in Para-sports, few studies have analyzed this exercise to determine muscle strength.[7,8,9,13] However, one of the main problems faced by strength and conditioning coaches is the issue of how to objectively quantify and monitor the athletes' strength capacity.[14] In this way, González-Badillo et al[13] determined that movement velocity, expressed as mean propulsive velocity (MPV), could be considered as the steadiest variable for muscle strength assessment. Movement velocity is dependent on both the magnitude of the load overcome and the voluntary intent of the athlete to move that load.[15] Thus, recent studies have established a very close relationship between movement velocity and the percentage of the maximum repetition (%1RM) for a variety of exercises such as the BP.[14,16] Moreover, since mechanical power is the product of movement velocity and applied force, large differences in velocity will influence different manifestations of power in the BP: mean concentric power (MP), mean propulsive power (MPP) and peak power (PP).[16] The relationship between MPV and 1RM in athletes has already been studied in able-bodied athletes,[16] however, to our knowledge, in Para-sports this relationship has only been analyzed in a case study with Paralympic powerlifting athletes.[13] Unfortunately, in WB players with a wide variety of eligible impairments, no study has analyzed the relationship between MPV and the percentage of 1RM in order to assess the possibility of using velocity data to estimate loading intensity in WB players in BP exercise. At the same time, these manifestations of force could also influence WB performance such as accelerations, velocity, Repeated Sprint Ability (RSA) and Change of Direction Ability (CODA).[17] In this way, coaches could quantify resistance training based on the MPV and they could also know the maximum daily repetition without having to do a maximum repetition test.

Not only in conventional team sports,[17,18,19] but also in WB,[1,2,4] short sprints, CODA and RSA are important performance capacities, since being faster than the opponent often determines keeping ball possession or taking the initiative in the next action. In order to determine the relationship of power outputs among CODA, linear sprint and RSA, several studies have found very strong relationships in basketball. [17,19] Although several studies have analyzed the physical performance,[2,6] strength[9,20] or mobility[21] the number of studies regarding the association between strength test and physical performance test in WB are scarce. Regarding WB, Turbanski et al[9] reported an improvement in linear sprint after BP resistance training, suggesting that strength improvement could be effective to enhance sprint performance, but the relationship between the one repetition maximum (1RM) parameters and linear sprint were not analyzed. Other authors [2,6,20] reported an inverse moderate relationship among different strength variables (i.e. power outputs in a Wingate test, handgrip, maximal pass and medicine ball throw) with linear sprint and CODA performance. Since BP is an exercise usually used in WB players' workouts, coaches should be interested in knowing how BP's performance relates to WB functional performance (i.e. linear sprint, CODA and RSA), in order to know how to train BP and how much time to devote to BP's work in resistance training.

Assessing if there is an association between MPV and %1RM could provide coaches with a possibility of using velocity data to estimate loading intensity in WB players in BP exercise. The association among BP performance, acceleration, RSA and CODA could provide information in order to use BP exercise to improve field performance. Therefore, the aims of this study were: 1) to analyze the relationship between MPV and relative load %1RM in the BP exercise in order to assess the possibility of using velocity data to estimate loading intensity in WB players, 2) to detect the maximum power outputs in the BP test according to %1RM, in addition to describe CODA, linear sprint and RSA in WB players, and 3) to determine the relationship of power variables (MP, MPP, PP) with CODA, linear sprint and RSA performance.

Methods

Subjects

Nine Spanish First Division WB players (age = 34 ± 8 years, time since disability was acquired = 17 ± 13 years, WB training experience = 9 ± 7 years and 4-6 training and competition hours per week) volunteered to participate in the study. The participants were classified according to the Classification rules of the International Wheelchair Basketball Federation (IWBF) (Table 1). This study was approved by the institutional research ethics committee and all participants provided written informed consent as outlined in the Declaration of Helsinki (2013), and met the ethical standards in Sport and Exercise Science Research.[22]

Please insert Table 1 near here

Design

Data were collected in an in-season period (February). During this period, players undertook two WB training sessions (Tuesday and Thursday) and one match per week. Moreover, no one had an injury, so everyone kept fit and healthy. Data was collected in two consecutive sessions. In the first session, players performed the BP test, and in the second session, they undertook a test battery consisting of CODA test, linear sprint and linear RSA with at least 48 h rest between sessions.

Measures

Bench press (BP). All participants performed an isoinertial strength test in free execution mode, with increasing loads up to the 1RM for the individual determination of the full load-velocity relationship in the BP exercise. Initial load was set at 20 kg for all participants (independently of the body mass and functional classification) and was progressively increased in increments of 10 kg until attained MPV was lower than .5 $m \cdot s^{-1}$ and .7 $m \cdot s^{-1}$.[16] Thereafter, load was individually adjusted using smaller increments (5 down to 2.5 kg) when the MPV was lower than .5 $m \cdot s^{-1}$. The heaviest load that each subject could properly lift while completing full range of motion and without any external help was considered to be his

1RM. The subjects lowered the bar to the chest but were not allowed to bounce the bar on the chest. They were required to press the bar to full elbow extension to compute a valid lift. Inter-set rest intervals were 3 min for the light and medium loads and 5 min for the heaviest loads. Kinematic data were recorded by attaching a linear encoder to one end of the bar (T-Force™ System, Ergotech, Murcia, Spain).[23] The vertical velocity was directly sampled by the device at a frequency of 1000 Hz[14], in addition, the propulsive (when the bar is accelerating) and breaking phases (when the bar is decelerating) during the lifting, have been also determined by the device. Only the best repetition at each load, according to the criteria of fastest MPV, [16] was considered for subsequent analysis. The variables used for statistics were the absolute load (1RM, one-repetition maximum), the best trials at each intensity for mean propulsive velocity (MPV) and different manifestations of power: mean concentric power (MP), mean propulsive power (MPP) and peak power (PP).

505 change of direction ability (505 CODA). The participants propelled themselves forward 10 m through a first set of time gates (Microgate, Polifemo Radio Ligth™, Bolzano, Italy), then a further 5 m, before the wheelchair completely crossed a marked line, turning 180º, and finishing the test by propelling themselves 5 m back through the time gates.[24] Time measurement started and finished when the athlete crossed the line between the timing gates situated .40 m above the floor. Participants completed 6 trials in a randomized order; making 3 changes of direction turning to the left, and another 3 changes of direction turning to the right with at least 3 min rest between trials. The best trials per side were used for statistical analysis.

Linear sprint (20 m). The participants undertook a wheelchair sprint test consisting of three maximal sprints of 20 m, with a 120 s rest period between each sprint. The participants were placed at .5 m from the starting point, and began when they felt ready.[2] Time was recorded using time gates (Microgate, Polifemo Radio Ligth™, Bolzano, Italy) placed .4 m above the ground. The timer was activated automatically as the participants passed the first gate at the .0 m mark and the split time was then recorded at 20 m.[2] The best sprint of each player was used for statistical analysis.

Repeated Sprint Ability (RSA) Test. The RSA protocol included a 12 x 20 m maximal sprint starting every 20 s.[18] Accordingly, the participants were instructed by the investigators to produce maximal effort during each sprint. Time was recorded using time gates situated .40 m above the floor (Microgate, Polifemo Radio Ligth™, Bolzano, Italy) and the total time (RSA_{TT}) and the mean time (RSAmean) of the sprints were used for statistical analysis. Moreover, the fatigue index associated with RSA using the sprint decrement index (RSA_{Sdec}) was determined using the equation: $Sdec = (\frac{RSAtotal}{RSA\ best\ X\ 12} \times 100\ ) - 100$.[25] In addition, the change in the fatigue index which relates the first and last sprint (RSA_{Change}) was calculated using the equation: $Change = (\frac{\text{RSA latest} - \text{RSA first}}{\text{RSA first}}) \times 100$.[26]

Statistical analysis

Standard statistical methods were used for the calculation of the mean and standard deviations (SD). The inter player coefficient of variation (CV) was calculated for each performance variable as: (SD/mean) x 100, in order to determine the mean variability.[27] In addition, reliability between trials for field test was assessed by intra-class correlation coefficient (ICC). Relationship between MPV and %1RM in the BP exercise was studied by fitting second-order polynomials to data and the coefficient of determination (R^2) was calculated, also the relationships among BP strength variables and CODA, linear sprint, and RSA scores were assessed using Pearson correlation coefficients (r), with 90% confidence limits (CL), as well as the coefficient of determination (R^2). The following scale of magnitudes was used to interpret the magnitude of the correlation coefficients: <.1, trivial; .1-

.3, small; .3-.5, moderate; .5-.7, large; .7-.9, very large; >.9, nearly perfect.[28] Data analysis was performed using the Statistical Package for Social Sciences (version 20.0 for Windows, SPSS™, Chicago, IL, USA). The P < .05 criterion was used for establishing statistical significance.

Results

Relationship between bench press relative loads and velocity and maximum power outputs

A nearly perfect and inverse relationship (r = -.97; R^2 = .945; P < .001) was found for the BP exercise between the MPV and %1RM (Figure 1). The MP, MPP, and PP obtained by means of the regression observed above are presented in Table 2, where the percentage of propulsive and breaking phases was also determined. The 1RM was 81.8 ± 26.9 kg while the power outcome variables (i.e. MP, MPP and PP) for the entire group were 151.4 ± 51.2 W, 151.4 ± 51.2 W and 360.9 ± 304.8 W, respectively. According to MPV in the 1RM, WB players ended the BP test with very similar values for all players (.19 ± .04 $m \cdot s^{-1}$).

Figure 1 near here

*** Please insert Table 2 near here ***

The best performance in values for power outputs, CODA, linear sprint and RSA

The highest values obtained in BP and physical fitness tests are presented in Table 3 and 4. According to power outputs, the maximum loads for MP, MPP and PP were obtained between 48.1 – 59.4% of the 1RM (MPV = .90 to 1.09 $m \cdot s^{-1}$; inter-player CV = 10.0 to 18.3%). The mean power outcomes had a large variability (inter-player CV = 37.4 to 40.1%). As opposed to BP variables, the CV of physical performance (i.e. CODA, linear sprint and RSA) was less than 10% in almost all the cases (except for RSA_{Sdec} and RSA_{Change}).

*** Please insert Table 3 near here ***
*** Please insert Table 4 near here ***

Relationship among power outputs, CODA, linear sprint and RSA

The inter-test result correlations are presented in Table 5. No significant correlations (P > .05) were observed among 1 RM absolute load or maximum power outputs (i.e. MP, MPP and PP) with the CODA, linear sprint or RSA performance.

*** Please insert Table 5 near here ***

Discussion

The purposes of this study were to determine the relationship between MPV and %1RM in the BP exercise in order to assess the possibility of using velocity data to estimate loading intensity, as well as to describe strength, CODA, linear sprint and RSA performance, and to analyze the relationship among BP performance (1RM, MP, MPP, PP) and CODA, linear sprint and RSA in WB players. In the present study, WB players showed a nearly perfect and inverse relationship for the BP exercise between the MPV and %1RM. Moreover, no significant relationships were observed among the absolute load (1RM) or optimal power loads (MP, MPP and PP), with CODA, linear sprint and RSA performance.

The relationship between MPV and relative load (%1RM) in upper limb exercises[14,28,29] and in lower limb exercises[31,32] has been analyzed in order to ascertain if the relative load (%1RM) could be predicted by the MPV. However, although some studies in WB have analyzed performance in a BP exercise,[7,8,9] as far as we know, only one study has analyzed the relation between MPV and the relative load (%1RM) in Para-sports.[13] In regular team sports where the BP exercise has been analyzed,[30,32] nearly perfect relations have been observed between MPV and % 1RM (R^2 = .96 to .97, P < .05). In this line of thought, Sánchez-Medina et al[16] and González-Badillo et al[14] also reported similar values in healthy adults in the BP exercise (R^2 = .97–.98, nearly perfect, P < .001). The WB players in the present study obtained similar but slightly smaller results than in conventional team sports players (R^2 = .95, P < .001), while the association between MPV and %1RM was also nearly perfect. Perhaps the use of free weights, instead of guided bars, may have had an influence as Loturco et al[30] also reported lower relationships in free execution mode than in guided execution mode (R^2 = .95 vs. .97, free execution mode vs. guided execution mode). These values were higher than those observed by Loturco et al[13] in male, female and dwarf Paralympic Powerlifters (R^2 = .78 - .88, very large) where the load-velocity relationship seems to be weaker in dwarf athletes (R^2 = .78, very large) than those found in their peers (R^2 = .87 - .88, very large). In the present study, the associations also evidenced that a free execution mode does not disturb the very strong correlation between relative load (%1RM) and MVP. Thus, it is feasible to use the MPV variable in players with physical impairments in a free weight BP exercise, in order to quantify resistance training.

Due to the high associations between MVP and %1RM, MPV has been used to determine power output in different neuromuscular exercises.[14,16] It has been observed that participants generate their peak power between 40 and 56% of their 1RM[16,33] in BP exercise. In the present study with WB players, the absolute maximum power values obtained for each variable (i.e. MP, MPP and PP) for the BP have been observed between 48.1 - 59.4% of 1RM (MPV = .90 to 1.09 $m \cdot s^{-1}$, inter-player CV = 10.0 to 18.3%). This similarity between the studies with people with and without functional impairment make us think that despite the physical characteristics of the WB players, peak power is normally generated close to ~50% of 1RM and a MPV close to ~1.00 $m \cdot s^{-1}$. Although, the variability in power outputs among players was high (CV > 10%), possibly due to impairment diversity, it could be interesting to design specific protocols from 40 to 60% of 1RM in order to obtained the maximal power outputs (i.e. MP, MPP and PP) in the BP exercise for WB players. In addition, it could be interesting in future studies to analyze neuromuscular capacity through relative values (normalized by body mass) to know if relative strength can provide more accurate information.

Apart from the associations between MVP and %1RM in the BP exercise, the applications of strength variables has also been analyzed in conventional basketball to try to understand the relationship of muscle strength and the functional field tests (i.e. CODA, linear sprint, RSA).[11,12,19,34] In WB few studies have analyzed the association between strength and different relevant capacities to WB performance,[2,20] but no study has determined the influence of power outputs in BP exercise on CODA, linear sprint and RSA. In the present study, no significant relationships were observed among BP strength variables, CODA, linear sprint and RSA. Nevertheless, the most clear relationships have been observed among strength variables (i.e. absolute load, MP, MPP, PP) and the linear sprint (P > .05; r = -.44;± .55 CL to -.51;± .52 CL, R^2 = .15 to .27, moderate to large), but also moderate relationships were observed between power outputs (MP, MPP, PP) and RSA_{Sdec} (P > .05; r = .43; ± .60 CL to .48; ± .58 CL, R^2 = .19 to .23). These results were slightly lower than those observed by other authors[2,6,20] in WB where the individual 20 m sprint time values correlated inversely with the individual strength values measured by handgrip, maximal pass and medicine ball throw tests ($P < .05$; r = -.52 to -.77, large to very large). Moreover, in this study, unclear relationships were observed among strength variables (i.e., absolute load, MP, MPP, PP), CODA, and RSA_{Change}. These results were contrary to other studies[20] where power outputs correlated inversely with different CODA tests ($P < .05$; -.51 to -.53, large). The results obtained in the present study lead us to think that the absolute load and power outputs in BP are not the only factor influencing CODA, sprint and RSA performance in WB players. Thus, researchers have to continue in this area doing research in relation to which muscles and exercises are the most influential in CODA, sprint and RSA. Other strength simple tests, such as handgrip, maximal pass and medicine ball throw may have a stronger association with sprint tests.[35] Possibly, other factors related to wheelchair propulsion could have an influence, such as wheelchair-user interface, trunk function/activity, or propulsion technique,[10] and not only the upper limb power output. Therefore, it might be interesting for coaches not only to train muscle strength with BP exercise, but also to implement specific exercises to improve wheelchair propulsion (i.e. braking and handling of the wheelchair), or even the muscles involved in the movement of the trunk.[36] In Addition, the performance in BP could be related with the capacity of acceleration in shorter distances (2.5 or 5m), due to the BP performance may have a greater influence in the first phases of pushing. Nevertheless, the results obtained in the present study should be taken with caution due to the limited sample, the disparity of players' profiles, and the players' years of experience in WB. In future studies it could be interesting to study the influence of the strength variables on physical condition according to functional classes. As it occurs in many adapted sports studies, if there are difficulties in obtaining a relevant sample, it could be interesting to highlight a qualitative analysis with the individual results of each player. This could give a very useful practical view for coaches.

Practical applications

It is feasible to use the MPV variable in players with physical impairments in a free weight BP exercise in order to measure the resistance-training load. Coaches could quantify resistance training based on the MPV. In addition, they could know the maximum daily repetition without having to do a maximum repetition test. It could also be interesting to design specific protocols regarding the functional diversity from 40 to 60% of 1RM (MPV = .90 to 1.09 $m \cdot s^{-1}$) in order to obtain the maximal power outputs (i.e. MP, MPP and PP) in the BP exercise. However, the results obtained in the present study lead us to think that the absolute load and power outputs in BP are not the only factor influencing CODA, sprint and RSA performance in WB players. Therefore, it might be interesting for coaches not only to train muscle strength with BP exercise, but also to implement specific exercises to improve wheelchair propulsion, or even the muscles involved in the movement of the trunk.

Conclusions

WB players with different functional impairments showed a nearly perfect and inverse relationship for the BP exercise (i.e. free execution mode) between the %1RM and MPV. Therefore, the MPV could be used to estimate the % 1RM in the BP exercise in WB players. The absolute maximum power values obtained for each variable (i.e. MP, MPP and PP) for the BP have been observed to be between 48.1 - 59.4% of the 1RM (MPV = .90 ± .09 to 1.09 ± .20 $m \cdot s^{-1}$), thus, the protocols to measure maximum power should be designed close to these percentages and MPV. However, no significant relationships were observed among these power values (i.e. absolute load, MP, MPP and PP), with regard to CODA, linear sprint and RSA performance. Possibly, in these field tests (i.e. CODA, linear sprint and RSA) performance could be influenced by other factors such as wheelchair-user interface, trunk muscular activity, or propulsion technique.

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Figures

Figure 1. Relationship between mean propulsive velocity (MVP) and the percentage of 1RM (%1RM). *r = Pearson's correlation coefficient; R^2 = Coefficient of determination; $P < 0.001$ significant relationship between MVP and %1RM.*

Player	Physical Impairment	IWBF Classification	Age (years)	Time since disability was acquired (years)	Training experience (years)	1 RM (Kg)
1	Spinal Cord Injury (T12-L3)	1	45	20	9	115
2	Spinal Cord Injury (T1-T2)	1	38	36	22	90
3	Spinal Cord Injury (T12-L3)	3	32	4	3	65
4	Double amputation above knee	2	29	11	4	77.5
5	Poliomyelitis	3.5	36	33	7	135
6	Double amputation above knee	4	20	7	6	67.5
7	Double amputation below knee	4	37	30	17	65
8	Labral tear	4.5	19	3	3	55
9	Knee injury	4.5	43	11	11	65
Total (n = 9)		-	34 ± 8	17 ± 13	9 ± 7	81.7 ± 25.6

Table 2. Mean propulsive velocity (MPV), mean power (MP), mean propulsive power (MPP), and peak power (PP) attained with each %1RM and the relative contribution of the propulsive and braking phases to the total concentric duration in the bench press.

Estimated Relative Load %1RM	MPV ($m·s^{-1}$)	MP (W)	MPP (W)	PP (W)	Propulsive phase (%)	Braking phase (%)
30%	1.29 ± .13	287.5 ± 97.1	417.6 ± 131.9	598.6 ± 160.4	74.2 ± 2.5	25.8 ± 3.5
35%	1.23 ± .11	325.9 ± 110.0	441.2 ± 142.6	621.4 ± 166.1	77.4 ± 2.6	22.6 ± 2.6
40%	1.17 ± .10	357.2 ± 120.8	458.4 ± 152.0	637.3 ± 171.3	80.4 ± 2.3	19.6 ± 2.2
45%	1.10 ± .10	381.3 ± 129.3	469.3 ± 159.3	646.4 ± 175.3	83.3 ± 2.3	16.7 ± 2.3
50%	1.03 ± .10	398.3 ± 135.4	473.8 ± 164.2	648.6 ± 177.6	85.9 ± 2.6	14.1 ± 2.6
55%	.96 ± .10	408.3 ± 139.0	472.1 ± 166.4	643.9 ± 177.8	88.3 ± 2.9	11.7 ± 2.9
60%	.89 ± .10	411.1 ± 140.1	464.0 ± 165.6	632.4 ± 175.9	90.6 ± 3.1	9.5 ± 3.1
65%	.81 ± .10	406.8 ± 138.6	449.6 ± 161.9	614.0 ± 171.5	92.6 ± 3.1	7.4 ± 3.1
70%	.73 ± .09	395.4 ± 134.7	428.9 ± 155.3	588.8 ± 164.7	94.3 ± 2.7	5.7 ± 2.7
75%	.65 ± .08	376.8 ± 128.3	401.8 ± 145.7	556.7 ± 155.5	95.8 ± 2.1	4.2 ± 2.1
80%	.57 ± .07	351.2 ± 119.7	368.5 ± 133.3	517.7 ± 143.8	97.2 ± 1.6	2.8 ± 1.6
85%	.48 ± .06	318.4 ± 108.9	328.8 ± 118.5	471.9 ± 130.0	98.4 ± 1.1	1.6 ± 1.1
90%	.39 ± .05	278.5 ± 96.4	282.7 ± 101.9	419.2 ± 114.4	99.5 ± .5	5 ± .5
95%	.30 ± .04	231.6 ± 83.0	230.4 ± 85.0	359.6 ± 97.8	100	0
100%	.19 ± .04	154.6 ± 49.3	154.2 ± 49.0	279.4 ± 99.4	100	0

Values are means ± standard deviation. 1RM = one repetition maximum.

Table 3. The values of load that maximized the power output for the outcome variable used [mean power (MP), mean propulsive power (MPP), and peak power (PP)].

	Percentage of 1 RM (%)	**CV (%)**	**MPV ($m \cdot s^{-1}$)**	**CV (%)**	**Outcome variable (W)**	**CV (%)**
MP	59.4 ± 3.0	5.1	.90 ± .09	10.0	408.5 ± 147.4	38.9
MPP	48.3 ± 11.2	23.2	1.09 ± .20	18.3	476.9 ± 167.7	40.3
PP	48.1 ± 8.4	17.5	1.09 ± .15	13.8	639.9 ± 182.7	37.4

Results are means ± standard deviation. MPV = mean propulsive velocity; CV = Inter-player coefficient of variation; 1RM = one repetition maximum.

Table 4. Physical performance of wheelchair basketball players in change of direction ability (CODA), linear sprint and repeated sprint ability (RSA) tests.

	Mean	SD	Min.	Max.	ICC	CV (%)
CODA						
505_{Right} (s)	4.30	.18	4.00	4.57	.79	4.2
505_{Left} (s)	4.23	.25	3.87	4.75	.65	5.9
Linear sprint						
20 m (s)	5.24	.30	4.84	5.72	.97	5.7
RSA						
RSA_{TT} (s)	65.40	3.83	61.41	72.31	-	5.8
RSA_{Mean} (s)	5.45	.32	5.12	6.03	-	5.8
RSA_{Sdec} (%)	5.22	1.66	2.14	7.54	-	31.8
RSA_{Change} (%)	5.41	3.63	-1.52	8.54	-	67.1

SD = standard deviation; Min. = minimum; Max. = maximum; Intra player Correlation Coefficient = ICC; Inter-player CV = Inter-player coefficient of variation; RSA_{TT} = repeated sprint ability – total time; RSA_{Mean} = repeated sprint ability – mean time; RSA_{Sdec} = repeated sprint ability – decrement index; RSA_{Change} = repeated sprint ability – change - fatigue index

Table 5. The individual correlations (r), 90% confident limits (±CL), coeficiente de determinacion (R^2) and the magnitude of the correlation coefficients qualitative interpretation between maximal power output for the outcome variables (mean power (MP), mean

propulsive power (MPP) and peak power (PP)) with change of direction ability (CODA), linear sprint and repeated sprint ability (RSA).

	505 CODA		**Linear sprint**	**RSA**			
	505_{Right} **r ;±CL** **(R^2)**	**505_{Left}** **r ;±CL** **(R^2)**	**20 m** **r ;±CL** **(R^2)**	**RSA_{TT}** **r ;±CL** **(R^2)**	**RSA_{Mean}** **r ;±CL** **(R^2)**	**RSA_{Sdec}** **r ;±CL** **(R^2)**	**RSA_{Change}** **r ;±CL** **(R^2)**
Absolute load (1 RM)	.00;± .63 (.000) 41.1/17.8/41.1 Unclear	-.02;± .63 (.001) 39.4/17.7/42.9 Unclear	-.51;± .52 (.265) 6.9/8.1/84.9 Likely large	-.48;± .53 (.235) 10.6/9.3/80.1 Likely moderate	-.48;± .53 (.235) 10.6/9.3/80.1 Likely moderate	.29;± .64 (.082) 65.4/13.3/21.2 Unclear	.20;± .66 (.039) 58.1/14.7/27.2 Unclear
Mean Power (MP)	.06;± .63 (.004) 46.4/17.6/36.0 Unclear	-.01;± .63 (.000) 40.3/17.7/42.0 Unclear	-.45;± .54 (.202) 9.5/10.0/80.5 Likely moderate	-.41;± .61 (.165) 14.2/10.9/74.9 Unclear	-.40;± .61 (.165) 14.7/11.2/74.1 Unclear	.47;± .59 (.226) 79.4/9.5/11.1 Likely moderate	.37;± .62 (.140) 71.8/11.8/16.4 Unclear
Mean Propulsive Power (MPP)	.05;± .63 (.002) 45.5/17.6/36.8 Unclear	-.03;± .63 (.001) 38.5/17.7/43.8 Unclear	-.44;± .55 (.189) 10.0/10.3/79.7 Likely moderate	-.40;± .61 (.163) 14.7/11.2/74.1 Unclear	-.40;± .61 (.163) 14.7/11.2/74.1 Unclear	.48;± .58 (.229) 80.1/9.3/10.6 Likely moderate	.38;± .62 (.141) 72.6/11.6/15.8 Unclear
Peak Power (PP)	.05;± .63 (.003) 54.9/15.1/30.0 Unclear	.03;± .63 (0.001) 54.0/15.2/30.7 Unclear	-.49;± .53 (.236) 7.7/8.8/83.5 Likely moderate	-.38;± .62 (.146) 15.8/11.6/72.6 Unclear	-.38;± .62 (.146) 15.8/11.6/72.6 Unclear	.43;± .60 (.188) 76.4/10.5/13.1 Likely moderate	.31;± .64 (.094) 67.0/13.0/20.0 Unclear

CODA = change of direction ability; RSA_{TT} = repeated sprint ability – total time; RSA_{Mean} = repeated sprint ability – mean time; RSA_{Sdec} = repeated sprint ability – decrement index; RSA_{Change} = repeated sprint ability – change - fatigue index.