Prova teórica PPGEF-UFPE 2022.2
Espelho prova teórica.

Questão 1 (referente ao artigo 1)

Questões 2 a 7 (referentes ao artigo 2)

Questão 1

Resp.

Resumo
Introdução: O treino de caminhada (TC) melhora a capacidade de marcha e reduz a pressão arterial (PA) clínica em pacientes com
doença arterial periférica (DAP), mas seus efeitos na PA ambulatorial permanecem desconhecidos.
Objetivos: Investigar o efeito de 12 semanas de TC na PA ambulatorial e sua variabilidade em pacientes com DAP.
Métodos: Trinta e cinco pacientes do sexo masculino com DAP e sintomas de claudicação foram alocados aleatoriamente em dois grupos: controle (n = 16, 30 min de alongamento) e TC (n = 19, 15 séries de 2 min de caminhada na frequência cardíaca da perna limiar de dor intercalado por 2 min de repouso em pé). Antes e após 12 semanas, a PA ambulatorial de 24 horas foi avaliada. Os índices de variabilidade da PA ambulatorial avaliados em ambos os momentos incluíram o desvio padrão de 24 horas (DP24), o desvio padrão ponderado de vigília e sono (DPdn) e a variabilidade real média de 24 horas (ARV24). Os dados foram analisados por ANOVAs de duas vias mistas, considerando P<0,05 como significativo.
Resultados: Após 12 semanas, nenhum dos grupos apresentou alterações significativas nas PA de 24 horas, vigília e sono. O TC diminuiu as variabilidades da PA sistólica e média (PA Sistólica – 13,3±2,8 vs 11,8±2,3, 12,1±2,84 vs 10,7±2,5 e 9,4±2,3 vs 8,8±2,2 mmHg); PA média – 11,0±1,7 vs 10,4±1,9, 10,1±1,6 vs 9,1±1,7 e 8,0±1,7 vs 7,2±1,5 mmHg) para SD24, SDdn e ARV24, respectivamente). Nenhum dos grupos apresentou alterações significativas nas variabilidades da PA diastólica após 12 semanas.
Conclusão: O TC não altera os níveis de PA ambulatorial, mas diminui a variabilidade da PA ambulatorial em pacientes com DAP. Essa melhora pode ter um impacto favorável no risco cardiovascular de pacientes com DAP sintomática.
Palavras-chave: Claudicação Intermitente; Andando; Pressão arterial; Ambulatório de Monitorização da Pressão Arterial; Fraqueza muscular; Treinamento de resistência.

Questão 2. Aponte um título para o trabalho, que esteja condizente com seu(s) principal(ais) achados e com a amostra estudada.

Resp. Relação entre a potência e o desempenho relacionado à velocidade em Jogadores Brasileiros de Basquetebol em Cadeira de Rodas

Questão 3. Aponte a lacuna do conhecimento abordada no estudo.

Resp. (...) ainda falta entender melhor a influência dessa capacidade física nas atividades em cadeira de rodas. Uma maneira de explorar essa questão é examinar as associações entre testes de potência e parâmetros de desempenho do basquete em cadeiras de rodas (BC), como aceleração da cadeira de rodas (ACC) e velocidade (VEL). No entanto, estudos envolvendo medidas diretas de potência muscular e jogadores de elite BC são escassos na literatura. (...) Iturricastillo et al. (2018) analisaram relações entre BP (supino reto) “carga de potência ótima” (OPL; carga que maximiza potência) e desempenho relacionado à velocidade em jogadores de BC de várias classes, sem correlações significativas mostradas entre essas variáveis. Segundo os autores, isso pode estar relacionado ao fato de que os testes funcionais são influenciados por diversos fatores, como interface cadeirante-usuário, atividade muscular e técnica. Apesar disso, é razoável considerar que as características heterogêneas da amostra (ou seja, atletas com deficiências distintas) afetaram os resultados. Além disso, o uso de um exercício único (ou seja, BP, supino reto) pode ter sido um fator, pois a propulsão da cadeira de rodas é uma tarefa motora complexa (de Groot, Bos, Koopman, Hoekstra, & Vegter, 2017; Vanlandewijck, Theisen, & Daly, 2001). Portanto, é importante examinar essas relações em um grupo mais homogêneo de indivíduos (por exemplo, jogadores com controle total do tronco) e usando uma variedade mista de exercícios (supino reto [BP], desenvolvimento de ombros [SP] e supino inclinado [3]. PBP]).

Questão 4. De acordo com o seu conhecimento sobre pesquisa científica, conceitue a investigação quanto ao seu desenho experimental e ao tipo de pesquisa.

Resp. Descritiva do tipo correlacional. Desenho transversal. Abordagem quantitativa.

Questão 5. De acordo com as informações contidas na tabela 1 e na figura 1 identifique o(s) principal(ais) resultado(s) da investigação.

Resp. A Tabela 1 demonstra os dados descritivos de velocidade (VEL) e aceleração (ACC) nas diferentes distâncias e dados de potência propulsiva média (MPP) e carga nos três exercícios testados. A Figura 1 mostra as correlações entre VEL e ACC com MPP. Relações significativas grandes a muito grandes foram observadas entre VEL e ACC, e MPP no supino [BP] (r = 0,66, 0,74, 0,77, 0,66, 0,75 e 0,65, para VEL 5, 10 e 20 m, e ACC 0–5, 5–10 e 10–20 m, respectivamente; $p < 0,05$), desenvolvimento de ombros [SP] (r = 0,60, 0,67, 0,68, 0,61, 0,68 e 0,57, para VEL 5 , 10 e 20 m, e ACC 0–5, 5–10 e 10–20 m, respectivamente; $p < 0,05$) e supino inclinado [PBP] (r = 0,66, 0,68, 0,72, 0,66, 0,62 , e 0,66, para VEL 5, 10 e 20 m, e ACC 0–5, 5–10 e 10–20 m, respectivamente; $p < 0,05$) exercícios.

Questão 6. Identifique as principais limitações do estudo.

Resp. Esta investigação é limitada por seu desenho transversal, impossibilitando a determinação de causalidade. Além disso, o pequeno tamanho da amostra e as características da amostra (ou seja, jogadores do sexo masculino com altos escores funcionais e níveis funcionais semelhantes) dificultam a extrapolação de nossos achados para outras classes de jogadores de basquete em cadeiras de rodas.

Questão 7. Identifique a(s) principal(ais) aplicação(ões) prática(s) a partir dos resultados do estudo.

Resp. A propulsão em cadeira de rodas tem sido descrita como uma tarefa motora muito complexa, que depende de uma série de aspectos fisiológicos, neuromecânicos e técnicos (Vanlandewijck et al., 2001). Apesar dessa natureza multifacetada, nossos dados demonstram que jogadores de basquete em cadeiras de rodas (BC) que produzem mais potência em determinados exercícios de força-potência também são capazes de acelerar mais rápido e atingir velocidades mais altas em distâncias curtas (5, 10 e 20 m). Considerando a importância crucial de acelerações altas e sucessivas durante as manobras relacionadas ao jogo, os cientistas do esporte são fortemente recomendados para avaliar a potência em BP (supino reto), SP (desenvolvimento de ombros) e PBP (supino inclinado) em jogadores de BC. Do ponto de vista aplicado, as correlações próximas observadas aqui podem sugerir que as variações na potência máxima estão diretamente relacionadas a mudanças significativas no desempenho de corrida de cadeira de rodas. Além disso, os treinadores paralímpicos podem usar essa faixa de carga como uma forma alternativa de desenvolver qualidades de força-potência em jogadores de BC. Embora essas respostas continuem a ser exploradas em estudos prospectivos, há um conjunto convincente de evidências que confirmam a eficácia da potência ótima em diferentes populações atléticas (Dello Iacono & Seitz, 2018; Freitas, Calleja- Gonzalez, Carlos-Vivas, Marin-Cascales, & Alcaraz, 2019; Ribeiro et al., 2020). Estudos futuros devem ser realizados para descrever completamente esses efeitos em atletas de elite em cadeira de rodas.

Original Article

Walking Training Improves Ambulatory Blood Pressure Variability in Claudication

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Abstract

Background: **Walking training (WT) improves walking capacity and reduces clinic blood pressure (BP) in patients with peripheral artery disease (PAD), but its effects on ambulatory BP remains unknown.**

Objectives: **To investigate the effect of 12 weeks of WT on ambulatory BP and its variability in patients with PAD.**

Methods: **Thirty-five male patients with PAD and claudication symptoms were randomly allocated into two groups: control (n = 16, 30 min of stretching) and WT (n = 19, 15 bouts of 2 min of walking at the heart rate of leg pain threshold interspersed by 2 min of upright rest). Before and after 12 weeks, 24-hour ambulatory BP was assessed. Ambulatory BP variability indices assessed at both time points included the 24-hour standard deviation (SD_{24}), the awake and asleep weighted standard deviation (SD_{dn}), and the 24-hour average real variability (ARV_{24}). Data were analyzed by mixed two-way ANOVAs, considering P<0.05 as significant.**

Results: **After 12 weeks, neither group had significant changes in 24-hour, awake and sleep BPs. The WT decreased systolic and mean BP variabilities (Systolic BP – 13.3±2.8 vs 11.8±2.3, 12.1±2.84 vs 10.7±2.5 and 9.4±2.3 vs 8.8±2.2 mmHg); Mean BP – 11.0±1.7 vs 10.4±1.9, 10.1±1.6 vs 9.1±1.7 and 8.0.±1.7 vs 7.2±1.5 mmHg) for $SD_{24,}$ SD_{dn} and ARV_{24}, respectively). Neither group had significant changes in diastolic BP variabilities after 12 weeks.**

Conclusion: **The WT does not change ambulatory BP levels but decreases ambulatory BP variability in patients with PAD. This improvement may have a favorable impact on the cardiovascular risk of patients with symptomatic PAD. (Arq Bras Cardiol. 2021; 116(5):898-905)**

Keywords: **Intermittent Claudication; Walking; Blood Pressure; Blood Pressure Monitoring Ambulatory; Muscle Weakness; Endurance Training.**

Introduction

Intermittent claudication, the most prevalent symptom of peripheral artery disease (PAD), impairs walking capacity, impacting on patient's physical activity levels[1] and quality of life.[2] In addition, this functional limitation is associated with increased rates of fatal and non-fatal cardiovascular events in this population.[3]

Among cardiovascular diseases, arterial hypertension is a common comorbidity that affects more than 80% of the patients with PAD,[4] who present higher clinic and specially higher ambulatory BP levels compared with healthy individuals.[5] Interestingly, we recently demonstrated that walking capacity was negatively associated with ambulatory BP in PAD,[6] indicating a poorer BP control in patients with greater functional impairment. Thus, therapeutic strategies that increase functional capacity, such as walking training, may improve cardiovascular outcomes and reduce cardiovascular risk in this group.

We have recently demonstrated that supervised walking training (WT) improves walking capacity in addition to reducing clinic BP in patients with symptomatic PAD,[7] however its effects on ambulatory BP remains unknown. This is a very important issue, since ambulatory BP is considered a stronger predictor of all-cause and cardiovascular mortality than clinic BP.[8] Additionally, a previous study reported no effect of resistance training on ambulatory BP levels, but an improvement in ambulatory BP variability,[9] a new and strong marker for target-organ damage, cardiovascular events, and mortality.[10] Given that

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aerobic training such as walking promotes considerable reduction on ambulatory BP levels compared to resistance training in normotensive and hypertensive populations,[11] one may suppose that this mode of exercise can also improve ambulatory BP and its variability in patients with PAD, which needs to be checked. Thus, the aim of this study was to investigate the effects of WT on ambulatory BP and its variability in patients with symptomatic PAD.

Methods

Study Population

This is a complementary data from a previous study.[7] Patients were recruited from the Clinic Hospital's Vascular Unit, University of Sao Paulo, Brazil. Male patients previously diagnosed with PAD and with symptoms of intermittent claudication were invited. Inclusion criteria were: (a) age ≥ 50 years; (b) ankle-brachial index (ABI) ≤ 0.90;[11,12] c) Fontaine stage II of PAD;[13] (d) body mass index ≤ 35 kg/m²; (e) resting systolic BP ≤ 160 mmHg and diastolic BP ≤ 105 mmHg; (f) not taking β-blockers or non-dihydropyridine calcium channel blockers; (g) absence of cardiovascular autonomic neuropathy for diabetic patients;[14] (h) ability to walk for at least 2 minutes at 3.2 km/h on a treadmill; (i) ability to undertake an incremental treadmill test limited by symptoms of intermittent claudication; (j) absence of myocardial ischemia or complex arrhythmias during a maximal treadmill test; (k) decrease of at least 15% in ABI after a maximal treadmill test; and (l) not engaged in any exercise program. In addition, patients were not included if they met at least one of the following criteria: 1) revascularization surgery or angioplasty less than one year earlier; 2) use of peripheral vasodilators, 3) lower limb amputation, and 4) orthopedic problems that contraindicate walking exercise. Subjects were excluded if they had their medications changed during the study. The study's protocol was registered at the Brazilian Clinical Trials (RBR-7M3D8W) and approved by the Human Research Ethics Committee of the School of Physical Education and Sport of the University of Sao Paulo (process: 39-2008/55) and the Clinic Hospital (process:1179/09), being conducted in accordance with the Declaration of Helsinki. A written informed consent was obtained from all patients prior to participation.

Participant screening

Diagnosis of PAD was made based on clinical history and ABI measurement at rest and after a treadmill maximal test.[15] Arm systolic BP was measured using the auscultatory method, and ankle systolic BP of each leg was assessed with a Doppler ultrasound (Martec, DV 6000, Ribeirão Preto, Brazil). For each patient, the lowest ABI was recorded. Body mass and height were measured (Welmy, 110, São Paulo, Brazil), and body mass index was calculated. Resting brachial BP was measured in two visits, and the mean value was calculated and used for analysis. In each visit, after five minutes of seated rest, three auscultatory measurements were taken in each arm, and the highest mean value was recorded. Medication use and exercise habits were assessed via interview. In diabetic patients, the presence of cardiovascular autonomic neuropathy, was assessed according to the recommendations of the American Diabetes Association.[14] Drug treatment was kept constant for all patients throughout the study.

Design

The experimental protocol is shown in Figure 1. The study had an initial pre-screening including a maximal treadmill test following Gardner's protocol for assessing pain threshold.[16] Then, subjects who met all the study criteria underwent 24-hour ambulatory BP monitoring at baseline and after 12-weeks of intervention. Patients were randomized using a specific online program (www.randomizer.org) into two groups: walking training (WTG) and control (CG).

For all the assessments, recommendations included no vigorous exercise in the previous 48 hours, a light meal 2 hours before, no ingestion of food with stimulant properties such as caffeine, no alcoholic beverages or smoking in the previous 12 hours. Clinic assessments were conducted in the morning in a temperature-controlled laboratory (20-22°C).

Measurements

Primary outcome: ambulatory blood pressure

Ambulatory BP monitoring was performed with a noninvasive oscillometric device (SpaceLabs Medical Inc, 90207, Washington, USA) placed on the non-dominant arm and programmed to perform measurements every 15 minutes for 24 hours. The accuracy of the device was confirmed by a mercury sphygmomanometer prior to use.

For the analysis, ambulatory systolic, diastolic and mean BP levels were calculated by the average of all BP measurements taken during the 24 hours as well as during the awake and asleep periods reported by the patient. In addition, ambulatory BP variability was calculated for systolic, diastolic and mean BP using three different indices:[17] the 24-hour standard deviation (SD_{24}); the awake and asleep weighted standard deviation (SD_{dn}), and the 24-hour average real variability (ARV_{24}). These indices were calculated as previously reported. Briefly, SD_{24} was calculated by the standard deviation (SD) over 24 hours weighted for the time interval between measures. SD_{dn} was calculated by the mean of awake and asleep SD corrected for the number of hours of each of these periods [i.e SD_{dn} = [(awake SD x awake hours) + (asleep SD x asleep hours)]/(wake + asleep hours)]. ARV_{24} was calculated by the average of absolute differences between consecutive measurements accounting for the order of measurement using following formula:

$$ARM = \frac{1}{\Sigma_w} \sum_{k=1}^{n-1} w \times |BP_{k+1} - BP_k|$$

where k ranges from 1 to N−1, BP is the blood pressure

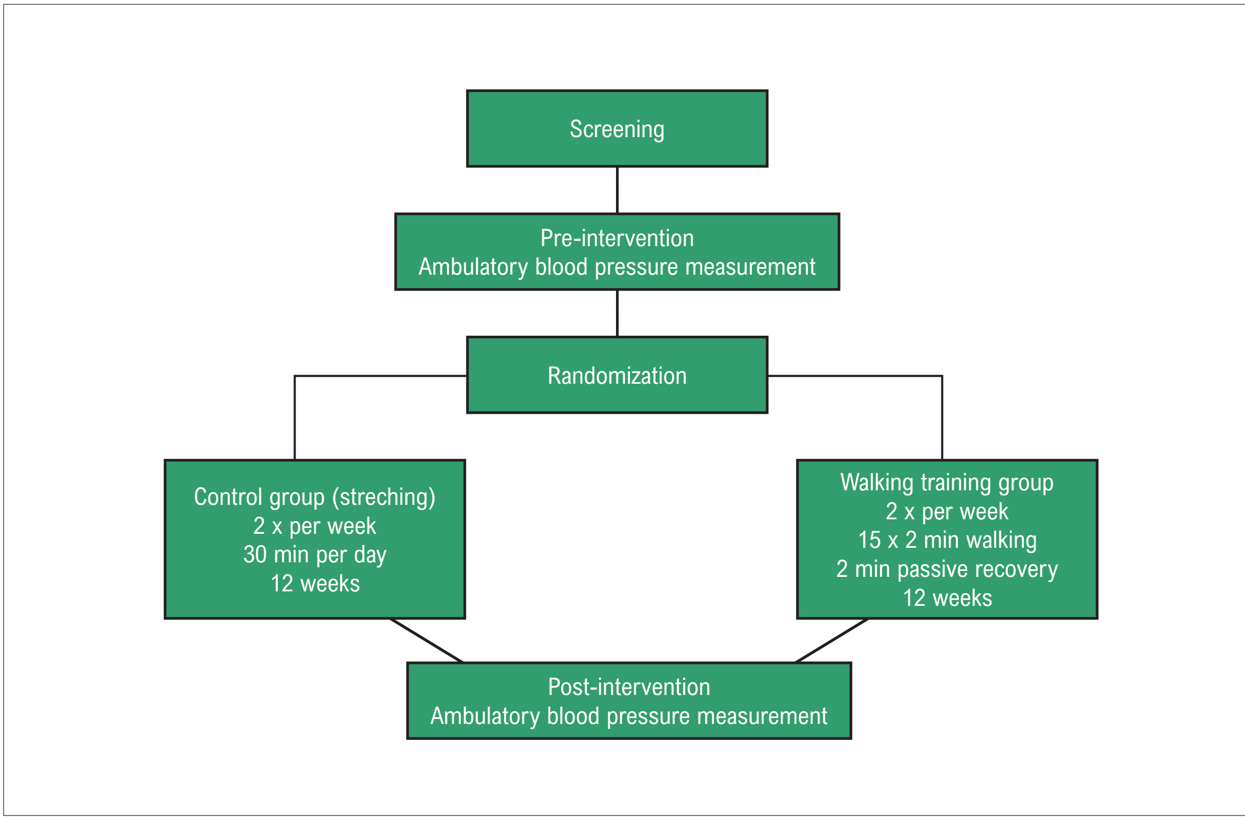

Figure 1 – *Experimental design of the study.*

and w is the time interval between BPk and BPk+1. N is the number of blood pressure readings.

Interventions

Details of the interventions have been previously reported.[7] Briefly, interventions were conducted twice a week for 12 weeks and supervised by one of the researchers. CG patients performed stretching exercises for 30 minutes. WTG patients performed 15 bouts of 2-minute walking on a treadmill intersected by 2 minutes of resting. During each walking bouts, speed was kept at 3.2 km/h and intensity was adjusted by setting the treadmill grade to maintain heart rate within 4 bpm of the heart rate obtained at the pain threshold assessed during maximal treadmill test[18] (e.g., if the patient reported the pain threshold during maximal treadmill test at 100 bpm, the heart rate during each training session was kept between 96 to 104 bpm).

Statistical analysis

As previously described,[7] the sample size was estimated considering a power of 90%, alpha error of 5%, and standard deviation of 3 mmHg for systolic BP. The minimal sample size necessary to detect a difference of 4 mmHg was 7 subjects in each group.

Normality of data distribution and homogeneity of variance were evaluated using the Shapiro-Wilk and Levene tests, respectively. Skewed distributions were normalized using logarithmic transformations. At baseline, group differences were identified via chi-square test (comorbidities and drug therapy prevalence) or unpaired Student's t-test (continuous variables). The effects of the interventions were assessed using a mixed two-way ANOVA (Statsoft, Statistic for Windows 4.3, Oklahoma, USA), the groups being the between factor, and the study phase (baseline and 12 weeks) being the within factor. Newman-Keuls post-hoc tests were used when necessary. $P<0.05$ was considered significant, and data were presented as mean ± SD.

Results

Patients flowchart is shown in Figure 2. Eighty-four patients were screened, but 35 were excluded for not meeting the eligibility criteria (n=7) or declining participation (n=28, not available to perform training sessions). The remaining 49 patients were randomly allocated in the CG (n=24) and the WTG (n=25). Fourteen patients withdrew due to circumstances unrelated to the the study. Thus, the final sample was composed of 35 patients (CG, n=16; WTG, n=19).

These groups had similar initial characteristics regarding age, obesity level, clinic BP levels, disease limitations, comorbidities, and medication use (Table 1).

Ambulatory BP levels were similar between WTG and CG at baseline, and neither group presented any significant change in 24-hour, awake and asleep BPs after the 12 weeks of intervention (Table 2).

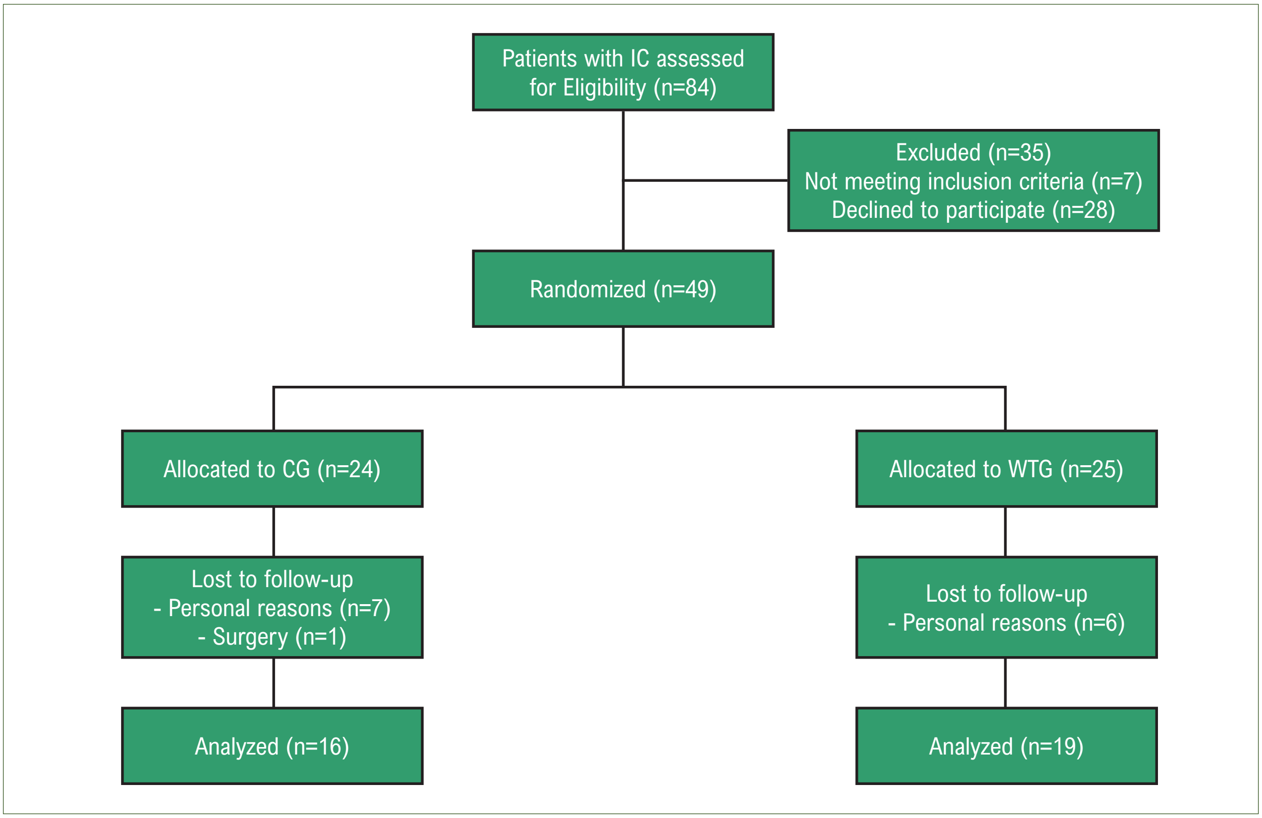

Figure 2 – *Participants flowchart. IC: Intermittent claudication, CG: Control group, WTG: Walking training group*

BP variability indices assessed at baseline were similar between WTG and CG. There was a significant interaction between group and study phase for systolic and mean BP variability indices (all $p<0,05$), showing a reduction in SD_{24}, SD_{dn}, and AVR_{24} of systolic and mean BP in the WTG (Table 3, Figure 3). Neither group had any significant change in the indices of diastolic BP variability.

Discussion

The main finding of this study was that 12 weeks of WT decreased systolic and mean BP variability indices without changing ambulatory BP levels.

In the present study, 12 weeks of WT did not alter ambulatory BP in patients with PAD, which contrasts with studies with normotensive subjects and hypertensive patients[19] that have consistently reported decreases around 3 mmHg for systolic and diastolic ambulatory BP after aerobic training. However, 12 weeks of resistance training have also not changed ambulatory BP in patients with PAD.[9] Thus, it has been hypothesized that the frequent episodes of ischemia during daily activities in patients with PAD produce claudication pain, oxidative stress and metabolic accumulation, increasing sympathetic nerve activity and, consequently, blunting any possible hypotensive effect of exercise training on ambulatory BP levels.[20] Another potential explanation, however, can be the too short duration of the training program, since a previous study[21] conducted with elderly hypertensive patients showed no change in ambulatory BP levels after 6 months of training, but a significant reduction after 12 months.

Despite the absence of change in ambulatory BP levels, reductions in ambulatory systolic and mean BP variabilities were observed for all variability indices: SD_{24}, SD_{dn} and ARV_{24}. These results are in accordance with a previous study with resistance training in symptomatic PAD patients.[9] In addition, this result is coherent with the concept that changes in autonomic control precede alterations in BP levels, since BP variability mainly reflects autonomic control of BP.[22,23] Additionally, these results are also in accordance with our previous clinic findings of improvements in cardiac autonomic modulation and baroreflex sensitivity, all markers of autonomic control, after WT in patients with PAD.[7] The absence of changes in diastolic ambulatory BP variability is also coherent with the absence of effects of walking training on calf vascular resistance, as previously described.[7]

Even without any changes in ambulatory BP levels, the decrease in ambulatory BP variability obtained with WT may have relevant clinical implications. BP variability has been associated with the presence and progression of subclinical organ damage as well as the incidence of hard endpoints such as cardiovascular events[10], leading to a worse cardiovascular prognosis.[8] Thus, the decrease induced by WT may have favorable impact on the cardiovascular risk of patients with PAD, reinforcing the recommendation of WT for these patients.

Table 1 – Characteristics of the patients allocated in the control (CG) and the walking (WTG) training groups.

	CG (n = 16)	WTG (n = 19)	p value
Age (years)	62 ± 7	63 ± 7	0.64
Body mass index (kg/m^2)	25.7 ± 3.9	26.1 ± 3.1	0.76
Ankle brachial index	0.60 ± 0.12	0.62 ± 0.14	0.61
Claudication onset distance (m)	319 ± 152	277 ± 164	0.45
Total walking distance (m)	759 ± 305	624 ± 255	0.16
Clinic systolic BP (mmHg)	136 ± 19	133 ± 14	0.60
Clinic diastolic BP (mmHg)	79 ± 10	77 ± 9	0.53
Comorbidities			
Obesity (%)	12.5	10.5	0.55
Hypertension (%)	81.3	84.2	0.89
Diabetes Mellitus (%)	25.0	21.1	0.61
Dyslipidemia (%)	100.0	89.5	0.17
Current Smokers (%)	37.5	26.3	0.38
Heart Disease/Stroke (%)	18.8	21.1	0.80
Drug therapy			
Aspirin (%)	93.8	100.0	0.28
Statin (%)	62.5	78.9	0.83
Angiotensin-converting enzyme inhibitor (%)	43.8	68.4	0.20
Diuretics (%)	25.0	47.4	0.17
Calcium channel blocker (%)	18.8	21.1	0.86
Oral hypoglycemic (%)	18.8	15.8	0.69
Number of antihypertensive			
Monotherapy	50.0		

Data are shown as mean ± SD or percentage (%). BP: Blood pressure. Continuous variable – unpaired Student's t-test. Categorical variable – chi-square test.

Table 2 – Ambulatory blood pressure levels measured at baseline and after the 12-week intervention period for the walking training (WTG) and the control (CG) groups

	CG (n = 16)		WTG (n = 19)		P group	P study phase	P interaction
	Baseline	12 weeks	Baseline	12 weeks			
24h							
Systolic BP (mmHg)	130 ± 14	132 ± 15	128 ± 14	126 ± 11	0.51	0.74	0.21
Diastolic BP (mmHg)	78 ± 7	80 ± 7	78 ± 12	76 ± 10	0.44	0.42	0.16
Mean BP (mmHg)	96 ± 9	98 ± 8	94 ± 9	93 ± 9	0.32	0.60	0.14
Awake							
Systolic BP (mmHg)	135 ± 14	137 ± 16	130 ± 14	129 ± 12	0.16	0.74	0.44
Diastolic BP (mmHg)	83 ± 7	84 ± 7	80 ± 12	79 ± 11	0.16	0.41	0.35
Mean BP (mmHg)	101 ± 9	103 ± 9	96 ± 10	95 ± 10	0.08	0.60	0.25
Asleep							
Systolic BP (mmHg)	119 ± 16	121 ± 16	124 ± 16	122 ± 12	0.50	0.85	0.51
Diastolic BP (mmHg)	69 ± 9	71 ± 8	73 ± 9	71 ± 11	0.61	0.80	0.32
Mean BP (mmHg)	87 ± 11	89 ± 11	89 ± 9	89 ± 9	0.63	0.82	0.33

Data are shown as mean ± standard deviation. BP: Blood pressure. Mixed two-way ANOVA, with the group being the between main factor and the study phase being the within main factor.

Table 3 – Ambulatory blood pressure variability indices assessed at baseline and after the 12-week intervention period for the walking training (WTG) and the control (CG) groups

	CG (n = 16)		WTG (n = 19)		P value group	P value study phase	P value interaction
	Baseline	12 weeks	Baseline	12 weeks			
SD_{24}							
Systolic BP (mmHg)	14.6 ± 3.0	15.5 ± 3.9	13.3 ± 2.8	11.8 ± 2.3*#	0.01	0.65	0.04
Diastolic BP (mmHg)	10.9 ± 1.8	11.2 ± 1.7	9.7 ± 2.3	10.0 ± 2.5	0.06	0.49	0.68
Mean BP (mmHg)	12.0 ± 2.6	13.0 ± 3.0	11.0 ± 1.7	10.4 ± 1.9#	0.01	0.71	0.04
SD_{dn}							
Systolic BP (mmHg)	12.2 ± 2.4	12.7 ± 3.0	12.1 ± 2.4	10.7 ± 2.5*#	0.18	0.27	0.03
Diastolic BP (mmHg)	8.7 ± 1.3	9.0 ± 1.6	9.0 ± 1.8	8.9 ± 2.2	0.98	0.95	0.48
Mean BP (mmHg)	10.0 ± 2.1	10.7 ± 2.2	10.1 ± 1.6	9.1 ± 1.7*#	0.23	0.82	0.01
ARV_{24}							
Systolic BP (mmHg)	9.4 ± 2.1	10.7 ± 2.4*	9.4 ± 2.3	8.8 ± 2.2#	0.18	0.28	0.02
Diastolic BP (mmHg)	6.9 ± 1.8	7.3 ± 1.8	7.3 ± 2.3	7.2 ± 1.6	0.75	0.67	0.54
Mean BP (mmHg)	8.1 ± 1.9	8.6 ± 1.7	8.0 ± 1.7	7.2 ± 1.5*#	0.15	0.88	0.01

*Values are shown as mean ± standard deviation. SD24 = 24-hour weighted standard deviation; SD_{dn}: awake and asleep weighted standard deviation; ARV: average real variability. Mixed two-way ANOVA, with the group being the between main factor and the study phase being the within main factor. *Different from baseline (P<0.05); # Different from CG (P<0.05)*

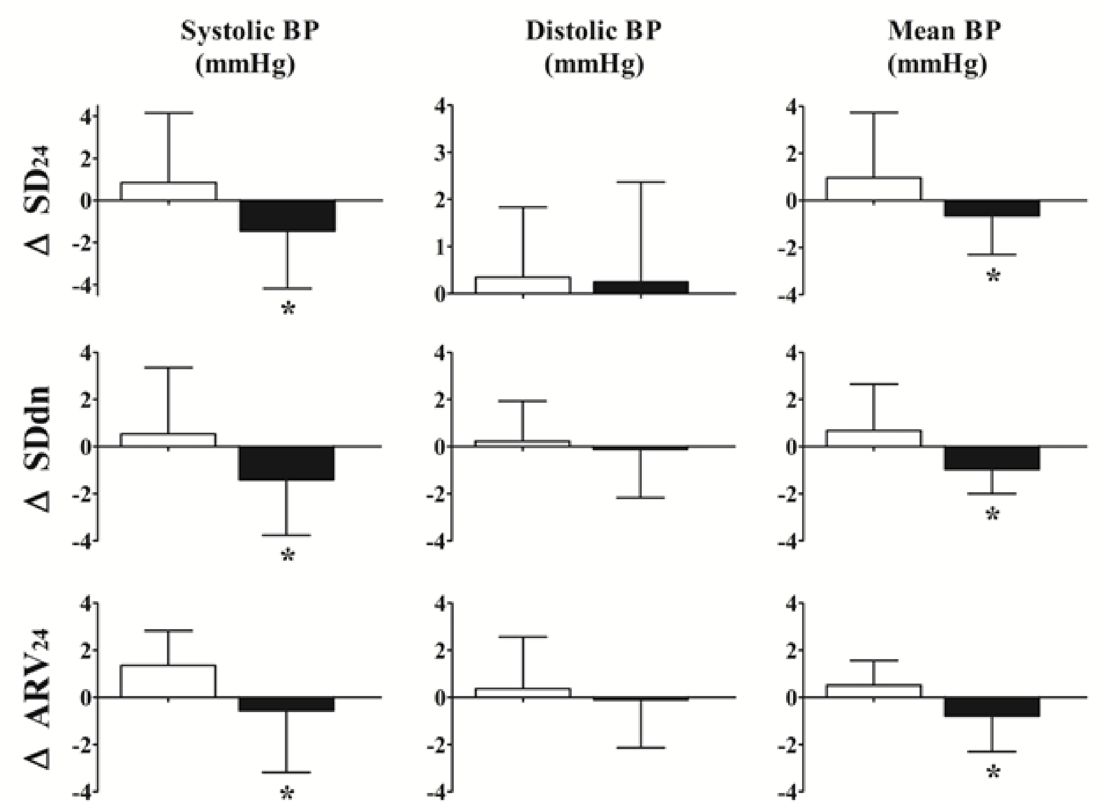

Figure 3 - *Absolute change (Δ) of ambulatory blood pressure variability for the control group (white bars) and walking training group (black bars). BP: blood pressure; SD_{24}: standard deviation over 24 hours weighted for the time interval between consecutive readings; SD_{dn}: the average of the daytime and nighttime SDs weighted for the duration of the daytime and nighttime interval; ARV_{24}: the average real variability weighted for the time interval between consecutive readings in 24-hour ambulatory BP recordings. *p<0.05 vs control group.*

This study has some limitations that should be acknowledged. It was conducted only with men, and training-induced adaptations may differ between genders.[24,25] Thus, future studies should investigate the impact of WT on ambulatory BP and its variability also in women, especially the elderly, who may experience greater cardiovascular risk than men.[24] The current study also only examined patients with claudication symptoms, and further studies should examine the effects of WT in other groups of patients, such as those who are asymptomatic (stage 1) and may also present a decrease in ambulatory BP levels after WT. Finally, the training program lasted 12 weeks, a length that improves functional capacity and clinic cardiovascular parameters in these patients,[7] but a longer training period may be necessary to decrease ambulatory BP levels.

Conclusion

In conclusion, 12 weeks of WT decreases ambulatory BP variability in men with symptomatic PAD.

Author Contributions

Conception and design of the research: Chehuen M, Cucato GG, Zerati AE, Leicht A, Ritti-Dias RM, Forjaz CLM; Acquisition of data: Chehuen M, Cucato GG; Analysis and interpretation of the data: Chehuen M, Cucato GG, Forjaz CLM; Statistical analysis and Obtaining financing: Forjaz CLM; Writing of the manuscript: Chehuen M, Cucato GG, Carvalho C, Wolosker N Ritti-Dias RM; Critical revision of the manuscript for intellectual contente: Chehuen M, Cucato GG, Carvalho C, Zerati AE, Leicht A, Wolosker N, Ritti-Dias RM, Forjaz CLM.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

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Human Kinetics
BRIEF RESEARCH NOTE

Relationship Between Power Output and Speed-Related Performance in Brazilian Wheelchair Basketball Players

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This study aimed to investigate the association between the optimum power load in the bench press (BP), shoulder press (SP), and prone bench pull (PBP) exercises and acceleration (ACC) and speed performances in 11 National Team wheelchair basketball (WB) players with similar levels of disability. All athletes were

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previously familiarized with the testing procedures that were performed on the same day during the competitive period of the season. First, athletes performed a wheelchair 20-m sprint assessment and, subsequently, a maximum power load test to determine the mean propulsive power (MPP) in the BP, SP, and PBP. A Pearson product–moment correlation was used to examine the relationships between sprint velocity (VEL), ACC, and the MPP in the three exercises. The significance level was set as $p < .05$. Large to very large significant associations were observed between VEL and ACC and the MPP in the BP, SP, and PBP exercises (r varying from .60 to .77; $p < .05$). The results reveal that WB players who produce more power in these three exercises are also able to accelerate faster and achieve higher speeds over short distances. Given the key importance of high and successive ACCs during wheelchair game-related maneuvers, it is recommended that coaches frequently assess the optimum power load in BP, SP, and PBP in WB players, even during their regular training sessions.

Keywords: muscle power, Paralympics, physical impairment, team sports

The ability to apply force at high velocities (i.e., power) is recognized as a key factor for successful sport performance (Cormie, McGuigan, & Newton, 2011; Loturco, Suchomel, et al., 2019). In Paralympic disciplines, it has been shown that more powerful athletes can achieve better results not only in speed tests (Pereira et al., 2016) but also in sprint competitions (Loturco, Winckler, et al., 2015). Notably, a recent study comparing Olympic and Paralympic judokas revealed that they present similar levels of strength in half-squat and bench press (BP) exercises but that power is superior in the Olympians (Loturco, Nakamura, et al., 2017). This suggests that the enhancement in power production may be a valuable way to improve the competitiveness of Paralympians, as Olympians are usually considered to be highly specialized athletes (Boullosa, Abreu, Varela-Sanz, & Mujika, 2013; Loturco, Nakamura, et al., 2017). Even so, few studies have investigated the influence of muscle power on the functional performance of top-level wheelchair athletes.

Specifically in wheelchair basketball (WB), some authors have used indirect power measurements to assess different player classes (Ayán, Cancela, & Fernández, 2014; Cavedon, Zancanaro, & Milanese, 2015; Gil et al., 2015). Ayán et al. (2014) employed the maximal pass test (i.e., a traditional WB test that assesses the maximal passing distance using a proper technique) to evaluate the changes in "passing explosiveness" on WB players, observing that this ability does not vary significantly throughout the season. Gil et al. (2015) reported that some power parameters are positively related to the disability level, with higher WB classes (i.e., athletes with high functional scores) achieving superior performances in medicine ball-throwing. Another study on WB players showed that the maximal pass test can also be used as a performance predictor, namely the ability to score points during an official match (Cavedon et al., 2015). Although these data provide evidence about the role played by muscle power in scoring, there is still a need to better understand the influence of this physical capacity on wheelchair-based activities. One way to explore this issue is to examine the associations between power tests and parameters of WB performance, such as wheelchair acceleration (ACC) and speed. However, studies involving direct measures of muscle power and elite WB players are scarce in the literature.

Iturricastillo et al. (2018) analyzed relationships between BP "optimum power load" (OPL; load that maximizes power output) and speed-related performance in WB players of various classes, with no significant correlations shown among these variables. According to the authors, this could be related to the fact that functional tests are influenced by many factors, such as the wheelchair–user interface, muscle activity, and technique. Nevertheless, it is reasonable to consider that the heterogeneous characteristics of the sample (i.e., athletes with distinct impairments) affected the results. In addition, the use of a unique exercise (i.e., BP) may have been a factor, as wheelchair propulsion is a complex motor task (de Groot, Bos, Koopman, Hoekstra, & Vegter, 2017; Vanlandewijck, Theisen, & Daly, 2001). Therefore, it is important to examine these relationships in a more homogeneous group of subjects (e.g., players with full trunk control) and using a mixed range of exercises (BP, shoulder press [SP], and prone bench pull [PBP]). This information could help coaches to select the most appropriate exercises and loads to prescribe and develop more effective and tailored strength–power training strategies for WB athletes (Iturricastillo et al., 2018; Loturco, Suchomel, et al., 2019; Yanci et al., 2015). Hence, the aim of this study was to investigate the associations between the OPL assessed in the BP, SP, and PBP and speed-related performance in WB players with similar levels of disability.

Methods

Participants

Eleven male WB players from the Brazilian National Team (overall champion in the last South-American WB Championship; age: 32.1 ± 8.1 years; cephalic-trunk height: 85.5 ± 15.7 cm; body mass [BM]: 77.3 ± 11.3 kg) were recruited. The Brazilian National Team was the overall champion in the most recent South-American WB Championship, attesting to the high level of competitiveness of the subjects involved in this study. Athletes were classified according to the rules of the International Wheelchair Basketball Federation and presented similar functional levels (classes ≥3; "full trunk control," "International Wheelchair Basketball Federation," 2014). This inclusion criterion was adopted to obtain a more homogeneous sample in terms of functional characteristics, which certainly had a direct impact on our analyses and findings. The study was approved by the local ethics committee.

Design

Athletes were assessed during the competitive phase of the season and were familiarized with testing procedures due to the regular assessments in our facilities. Before the tests, athletes performed a standardized warm-up protocol comprising general (5 min of dynamic stretching) and specific exercises (submaximal attempts of sprints, BP, SP, and PBP). All athletes performed the tests in the following order: 20-m wheelchair sprinting speed and bar-power outputs in the BP, SP, and PBP exercises. Between each test, a 10-min interval was given to explain the procedures, adjust the equipment, and provide sufficient recovery time for the athletes.

Methodology

Sprint Velocity. Four photocell gates (Smart Speed, Fusion Sport, Brisbane, Australia) were positioned at the starting line and at 5, 10, and 20 m along the course, on an indoor court. Athletes performed two sprints, starting with the wheelchair positioned 0.5 m behind the starting line (Iturricastillo et al., 2018). A 3-min rest was allowed between attempts. The best sprint performance from the two attempts was recorded for analysis. Velocity (VEL) was calculated as the distance traveled over time and ACC as the rate of VEL change with respect to time. Both VEL and ACC were calculated using the best sprint attempt.

Bar–Power Outputs. Mean propulsive power (MPP) was measured in the BP (Loturco, Nakamura, et al., 2017) and SP (Hatfield et al., 2006), performed on a Smith machine (Hammer Strength Equipment, Rosemont, IL), and in the PBP (Loturco et al., 2018), performed using a barbell. Tests started at a load corresponding to 30% BM. A load of 5% BM was gradually added in each set until a decrement in the MPP was observed. In all attempts, athletes were required to move the bar as fast as possible, which was connected to a linear position transducer (T-Force, Dynamic Measurement System; Ergotech Consulting S.L., Murcia, Spain). The finite differentiation technique was used to calculate bar VEL and ACC. The vertical instantaneous VEL (v) was automatically detected by the system at a sample frequency of 1,000 Hz. The derived mechanical variables were calculated by the software as follows: displacement was obtained by integration of v data with respect to time; instantaneous ACC (a) was obtained from differentiation of v with respect to time; instantaneous force (F) was calculated as $F = m \times (a + g)$, where m is the moving mass (in kilograms, considering the bar weight) and g is the ACC due to gravity; instantaneous MPP resulted from the product of the applied force and bar VEL ($P = F \times v$). The MPP was calculated during the propulsive phase, defined as that portion of the concentric action during which the measured ACC is greater than ACC due to gravity (Loturco, Pereira, Abad, et al., 2017; Sanchez-Medina, Perez, & Gonzalez-Badillo, 2010). A 5-min interval was allowed between attempts. The maximum MPP value and its respective load (i.e., OPL) of each exercise was recorded and subsequently normalized by BM (in watts per kilogram).

Statistical Analyses

Data are presented as means ± *SD*. Normality of data was confirmed via the Shapiro–Wilk test. A Pearson product–moment was performed to determine relationships. Correlation coefficients were qualitatively interpreted as follows: <.1, trivial; .1–.3, small; .3–.5, moderate; .5–.7, large; .7–.9, very large; >.9 nearly perfect (Hopkins, Marshall, Batterham, & Hanin, 2009). Significance level was set as $p < .05$. All tests presented good levels of reliability (coefficient of variation < 10% and intraclass correlation coefficient > .90).

Results

Table 1 demonstrates the descriptive data of VEL and ACC over the different distances and MPP data and load in the three tested exercises. Figure 1 shows the

Table 1 Descriptive Data of Wheelchair Sprint Acceleration and Velocity Over 5, 10, and 20 m; Load and Bar-Mean Propulsive Power Output in the Three Tested Exercises

Variable		*M* ± *SD*
Acceleration (m/s^2)	0–5 m	1.56 ± 0.19
	5–10 m	0.38 ± 0.12
	10–20 m	0.27 ± 0.05
Velocity (m/s)	5 m	2.79 ± 0.17
	10 m	3.26 ± 0.26
	20 m	3.83 ± 0.31
Load (kg)	Bench press	29.5 ± 6.7
	Shoulder press	28.2 ± 4.2
	Prone bench pull	39.3 ± 8.1
Mean propulsive power (W/kg)	Bench press	6.08 ± 1.76
	Shoulder press	5.41 ± 1.48
	Prone bench pull	7.49 ± 1.93

correlations between VEL and ACC with MPP. Large to very large significant relationships were observed between VEL and ACC, and MPP in the BP ($r = .66$, .74, .77, .66, .75, and .65, for VEL 5, 10, and 20 m, and ACC 0–5, 5–10, and 10–20 m, respectively; $p < .05$), SP ($r = .60$, .67, .68, .61, .68, and .57, for VEL 5, 10, and 20 m, and ACC 0–5, 5–10, and 10–20 m, respectively; $p < .05$), and PBP ($r = .66$, .68, .72, .66, .62, and .66, for VEL 5, 10, and 20 m, and ACC 0–5, 5–10, and 10–20 m, respectively; $p < .05$) exercises.

Discussion

This study examined the relationships between bar–power production in different upper-limb exercises with speed and ACC capacities in WB players with similar functional levels. Overall, we found strong correlations among these mechanical variables, suggesting that muscle power plays an important and key role in determining the speed-related performance of elite WB players.

The presence of high positive correlations is commonplace in studies involving OPL and speed qualities (Loturco, Pereira, et al., 2015; Loturco, Winckler, et al., 2015). As previously mentioned, Olympic and Paralympic sprinters able to generate more power at the OPL are also able to perform better in track and field competitions (Loturco, Pereira, et al., 2015; Loturco, Winckler, et al., 2015). These results are similar to our findings, even considering the marked differences between "traditional" and wheelchair-based sprint VEL assessments. Still in this context, it was reported that a more heterogeneous sample of WB players (athletes with different functional levels) present a nearly perfect inverse load–VEL relationship for the BP (i.e., as intensity increases, the movement speed decreases in a similar proportion, Iturricastillo et al., 2018), a phenomenon which

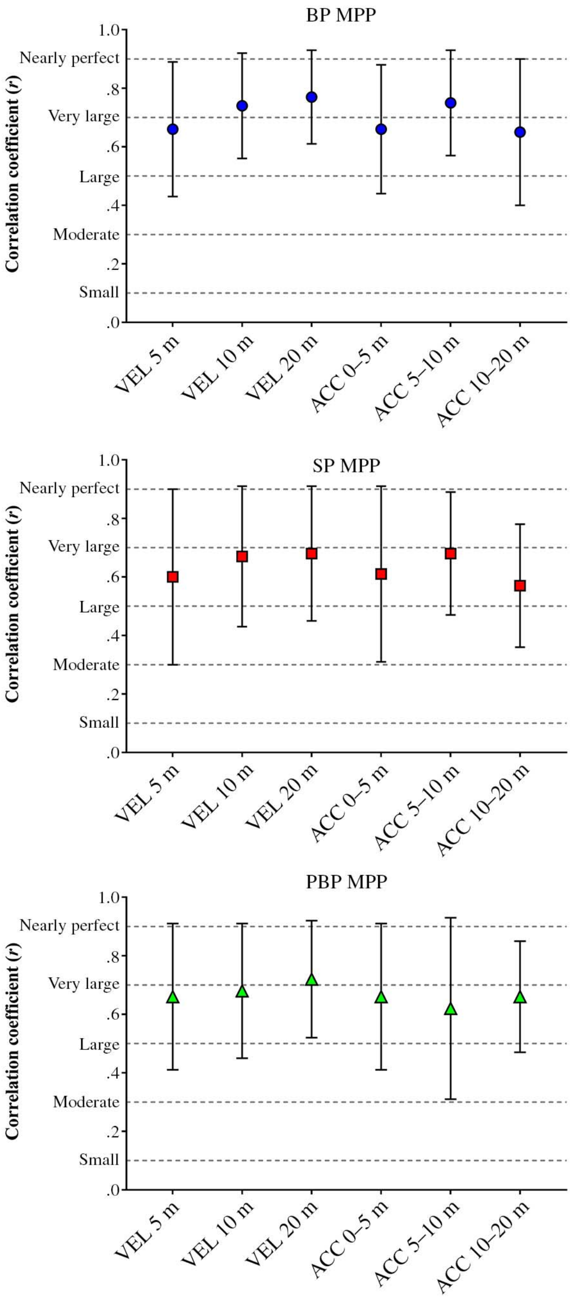

Figure 1 — Correlation coefficients (r) between sprint velocity (VEL) and acceleration (ACC) in the different distances tested with the mean propulsive power (MPP) in the bench press (BP), shoulder press (SP), and prone bench pull (PBP) exercises. Error bars represent 90% confidence limits. Verbal descriptors correspond to the qualitative thresholds for the correlation coefficients.

has also been observed in other populations (including Paralympic powerlifters; Loturco, Kobal, et al., 2017; Loturco, Pereira, et al., 2019; Sanchez-Medina et al., 2010). This indicates that the load–VEL relationship is not affected by the impairment level in WB players, allowing practitioners to perform accurate strength–power measurements in this Paralympic group. Based on these findings, coaches and researchers are encouraged to assess power production in WB athletes, not only to evaluate their functional capacity but also to define a loading range (i.e., OPL) which potentially leads to positive adaptations in their speed-related abilities, as previously demonstrated (Dello Iacono & Seitz, 2018; Ribeiro et al., 2020). These effects should be confirmed by longitudinal interventions.

Wheelchair propulsion is a strenuous, continuous, and relatively inefficient form of locomotion (de Groot et al., 2017; Lenton, Fowler, van der Woude, & Goosey-Tolfrey, 2008; Sauret, Vaslin, Dabonneville, & Cid, 2009); therefore, it is complex to accurately infer why the BP, SP, and PBP power outputs are strongly related to wheelchair speed. Nonetheless, the associations between OPL and different measures of performance, such as punching impact, change of direction speed, and jumping height have been extensively described in the literature (Loturco et al., 2016; Loturco, Pereira, Moraes, et al., 2017; Loturco, Suchomel, et al., 2019). A plausible explanation for this observation is that the OPL is capable of simultaneously optimizing the force and VEL applied to the barbell, better reflecting the abilities required in many sport-specific actions, where athletes are usually required to move substantial amounts of loads at high speeds (e.g., the BM during sprinting, Loturco, Suchomel, et al., 2019). In the specific case of wheelchair maneuvers, to achieve higher velocities, WB players need to execute a sequential series of flexion and extension movements with the upper limbs, with a high predominance of shoulder and elbow joints (Collinger et al., 2008; Vanlandewijck et al., 2001). Several studies have already highlighted the biomechanical complexity of wheelchair-based drills, which appears to be even more increased during the frequent ACCs performed during a WB game (Seron, Oliveira de Carvalho, & Greguol, 2019; Vanlandewijck et al., 2001; Yanci et al., 2015). Interestingly, all correlations reported here are large to very large; independent of the exercise (BP, SP, and PBP); distance (5, 10, and 20 m); or variable (VEL or ACC) analyzed. Thus, despite the key differences in kinematics and kinetics between upper body push (BP and SP) and pull (PBP) movements, it can be suggested that these three exercises, acting at distinct points of the propulsion cycle, might have a potential impact on enhancing wheelchair sprint performance. With this in mind, WB players are advised to include these exercises in their training routines, to maximize their propulsion efficiency, especially during high ACCs from a standstill, which is considered one of the most important features in WB (Vanlandewijck et al., 2001).

This investigation is limited by its cross-sectional design, thus precluding determination of causality. In addition, the small sample size and sample characteristics (i.e., male players with high functional scores and similar functional levels) hamper the extrapolation of our findings to other WB classes and female players. However, this is the first study to report the relationships existing between power and speed-related performance in WB players with similar functional levels, opening a new research field for future experiments involving wheelchair athletes.

Practical Applications

Wheelchair propulsion has been described as a very complex motor task, which relies on a series of physiological, neuromechanical, and technical aspects (Vanlandewijck et al., 2001). Despite this multifaceted nature, our data demonstrate that WB players who produce more power in certain strength–power exercises are also able to accelerate faster and achieve higher speeds over short distances (5, 10, and 20 m). Considering the crucial importance of high and successive ACCs during game-related maneuvers, sport scientists are strongly recommended to assess the OPL in BP, SP, and PBP in WB players. From an applied standpoint, the close correlations observed here might suggest that variations in maximum power output are directly related to meaningful changes in wheelchair sprinting performance. Moreover, Paralympic coaches can use this load range as an alternative way to develop strength–power qualities in WB players. Although these responses remain to be explored in prospective studies, there is a compelling body of evidence confirming the effectiveness of OPL in different athletic populations (Dello Iacono & Seitz, 2018; Freitas, Calleja-Gonzalez, Carlos-Vivas, Marin-Cascales, & Alcaraz, 2019; Ribeiro et al., 2020). Future studies should be conducted to fully describe these effects in elite wheelchair athletes.

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