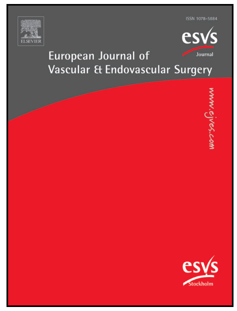
Journal Pre-proof



Sit-to-stand muscle power is related to functional performance at baseline and after supervised exercise training in patients with lower extremity peripheral artery disease

Stefano Lanzi, Anina Pousaz, Luca Calanca, Lucia Mazzolai

PII: S1078-5884(22)00871-1

DOI: https://doi.org/10.1016/j.ejvs.2022.12.029

Reference: YEJVS 8624

To appear in: *European Journal of Vascular & Endovascular Surgery*

Received Date: 24 March 2022

Revised Date: 1 December 2022

Accepted Date: 24 December 2022

Title page - original article

Sit-to-stand muscle power is related to functional performance at baseline and after supervised exercise training in patients with lower extremity peripheral artery disease

Stefano Lanzi* **(0000-0003-1089-6309)**, Anina Pousaz, Luca Calanca, Lucia Mazzolai

Division of Angiology, Heart and Vessel Department, Lausanne University Hospital, Switzerland

Running title: Leg muscle power, functional performance and PAD

Word count, abstract: 300

Word count, WTPA: 100

Word count, text body: 2 964

Number of Tables: 4

Number of Supplementary Tables: 5

Number of Figures: 0

***Corresponding author**

Stefano Lanzi, PhD

Division of Angiology, Heart and Vessel Department

Ch. de Mont-Paisible 18-1011 Lausanne, Switzerland

Tél. +41 079 556 49 11

stefano.lanzi@chuv.ch

https://orcid.org/0000-0003-1089-6309

@ste_lanzi

Abstract

Objective. Patients with peripheral artery disease (PAD) have decreased muscle power contributing to functional limitations. The sit-to-stand (STS) is a validated test to assess muscle power in older individuals; however, it has never been investigated in patients with PAD. We evaluated the relationship between STS muscle power and common disease-related outcomes at baseline and following supervised exercise training (SET) in patients with PAD.

Design and Methods. This observational study investigated patients with Fontaine stage II. Before and after SET, maximal treadmill walking distance (MWD), functional performance tests (six-min walk, STS, stair climbing, habitual gait speed) and quality of life (SF-36 questionnaire) were assessed. Relative ($W \cdot kg^{-1}$) STS muscle power was calculated using a validated equation. Multiple regressions models were used.

Results. Ninety-five patients with PAD were included (63.1±12.1 years, 67% male). Relative STS muscle power [before: 2.7 $W \cdot kg^{-1}$ (95%CI 2.5–2.9); after: 3.3 (95%CI 3.1–3.6)], MWD [before: 367.0 m (95%IC 302.4–431.5); after: 598.4 (95%IC 515.6–681.3)], six-min walking distance [before: 418.3 m (95%IC 399.4–437.2); after: 468.8 (95%IC 452.7–484.9)], stair climbing performance [before: 6.8 s (95%IC 6.2–7.4); after: 5.3 (95%IC 4.9–5.7)], habitual gait speed [before: 1.10 $m \cdot s^{-1}$ (95%IC 1.05–1.14); after: 1.18 (95%IC 1.14–1.22)] significantly increased following SET (P≤.001). Similarly, physical [before: 31.4 (95%IC 29.4–33.3); after: 35.8 (95%IC 33.9–37.7)] and mental [before: 39.5 (95%IC 37.0–42.0); after: 43.1 (95%IC 40.9–45.4)] component summaries of the SF-36 significantly increased (P≤.001). Greater relative STS muscle power at baseline was significantly related to greater baseline treadmill (β≤.380; P≤.002) and functional (β≤.597; P≤.001) performance, and quality of life (β≤.291; P≤.050). Larger increases in relative STS muscle power following SET were associated with greater improvements in functional performance (β≤.419; P≤.009).

Conclusion. STS test is a valid clinical tool to monitor overall functional status in patients with symptomatic PAD.

Keywords

Rehabilitation, walking performance, physical activity, quality of life

Journal Pre-proof

What does this study add to the existing literature, and how will it influence future clinical practice?

Patients with PAD have decreased muscle power contributing to functional limitations. The instruments to assess muscle power are usually expensive. The sit-to-stand (STS) is an easy clinical test to assess muscle power in older individuals. This observational study investigated the relationships between baseline STS muscle power and baseline treadmill and functional performance, and quality of life in patients with symptomatic PAD. These relationships were also investigated following supervised exercise training program. The results showed that STS muscle power was related to common disease-related outcomes before and after training, highlighting its clinical value to monitor overall functional status in these individuals.

Introduction

Lower extremity peripheral artery disease (PAD) is an atherosclerotic vascular disease leading to narrowing and/or occlusion of the arteries supplying the legs [1]. PAD has a great impact on walking capacities, physical function, and quality of life [1-3]. Supervised exercise therapy (SET) is a first-line therapeutic option for the management of patients with symptomatic PAD [1,4-6]. SET is effective in improving treadmill performance and quality of life [7,8]. Changes in functional performance (the rate at which an individual is able to perform a daily functional task) following SET have been poorly investigated [9]. Patients with PAD have decreased type II fiber cross-sectional area, calf skeletal muscle fiber denervation, and decreased maximal lower limb muscle strength compared to controls [10-12]. Further strength deficits occur with the onset of claudication pain [13]. These skeletal muscle changes are associated with functional impairment [10,14]. Although less investigated, leg muscle power is also impaired in patients with PAD compared to controls [15]. These results are important since muscle power has been demonstrated to be a stronger predictor of functional limitations than muscle strength in older individuals [16]. Moreover, muscle power declines with age at a faster rate than muscle strength and size [17]. In patients with PAD, reduced leg muscle power contributes to low functional performance [15]. The main difference between muscle strength and power resides in the velocity factor. Indeed, while muscle strength is the ability to overcome resistance, muscle power is the ability to overcome resistance in the shortest period of time ("as fast as possible"). The stronger relationship observed between muscle power and functional performance may be linked to the velocity factor in generating force that is needed to perform the daily life tasks.

The instruments to assess leg muscle power are expensive, requiring technical support. The sit-to-stand (STS) test is an easy and inexpensive tool to assess the time required to stand and sit as fast as possible five times or the number of repetitions in a given period. Recently, a simple equation to assess relative ($W \cdot kg^{-1}$) STS muscle power from STS time performance has been validated [18]. The expression of relative muscle power is judicious since during most daily life activities, people must carry their body mass. STS performance and relative STS muscle power were also related to quality of life [18].

To our knowledge, the associations between STS performance and relative STS muscle power, and walking performance, functional performance, and quality of life have not been investigated in patients with PAD. The first aim of this study was to evaluate the relationships between baseline STS performance and relative STS muscle power, and baseline treadmill performance, functional performance, and quality of life in patients with symptomatic PAD. The second aim was to evaluate the relationships between SET-induced changes in STS performance and relative STS muscle power, and changes in treadmill performance, functional performance, and quality of life.

Methods

Participants

Patients with lower extremity PAD were investigated. Patients were recruited from the Division of Angiology at the Lausanne University Hospital, Switzerland. Patients were included in the Angiofit study, an observational cohort of Fontaine stage II men and women with symptomatic PAD participating in the 3-month SET program [19-21]. The inclusion criteria of the SET program were stable (≥6 months) uni- or bilateral lower limb claudication and a resting ankle-brachial index (ABI) ⩽0.9 or an ABI decreased postexercise by >20% [1]. The exclusion criteria were the inability to participate in the SET program three times per week and critical limb ischemia (assessed by a vascular physician before SET), and a cardiac contraindication to exercise (assessed by a cardiologist before SET). Compared to previous observations [19-23], we included all the patients having an assessment of treadmill performance, functional performance (six-minute walk, sit-to-stand, stair climbing, and habitual gait speed), and quality of life. Patients provided written, voluntary informed consent. The study was approved by the local ethics committee and was conducted according to the Declaration of Helsinki.

Experimental design

The experimental design was planned as follows: (i) the pre-SET vascular medicine examination and treadmill test; (ii) the pre-SET functional assessment; (iii) the 3-month SET program; (iv) the post-SET functional assessment; and (v) the post-SET vascular medicine examination and treadmill test. The SET program started 1-2 weeks following the vascular examination, and 1-3 days after the pre-SET functional assessment. The functional assessments were performed on the same day and patients allowed to rest between measures. The following order was always used: six-minute walk test, stair climbing test, habitual gait-speed, and STS test. The patients were asked to rest well prior to the tests. Following SET, all the assessments were performed at least 48 h after the last training session.

Medical history, physical characteristics, and vascular examination

The medical history and physical examination were assessed. Body mass index (BMI), cardiovascular risk factors (tobacco use, dyslipidemia, type 2 diabetes mellitus, hypertension) and ongoing treatment were recorded. Resting ABI and toe-brachial index (TBI) were measured in the supine position [1].

Treadmill performance

Pain-free and maximal walking distances (PFWD and MWD) were determined during a constant-speed treadmill test [6,24]. This test was performed at 3.2 $km \cdot h^{-1}$ with a 12% slope. However, the speed was adapted depending on patients' safety and feasibility, and the same parameters were used before and after SET.

Functional performance

The six-minute walking distance (6MWD) was determined during a six-minute walk test [25]. Patients were asked to walk as far as possible within six minutes in an indoor 50 m corridor. During the test, patients were allowed to stop and lean against the wall. If so, they were instructed to resume walking as soon as they could.

The stair climbing performance was assessed during a stair climbing test [26]. After the cue "*ready, set, go!*" patients were asked to climb a 12-stair flight as quickly as possible. The height of each stair was 17 cm. Patients were allowed to hold the handrail during the test. The stopwatch was stopped when both of the patient's feet reached the 12th stair, and the time was recorded to the nearest 0.01 s. This test was performed twice, and the average value were considered for analysis [26].

Habitual gait speed was assessed over a 4-meter walk. After the cue "*ready, set, go!*" patients were asked to cover 4 meters at their habitual walking speed. The time was recorded with a stopwatch to the nearest 0.01 s. This test was performed twice, and the best time of two attempts was chosen for analysis [27].

The STS test was performed on a standardized armless chair (0.45 m height) [18]. Patients familiarized with the STS test performed one set of five repetitions, followed by a brief resting period. After the cue "*ready, set, go!*" the patients started to perform STS repetitions. From a sitting position, arms across the chest, patients were asked to stand five times as fast as they could. The stopwatch was stopped immediately after the fifth repetition, and the time was recorded to the nearest 0.01 s. Verbal encouragement was given. Relative ($W \cdot kg^{-1}$) STS muscle power was calculated as follows [18]:

$$Relative\ STS\ mean\ power = \frac{0.9\ x\ g\ x\ [Height\ x\ 0.5 - Chair\ Height]}{Five\ STS\ Time\ x\ 0.1}$$

where height and chair height are in meters, time is in seconds, and *g* is gravity.

Quality of life. The Medical Outcomes Study Short-Form 36 (SF-36) was used to evaluate physical and mental health-related quality of life [28]. Physical component and mental component summaries (PCS and MCS) were computed using weighting coefficients [29]. The Walking Impairment Questionnaire (WIQ) was used to evaluate self-perceived walking limitations [30].

SET program

The program consisted of three weekly training sessions combining two different exercise modalities, strengthening of the lower limbs (once weekly) and Nordic walking (twice weekly), for a 3-month duration. Each training session lasted up to 60 min. A detailed description has been widely reported elsewhere [19-23]. All the training sessions were supervised by a clinical exercise physiologist. In accordance with the guidelines [5,6,31], the claudication pain intensity during the training sessions was set at moderate-to-severe on the claudication scale. The rate of perceived exertion (RPE) on Borg's scale was used to monitor the exercise training intensity. The RPE was mainly set between low (9-11 on Borg's scale) and moderate (12-13 on Borg's scale) intensity. If tolerated, patients also performed at moderate-to-vigorous intensity (14-16 on Borg's scale).

Compliance with the SET program was defined by the percentage of attended sessions out of the total number of sessions.

Statistical analysis

Based on previous data [22], a sample size of 55 patients (power 95%; α=5%) was needed to detect significant differences in walking performance following SET. Data were analyzed with an intention-to-treat approach. This increases the statistical power and avoids potential selection bias. The first step was to perform multiple imputations for patients who did not complete the training program. Multiple imputations for missing data were performed to obtain twenty imputed datasets. We used a fully conditional specification with predictive mean matching to simultaneously impute all variables [32]. Baseline anthropometric characteristics, cardiovascular risk factors, vascular parameters, and baseline outcome values were used to impute the datasets.

Thereafter, the normality of the distribution was statistically (Kolmogorov-Smirnov) and visually assessed. Log-transformation was performed for nonparametric values. The influence of covariates (age and gender) on the different outcomes was assessed a priori with simple linear regressions. Comparisons between before and after SET were assessed using repeated measures ANOVA adjusted for covariates when appropriate. To assess whether baseline or changes (deltas: post minus pre values) in STS performance and relative STS muscle power were related to baseline or changes in treadmill performance, functional performance, and quality of life, simple and multiple regression models were computed. Age and gender were added to the regression models as covariates when appropriate. Multicollinearity was assessed to confirm that the independent variables were not highly correlated with each other. This assumption was tested using variance inflation factor values. These analyses were also performed according to the stenosis localisation (aorto-iliac (n=29) and femoral-distal (n=66) group). The level of significance was set at $P \leq .05$.

SPSS 27 software (IBM Corporation, Armonk, NY) was used to perform all statistical analyses.

Results

Participants

Ninety-five patients with symptomatic PAD were included. Of those, twenty-two patients (23%) did not complete the SET program. The reasons for stopping SET were worsening of symptoms of claudication (n=4), endovascular revascularization required during SET (n=4), schedule conflict with work (n=2), feeling anxious about participating during the pandemic period (n=3) and other reasons not related to SET (n=9). The attendance rate for SET was 79.9%.

STS performance and muscle power, treadmill and functional performance, and quality of life

STS performance and relative STS muscle power significantly increased following SET (Table 2). Both obstructive aorto-iliac and femoral-distal groups significantly improved STS performance and relative STS muscle power following SET, with no significant difference between groups (Supplementary Table S1). PFWD, MWD, 6MWD, stair climbing performance, habitual gait speed, PCS, MCS, WIQ distance, speed, and stair climbing scores significantly improved after SET (Table 2). The *a posteriori* statistical power was ≥82%, except for the WIQ distance (68%).

Relationships between baseline STS performance and muscle power, and baseline treadmill and functional performance, and quality of life

Greater STS performance (lower STS time) and relative STS muscle power at baseline were significantly related to greater baseline PFWD, MWD, 6MWD, stair climbing performance, habitual walking speed, PCS, WIQ distance, WIQ speed, and WIQ stair climbing scores (Table 3). There was no significant relationship between baseline STS performance and relative STS muscle power, and baseline MCS (Table 3). Similar results were found when patients were analyzed according to the stenosis localisation (Supplementary Table S2).

Relationships between STS performance and muscle power changes, and changes in treadmill and functional performance, and quality of life

Larger increases in STS performance (lower STS time) and relative STS muscle power following SET were associated with greater improvements in 6MWD, stair climbing performance, and habitual gait speed (Table 4). There was no significant relationship between changes in STS performance and relative STS muscle power, and changes in treadmill performance and quality of life following SET (Table 4). Similar results were found when patients were analyzed according to the stenosis localisation (Supplementary Table S3).

Physical characteristics and vascular parameters

BMI [before: 26.9 $kg{\cdot}m^{-2}$ (95%IC 25.8-28.0); after: 27.4 (95%IC 26.4-28.4), P=.10], ABI [before: 0.80 (95%IC 0.75-0.84); after: 0.79 (95%IC 0.76-0.82), P=.62] and TBI [before: 0.61 (95%IC 0.57-0.65); after: 0.60 (95%IC 0.57-0.63), P=.83] were unchanged following SET.

Discussion

The main findings showed that 1) baseline STS performance and relative STS muscle power were related to baseline treadmill and functional performance, and quality of life; 2) larger increases in STS performance and relative STS muscle power following SET were associated with greater improvements in functional performance only. There was no significant relationship between changes in STS performance and relative STS muscle power, and changes in treadmill performance and quality of life.

The present study showed that SET improved functional performance assessed by several functional tests. As previously reported [9], performance-based tests of physical function are understudied following SET in patients with PAD. Our results showed that SET improves STS performance, relative STS muscle power, stair climbing performance and habitual gait speed, which are all representative of functional daily life activities. The mean increase in habitual walking speed was +0.08 $m \cdot s^{-1}$, which is similar to the minimal clinically important difference for substantial change in walking speed following SET in patients with PAD [33]. These results highlight the importance of exercise therapy to improve functional performance. This is clinically important since improved functional mobility may predict functional independence in these individuals [34].

The results presented herein showed that greater STS performance and relative STS muscle power at baseline were significantly related to greater baseline treadmill (PFWD, MWD) and overground (6MWD) performance, stair climbing performance, habitual walking speed, physical health-related quality of life, and WIQ scores. In contrast, mental health-related quality of life was not related to baseline STS performance or relative STS muscle power. Taken together, these results are in line with previous observations showing that muscle power is linked to functional performance in patients with PAD [15]. It is likely that muscle power is a more important determinant of physical rather than mental health-related quality of life, which is mainly composed of self-reported vitality, social and emotional functioning [18]. Our results also showed that larger increases in STS performance and relative STS muscle power following SET were associated with greater improvements in functional performance only. Indeed, changes in STS performance and relative STS muscle power after SET were related to changes in overground walking and stair climbing performance, and habitual gait speed. Since it has been shown that improved walking performance correlates with lower limb strength gain following resistance training in patients with PAD [35], the results of the present investigation further extend these associations on leg muscle power. Although the mechanisms underlying the effects of muscle power gain on functional performance remain to be clearly determined [36], it is possible that better muscle fibre recruitment, which may also induce a reduction in the energy cost during walking, may be mainly implicated [35,36]. In contrast, our results showed no significant relationship between changes in STS performance and relative STS muscle power, and changes in treadmill performance and quality of life. The lack of significance between muscle power and treadmill performance may be directly linked to characteristics of the test. Indeed, relative to the six-min walk, the maximal treadmill test is less representative of daily life walking and submaximal daily life activities [37]. Therefore, since muscle power has been found to be a strong predictor of functional abilities [16], it is likely that better associations were found with more functional assessments of performance. Finally, improvement in muscle power following a 3-month SET may occur before self-perception of greater improvements in quality of life. It is likely that longer training programs may induce better associations between muscle power and self-perceived quality of life. Further studies are needed to better assess this speculation.

These results feature important clinical implications. First, since larger increases in muscle power following SET were associated with greater improvements in functional performance, further investigations are needed regarding the specific effects of high-velocity power-oriented resistance training on functional status in patients with PAD. Indeed, previous meta-analyses showed that this type of training induces better improvements in muscle power and functional performance than traditional (slow-velocity) strength training in older individuals [38-40]. The explosive (high-velocity) movements performed during the power-oriented resistance training may be more effective in improving daily life functional performance, especially in activities where intense and rapid movements are essential, such as counteracting a forward fall, climbing steps, brisk walking, or crossing the road. Second, because of its easy administration, the STS test should be used to monitor the training response following and during the exercise rehabilitation programs. This may allow to investigate the time-course evolution of the overall physical function and, subsequently, to improve the training guidance. This is in line with previous validated tools aiming to improve monitoring and training individualization in these individuals [41].

The first limitation of this study was that missing data were replaced using multiple imputations. However, the results did not substantially change when analyses were performed without multiple imputations (Supplementary Table S4 and S5). In addition, since the sample size was small, this may improve the statistical power. Second, this study lacks of a control group. Patients participated in our clinical SET program and were recruited during routine vascular visits. For ethical considerations, all patients willing to participate in SET must be included. Third, patients had a moderate-high walking performance and results may not be generalized to patients with more severe PAD.

In conclusion, these results suggest that STS test may provide a practical and easy clinical tool to monitor overall functional status before and after exercise interventions in patients with symptomatic PAD.

Acknowledgements

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interest

None.

References

1. Aboyans V, Ricco JB, Bartelink MEL, Bjorck M, Brodmann M, Cohnert T*, et al.* Editor's Choice - 2017 ESC Guidelines on the Diagnosis and Treatment of Peripheral Arterial Diseases, in collaboration with the European Society for Vascular Surgery (ESVS). *Eur J Vasc Endovasc Surg* 2018;55:305-368.
2. Liles DR, Kallen MA, Petersen LA, Bush RL. Quality of life and peripheral arterial disease. *J Surg Res* 2006;136:294-301.
3. McDermott MM, Liu K, Greenland P, Guralnik JM, Criqui MH, Chan C*, et al.* Functional decline in peripheral arterial disease: associations with the ankle brachial index and leg symptoms. *JAMA* 2004;292:453-461.
4. Frank U, Nikol S, Belch J. 5 Conservative treatment for PAD - Risk factor management. *Vasa* 2019;48:1-12.
5. Harwood A, Pymer S, Ingle L, Doherty P, Chetter I, Parmenter B*, et al.* Exercise training for intermittent claudication: a narrative review and summary of guidelines for practitioners. *BMJ Open Sport & Exercise Medicine* 2020;6:e000897.
6. Treat-Jacobson D, McDermott MM, Bronas UG, Campia U, Collins TC, Criqui MH*, et al.* Optimal Exercise Programs for Patients With Peripheral Artery Disease: A Scientific Statement From the American Heart Association. *Circulation* 2019;139:e10-e33.
7. Lane R, Harwood A, Watson L, Leng GC. Exercise for intermittent claudication. *Cochrane Database Syst Rev* 2017;12:CD000990.
8. Parmenter BJ, Dieberg G, Smart NA. Exercise training for management of peripheral arterial disease: a systematic review and meta-analysis. *Sports Med* 2015;45:231-244.

9. Parmenter BJ, Raymond J, Fiatarone Singh MA. The effect of exercise on fitness and performance-based tests of function in intermittent claudication: a systematic review. *Sports Med* 2013;43:513-524.

10. McDermott MM, Criqui MH, Greenland P, Guralnik JM, Liu K, Pearce WH*, et al.* Leg strength in peripheral arterial disease: associations with disease severity and lower-extremity performance. *J Vasc Surg* 2004;39:523-530.

11. McDermott MM, Hoff F, Ferrucci L, Pearce WH, Guralnik JM, Tian L*, et al.* Lower extremity ischemia, calf skeletal muscle characteristics, and functional impairment in peripheral arterial disease. *J Am Geriatr Soc* 2007;55:400-406.

12. Regensteiner JG, Wolfel EE, Brass EP, Carry MR, Ringel SP, Hargarten ME*, et al.* Chronic changes in skeletal muscle histology and function in peripheral arterial disease. *Circulation* 1993;87:413-421.

13. Schieber MN, Hasenkamp RM, Pipinos, II, Johanning JM, Stergiou N, DeSpiegelaere HK*, et al.* Muscle strength and control characteristics are altered by peripheral artery disease. *J Vasc Surg* 2017;66:178-186 e12.

14. McDermott MM, Tian L, Ferrucci L, Liu K, Guralnik JM, Liao Y*, et al.* Associations between lower extremity ischemia, upper and lower extremity strength, and functional impairment with peripheral arterial disease. *J Am Geriatr Soc* 2008;56:724-729.

15. McDermott MM, Guralnik JM, Albay M, Bandinelli S, Miniati B, Ferrucci L. Impairments of muscles and nerves associated with peripheral arterial disease and their relationship with lower extremity functioning: the InCHIANTI Study. *J Am Geriatr Soc* 2004;52:405-410.

16. Bean JF, Leveille SG, Kiely DK, Bandinelli S, Guralnik JM, Ferrucci L. A comparison of leg power and leg strength within the InCHIANTI study: which influences mobility more? *J Gerontol A Biol Sci Med Sci* 2003;58:728-733.

17. Reid KF, Pasha E, Doros G, Clark DJ, Patten C, Phillips EM*, et al.* Longitudinal decline of lower extremity muscle power in healthy and mobility-limited older adults: influence of muscle mass, strength, composition, neuromuscular activation and single fiber contractile properties. *Eur J Appl Physiol* 2014;114:29-39.

18. Alcazar J, Losa-Reyna J, Rodriguez-Lopez C, Alfaro-Acha A, Rodriguez-Manas L, Ara I*, et al.* The sit-to-stand muscle power test: An easy, inexpensive and portable procedure to assess muscle power in older people. *Exp Gerontol* 2018;112:38-43.

19. Lanzi S, Boichat J, Calanca L, Aubertin P, Malatesta D, Mazzolai L. Gait changes after supervised exercise training in patients with symptomatic lower extremity peripheral artery disease. *Vasc Med* 2021;26:259-266.

20. Lanzi S, Boichat J, Calanca L, Mazzolai L, Malatesta D. Supervised Exercise Training Improves 6 min Walking Distance and Modifies Gait Pattern during Pain-Free Walking Condition in Patients with Symptomatic Lower Extremity Peripheral Artery Disease. *Sensors (Basel)* 2021;21:7989.

21. Lanzi S, Calanca L, Berchtold A, Mazzolai L. Improvement in 6-Minute Walking Distance after Supervised Exercise Training Is Related to Changes in Quality of Life in Patients with Lower Extremity Peripheral Artery Disease. *J Clin Med* 2021;10:3330.

22. Calanca L, Lanzi S, Ney B, Berchtold A, Mazzolai L. Multimodal Supervised Exercise Significantly Improves Walking Performances Without Changing

Hemodynamic Parameters in Patients With Symptomatic Lower Extremity Peripheral Artery Disease. *Vasc Endovascular Surg* 2020;54:605-611.

23. Ney B, Lanzi S, Calanca L, Mazzolai L. Multimodal Supervised Exercise Training Is Effective in Improving Long Term Walking Performance in Patients with Symptomatic Lower Extremity Peripheral Artery Disease. 2021;10:2057.
24. Hiatt WR, Hirsch AT, Regensteiner JG, Brass EP. Clinical trials for claudication. Assessment of exercise performance, functional status, and clinical end points. Vascular Clinical Trialists. *Circulation* 1995;92:614-621.
25. ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories. ATS statement: guidelines for the six-minute walk test. *Am J Respir Crit Care Med* 2002;166:111-117.
26. Bean JF, Kiely DK, LaRose S, Alian J, Frontera WR. Is stair climb power a clinically relevant measure of leg power impairments in at-risk older adults? *Arch Phys Med Rehabil* 2007;88:604-609.
27. Guralnik JM, Simonsick EM, Ferrucci L, Glynn RJ, Berkman LF, Blazer DG*, et al.* A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. *J Gerontol* 1994;49:M85-94.
28. Ware JE, Jr., Sherbourne CD. The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. *Med Care* 1992;30:473-483.
29. Roser K, Mader L, Baenziger J, Sommer G, Kuehni CE, Michel G. Health-related quality of life in Switzerland: normative data for the SF-36v2 questionnaire. *Qual Life Res* 2019;28:1963-1977.

30. Coyne KS, Margolis MK, Gilchrist KA, Grandy SP, Hiatt WR, Ratchford A*, et al.* Evaluating effects of method of administration on Walking Impairment Questionnaire. *J Vasc Surg* 2003;38:296-304.

31. Treat-Jacobson D, McDermott MM, Beckman JA, Burt MA, Creager MA, Ehrman JK*, et al.* Implementation of Supervised Exercise Therapy for Patients With Symptomatic Peripheral Artery Disease: A Science Advisory From the American Heart Association. *Circulation* 2019;140:e700-e710.

32. van Buuren S. Multiple imputation of discrete and continuous data by fully conditional specification. *Stat Methods Med Res* 2007;16:219-242.

33. Rahman H, Pipinos, II, Johanning JM, Casale G, Williams MA, Thompson JR*, et al.* Claudicating patients with peripheral artery disease have meaningful improvement in walking speed after supervised exercise therapy. *J Vasc Surg* 2021;74:1987-1995.

34. McDermott MM, Liu K, Ferrucci L, Tian L, Guralnik JM, Liao Y*, et al.* Decline in functional performance predicts later increased mobility loss and mortality in peripheral arterial disease. *J Am Coll Cardiol* 2011;57:962-970.

35. Parmenter BJ, Mavros Y, Ritti Dias R, King S, Fiatarone Singh M. Resistance training as a treatment for older persons with peripheral artery disease: a systematic review and meta-analysis. *Br J Sports Med* 2019;54:452-461.

36. McDermott MM, Dayanidhi S, Kosmac K, Saini S, Slysz J, Leeuwenburgh C*, et al.* Walking Exercise Therapy Effects on Lower Extremity Skeletal Muscle in Peripheral Artery Disease. *Circ Res* 2021;128:1851-1867.

37. McDermott MM, Guralnik JM, Criqui MH, Liu K, Kibbe MR, Ferrucci L. Six-minute walk is a better outcome measure than treadmill walking tests in therapeutic trials of patients with peripheral artery disease. *Circulation* 2014;130:61-68.

38. Balachandran AT, Steele J, Angielczyk D, Belio M, Schoenfeld BJ, Quiles N, *et al.* Comparison of Power Training vs Traditional Strength Training on Physical Function in Older Adults: A Systematic Review and Meta-analysis. *JAMA Netw Open* 2022;5:e2211623.

39. Byrne C, Faure C, Keene DJ, Lamb SE. Ageing, Muscle Power and Physical Function: A Systematic Review and Implications for Pragmatic Training Interventions. *Sports Med* 2016;46:1311-1332.

40. Tschopp M, Sattelmayer MK, Hilfiker R. Is power training or conventional resistance training better for function in elderly persons? A meta-analysis. *Age Ageing* 2011;40:549-556.

41. Manfredini F, Conconi F, Malagoni AM, Manfredini R, Mascoli F, Liboni A, *et al.* Speed rather than distance: a novel graded treadmill test to assess claudication. *Eur J Vasc Endovasc Surg* 2004;28:303-309.

Table 1. Baseline characteristics of 95 patients with symptomatic peripheral artery disease (PAD)

Variables	**Patients with symptomatic PAD (n = 95)**
Women	31 (33)
Age - y	63.1 ± 12.1
BMI - kg·m^{-2}	26.9 ± 5.3
Ankle-brachial Index	0.80 ± 0.20
Toe-brachial Index	0.61 ± 0.20
Cardio-vascular risks factors	
Hypercholesterolemia	78 (82)
Hypertension	67 (71)
Smoking (current)	49 (52)
Smoking (former)	37 (39)
Smoking (never)	9 (9)
Family history of CVD	34 (36)
Type 1 diabetes	1 (1)
Type 2 diabetes mellitus	32 (34)
Prior arterial revascularisation	43 (45)
Stenosis localisation	
Aorto-iliac	29 (30)
Femoral-distal	66 (70)
Ongoing treatment	
Antiplatelet	89 (94)
Antihypertensive	69 (73)
Lipid lowering	74 (78)
Anticoagulant	10 (11)
Antidiabetic	31 (33)

Data are presented as mean ± standard deviation or *n* (%). BMI = body mass index; CVD = cardio-vascular disease.

Table 2. Sit-to-stand (STS) performance and muscle power, treadmill performance, functional performance, and quality of life before and after the supervised exercise training (SET) of 95 patients with symptomatic peripheral artery disease (PAD)

Variable	Before SET (n = 95)	After SET (n = 95)	*P* value
STS performance and muscle power			
STS – s	15.0 (12.9 – 17.1)	12.2 (10.4 – 14.1)	≤.001
Relative STS power – $W{\cdot}kg^{-1}$	2.7 (2.5 – 2.9)	3.3 (3.1 – 3.6)	≤.001
Treadmill performance			
Pain-free walking distance – m	109.0 (81.4 – 136.6)	152.8 (133.0 – 172.6)	≤.001
Maximal walking distance – m	367.0 (302.4 – 431.5)	598.4 (515.6 – 681.3)	≤.001
Functional performance			
Six-minute walking distance * – m	418.3 (399.4 – 437.2)	468.8 (452.7 – 484.9)	≤.001
Stair climbing test * - s	6.8 (6.2 – 7.4)	5.3 (4.9 – 5.7)	≤.001
Habitual gait speed – $m{\cdot}s^{-1}$	1.10 (1.05 – 1.14)	1.18 (1.14 – 1.22)	≤.001
Quality of life			
Physical component score * - %	31.4 (29.4 – 33.3)	35.8 (33.9 – 37.7)	≤.001
Mental component score - %	39.5 (37.0 – 42.0)	43.1 (40.9 – 45.4)	.001
WIQ distance score * - %	62.2 (57.8 – 66.6)	67.8 (64.1 – 71.5)	.002
WIQ speed score - %	55.6 (50.7 – 60.5)	63.7 (59.8 – 67.6)	.001
WIQ stair climbing score - %	60.1 (55.6 – 64.6)	67.4 (63.7 – 71.1)	.001

Data are presented as mean and 95%CI. WIQ = walking impairment questionnaire, scored on a 0 (worse score) to 100 (best score) scale. * adjusted for gender.

Table 3. Relationship between baseline sit-to-stand (STS) performance and relative STS muscle power, and baseline treadmill performance, functional performance, and quality of life of 95 patients with symptomatic peripheral artery disease (PAD)

	STS time performance (n = 95)		Relative STS muscle power (n = 95)	
Baseline values	***β* standardized coefficient**	***P* value**	***β* standardized coefficient**	***P* value**
Pain-free walking distance – m	-.29	.005	.32	.002
Maximal walking distance – m	-.36	≤.001	.38	≤.001
Six-minute walking distance † – m	-.53	≤.001	.60	≤.001
Stair climbing test *† - s	.49	≤.001	-.58	≤.001
Habitual gait speed *† – m·s^{-1}	-.29	.002	.43	≤.001
Physical component score - %	-.29	.005	.25	.015
Mental component score † - %	-.13	.23	.17	.12
WIQ distance score - %	-.30	.004	.29	.004
WIQ speed score - %	-.30	.003	.28	.005
WIQ stair climbing score - %	-.24	.022	.20	.050

WIQ = walking impairment questionnaire, scored on a 0 (worse score) to 100 (best score) scale. * adjusted for gender; † adjusted for age.

Table 4. Relationship between changes in sit-to-stand (STS) performance and relative STS muscle power, and changes in treadmill performance, functional performance, and quality of life following supervised exercise training of 95 patients with symptomatic peripheral artery disease (PAD)

	Delta STS performance (n = 95)		**Delta relative STS muscle power (n = 95)**	
Delta values	***β* standardized coefficient**	***P* value**	***β* standardized coefficient**	***P* value**
Pain-free walking distance – m	-.11	.29	.070	.50
Maximal walking distance – m	-.067	.52	.054	.60
6 minute walking distance * – m	-.36	≤.001	.42	≤.001
Stair climbing test * - s	.39	≤.001	-.45	≤.001
Habitual gait speed – $m \cdot s^{-1}$	-.24	.019	.27	.009
Physical component score * - %	.070	.94	.024	.82
Mental component score - %	-.017	.87	.037	.72
WIQ distance score * - %	.064	.53	.005	.96
WIQ speed score - %	.051	.62	-.035	.74
WIQ stair climbing score - %	-.091	.38	.10	.32

WIQ = walking impairment questionnaire, scored on a 0 (worse score) to 100 (best score) scale. * adjusted for gender.