

Article

Association Between Physical Activity and Peripheral Arterial Disease in Patients with Diabetes: A Multicentre Cross-Sectional Study

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Abstract

Background and Objectives: Physical inactivity is a modifiable risk factor for vascular complications in individuals with diabetes mellitus. The aim of this study was to evaluate the predictive capacity of physical activity level for peripheral arterial disease (PAD) in patients with diabetes. **Methods:** A multicentre cross-sectional study was conducted in adults with diabetes undergoing vascular screening. Physical activity was assessed using the Spanish short version of the Minnesota Leisure-Time Physical Activity Questionnaire (VREM), with energy expenditure expressed as metabolic equivalents (MET-min/14 days). PAD was defined according to standard vascular criteria. Analyses included bivariate tests, Spearman correlation, multivariable logistic regression, and receiver operating characteristic (ROC) curve analysis. **Results:** Fifty-four participants were included, with a mean energy expenditure of 4031.8 ± 3986.9 MET-min/14 days. Physical activity was inversely correlated with PAD ($\rho = -0.380$; $p = 0.005$). Participants without PAD had significantly higher activity levels than those with PAD ($p = 0.006$). After adjustment for age, body mass index, glycated haemoglobin, and diabetes duration, higher physical activity remained independently associated with lower odds of PAD (OR = 0.621; 95% CI: 0.392–0.983; $p = 0.042$). The model showed good discrimination (AUC = 0.840). **Conclusions:** Higher leisure-time physical activity is associated with a reduced likelihood of PAD in individuals with diabetes, although the findings should be interpreted cautiously due to the study design and sample size.

Keywords: physical activity; diabetes mellitus; peripheral arterial disease; prevention



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1. Introduction

Peripheral arterial disease (PAD) is a cardiovascular condition affecting over 200 million people worldwide [1]. It is characterised by the narrowing or occlusion of the peripheral arteries, extending from the distal aorta to the arteries supplying the feet. The condition results in reduced or absent blood flow in one or both lower limbs. Peripheral arterial disease presents with clinical symptoms as well as abnormalities on imaging and non-invasive diagnostic tests [2]. Diabetes mellitus (DM) is strongly associated with PAD, particularly in cases of long-standing diabetes [3]. The prognosis of PAD is notably worse

in individuals with DM; such individuals have up to a five-fold higher risk of amputation compared with individuals without diabetes [4,5].

Current international guidelines emphasise the importance of physical activity (PA) in the management and improvement of cardiovascular risk factors such as glycaemic control, blood pressure, and endothelial function [6,7]. Physical activity promotes increased blood flow, which in turn enhances nitric oxide (NO) synthesis and reduces oxidative stress in individuals with DM [8]. The American Diabetes Association (ADA) recommends that individuals with DM engage in at least 150 min of moderate-intensity or 75 min of vigorous-intensity PA per week to maintain or improve health [9]. However, PA tends to decline gradually in individuals with DM as they age [10]. Diabetes appears to cause premature deterioration in physical function, and complications such as neuropathy may lead to reduced muscle strength and/or pain [11,12]. Nonetheless, some studies have suggested that PA can improve plantar pressure distribution, nerve conduction, and joint mobility, as well as increase maximum walking time [13,14]. These improvements may reduce the incidence of foot injuries and enhance the quality of life of individuals with DM [6,13,14].

The Minnesota Leisure-Time Physical Activity Questionnaire (MLTPAQ) was originally developed to assess the amount of PA performed during leisure time over the year preceding data collection, specifically in middle-aged American men [15]. Subsequently, Elosua et al. [16,17] validated the Spanish version of this questionnaire in Spanish men and women aged between 18 and 61. The questionnaire, consisting of 67 items, is administered via an interview lasting approximately 15–20 min.

The Spanish Short Version of the Minnesota Leisure-Time Physical Activity Questionnaire (VREM) is a validated instrument for individuals over the age of 50, developed in response to the need for shorter PA questionnaires that can be applied rapidly in clinical practice and epidemiological studies. It consists of only six questions and takes approximately five minutes to complete; it is administered via a face-to-face interview [18].

To measure the intensity of PA, this questionnaire uses Metabolic Equivalent of Task (MET), which represents the amount of oxygen required to maintain the body's metabolic functions for one minute while at rest in a seated position. Each PA performed is assigned a specific number of METs, based on the Compendium of Physical Activities developed by Ainsworth et al. [19], which quantified the intensity of 821 activities in adults.

Physical exercise is a fundamental component in the prevention of vascular complications that are associated with inadequate glycaemic control. For this reason, it is crucial to understand how the practice of PA and exercise influences vascular parameters in individuals with DM. This knowledge is valuable for healthcare professionals, as it enables the design and recommendation of more effective preventive strategies. By identifying the types and levels of exercise that provide the greatest benefits, PA programmes can be developed to reduce the risk of long-term vascular complications.

Previous studies [20–22] have consistently demonstrated an inverse association between PA and PAD, with individuals with PAD showing lower levels of PA and greater sedentary behaviour than those without the disease. However, less attention has been paid to the potential clinical utility of simple, validated questionnaires as pragmatic tools to help identify individuals who may benefit from objective vascular assessment in routine clinical practice.

Early identification of PAD is particularly important in people with DM. Although current international guidelines recommend objective vascular assessment in patients at increased risk, the systematic implementation of vascular screening may vary across clinical contexts depending on available resources and local practice. Therefore, a simple, inexpensive, and easily administered tool capable of identifying individuals with a higher

likelihood of prevalent PAD could complement routine clinical assessment and facilitate timely referral for comprehensive vascular evaluation.

Accordingly, the primary aim of this study was to evaluate the association between PA level, expressed as MET-min/14 days and measured using the VREM questionnaire, and the presence of PAD in patients with DM. As a secondary objective, we explored the discriminative ability of the questionnaire to identify patients with prevalent PAD and examined which types and durations of leisure-time physical activity were most strongly associated with a lower prevalence of the disease.

2. Materials and Methods

2.1. Study Design

This multicentre, cross-sectional observational study included 54 patients with DM. The study analysed the association between responses obtained from the VREM questionnaire on PA and vascular parameters measured during screening. Vascular screening was conducted via palpation of distal pulses (dorsalis pedis and posterior tibial), the Ankle–Brachial Index (ABI), the Toe–Brachial Index (TBI), and transcutaneous oxygen pressure (TcPO₂); ABI and TBI were used alone when severe PAD was not suspected. The VREM questionnaire comprises six questions grouped into two domains, as detailed below:

- Physical activities performed during leisure time in the past month or a usual month:
 - Walking: days per month, minutes per day, and months per year.
 - Gardening: days per month, minutes per day, and months per year.
 - Playing sports or dancing: days per month, minutes per day, and months per year.
 - Climbing stairs: days per month and floors climbed per day.
- Activities performed during the past week or a usual week:
 - Walking to go shopping: minutes per week.
 - House cleaning: minutes per week.

For the analysis of individual leisure-time activities, walking duration was dichotomised (>60 vs. ≤60 min/day) to facilitate statistical analysis and interpretation. This threshold was defined for exploratory purposes and should not be interpreted as a clinically validated cut-off. MET-min/14 days were calculated from the type, frequency, and duration of each activity. Specifically, the MET value assigned to each activity was multiplied by its duration (minutes), the number of days the activity was performed during the previous month, and the number of months per year in which it was performed. The resulting value was divided by 365 and multiplied by 14 to estimate energy expenditure over a 14-day period. Following the methodology of Ruiz-Comellas et al. [23], participants were classified according to the predefined physical activity categories (quartiles) proposed in that study, based on leisure-time energy expenditures:

- Q1: energy expenditure < 3060 MET-min/14 days.
- Q2: energy expenditure between 3060 and 5000 MET-min/14 days.
- Q3: energy expenditure between 5001 and 7550 MET-min/14 days.
- Q4: energy expenditure > 7550 MET-min/14 days.

Measurement bias was minimised by applying standardised vascular assessment protocols and using validated instruments. Additionally, multivariable logistic regression analyses adjusted for relevant clinical and sociodemographic variables (age, BMI, HbA_{1c}, and duration of diabetes) were performed to control for potential confounding factors.

This study was approved by the local ethics committee with favourable report number 24/834-E; it was performed according to the guidelines of the Declaration of Helsinki [24]. All participants were informed about the study and its objectives. Each patient voluntarily

consented to participate by signing an informed consent form. Data analysis was conducted between June and July 2025.

2.2. Inclusion Criteria

The study included patients of both sexes, aged over 50 years, diagnosed with type 1 or type 2 DM, regardless of pharmacological treatment. Patients with active ulcers and/or major lower limb amputations, or those unable to complete the questionnaire due to severe cognitive or behavioural impairments, were excluded.

2.3. Sample Size Calculation

The sample size calculation was performed using the Granmo[®] application (version 7.12; Institut Municipal d'Investigació Mèdica, Barcelona, Spain). We used two-tailed correlation analysis, considering a confidence level of 95% ($\alpha = 0.05$), a statistical power of 80% ($1 - \beta = 0.80$), and an expected correlation of 0.4, which corresponds to a moderate effect size. Under these assumptions, a minimum of 47 subjects was deemed necessary. No data loss was anticipated given the cross-sectional nature of the study.

2.4. Data Collection

We collected data using a case report form by two researchers between December 2024 and June 2025. We analysed parameters related to circulatory status, including the presence or absence of distal pulses, ABI, TBI, and TcPO₂. Vascular screening was performed using the PeriFlux 6000 Combined System[®] (PeriMed AB, Järfälla, Sweden). Prior to the examination, patients were asked to remain barefoot and remain at rest for 10 min. Data collection was carried out in a specialised clinical setting—a diabetic foot unit—and in the community setting, through two diabetes patient associations.

2.5. Data Analysis

We conducted a descriptive analysis of qualitative variables using absolute frequencies and percentages; we analysed quantitative variables by calculating means and standard deviations. The normality of the quantitative variables was assessed using the Kolmogorov–Smirnov test, which indicated that energy expenditure, expressed in METs, did not follow a normal distribution ($p < 0.001$). We used the Mann–Whitney U test to compare quantitative variables and Spearman's correlation test to explore the relationship between energy expenditure and the presence of PAD.

Peripheral artery disease was primarily defined by an ABI < 0.9 . In participants with non-compressible arteries or potentially unreliable ABI values due to medial arterial calcification (e.g., ABI ≥ 1.4), TBI < 0.7 was considered according to current international recommendations [25]. TcPO₂ was used as a complementary assessment of tissue perfusion and was not included in the statistical definition of PAD. We used binary logistic regression to identify factors associated with PAD; we used energy expenditure and PA variables (e.g., climbing stairs, gardening, walking, shopping, and cleaning) as independent variables. These activities were categorised with clinically relevant cut-off points to facilitate interpretation.

Subgroup analyses were conducted by categorising participants according to their level of energy expenditure from leisure-time physical activity (quartiles Q1–Q4), based on previously described methodology. This approach allowed the exploration of differences in vascular parameters and the presence of peripheral arterial disease (PAD) across different levels of physical activity. Interaction effects between physical activity variables and PAD were explored within the logistic regression models.

An exploratory binary logistic regression analysis was subsequently performed, adjusted for clinical and sociodemographic variables. Those variables included age, body mass index (BMI), HbA1c, and the duration of DM. Model fit was assessed using the Hosmer–Lemeshow test and Cox and Snell and Nagelkerke R^2 statistics. We presumed that p -values less than 0.05 indicated statistical significance. For interpretability purposes, PA was also rescaled (per 1000 MET-min/14 days) when reporting effect sizes, although the original continuous variable was used in the primary analyses. We performed all the analyses using IBM® SPSS Statistics (version 27.0; IBM Corp., Armonk, NY, USA).

As participants were recruited through convenience sampling from a specialised diabetic foot unit and community-based diabetes associations, no analytical adjustments related to complex sampling strategies were required. No formal sensitivity analyses or internal validation procedures (e.g., bootstrapping or cross-validation) were performed due to the limited sample size. Therefore, the multivariable logistic regression model should be considered exploratory and was primarily intended to assess the robustness of the observed association after adjustment for clinically relevant covariates rather than to develop or validate a prediction model.

3. Results

A total of 54 patients with DM were included in the study. All participants were assessed for eligibility according to the predefined inclusion and exclusion criteria and agreed to participate after providing written informed consent. Given the cross-sectional design of the study, no follow-up period was required, and all included participants were analysed.

Of the 54 patients in the study, 30 (55.6%) were male. The mean age of the entire cohort was 69.9 (SD 8.5) years. The patients' BMI was 26.8 (4.5). Forty of the patients (74%) had type 2 DM, with a mean disease duration of 23.9 (SD 15.1) years. Nineteen of the patients (35%) were receiving insulin treatment, compared with 15 patients (28%) treated with oral antidiabetic agents. The patients' average blood glucose levels were 119.06 (SD 25.29) mg/dL; their average HbA1c was 6.85 (SD 0.89) % (51.4 mmol/mol; SD $\pm$ 9.7). Peripheral arterial disease was identified in 29 patients (54%) of the sample. Fifteen of the patients (28%) were classified as high risk for ulceration according to the International Working Group on the Diabetic Foot (IWGDF), based on a history of diabetic foot ulcers (DFUs). Eleven patients (20%) were classified as low risk, nine (17%) were classified as mild risk, and 19 (35%) were classified as moderate risk. Six patients (11%) had previously undergone amputation. Additional clinical characteristics of the cohort are listed in Table 1, and neurological and vascular parameters are detailed in Table 2.

Table 1. Clinical characteristics.

Variable	Frequency (<i>n</i>)	Percentage (%)
Hypertension	38	70
Hypercholesterolemia	35	65
Retinopathy	10	19
Diabetic nephropathy	3	6
Cardiovascular history	17	32
Smoking	2	4
Ex-smoker	11	20
Enolism	4	7
Enolism history	9	17

Table 2. Vascular and neurological screening.

Variable	Mean	SD
ABI	1.12	0.28
Ankle pressure (mmHg)	150.26	35.79
TBI	0.82	0.25
TcPO2 (mmHg)	41.65	12.21
Variable	Frequency (n)	Percentage (%)
PAD	29	54
Absence of pedal pulse	22	41
Absence of posterior tibialis pulse	25	46
Peripheral neuropathy	30	56

ABI: Ankle–Brachial Index; PAD: peripheral artery disease; TBI: Toe–Brachial Index; TcPO2: transcutaneous oxygen pressure.

On average, the patients walked for 62.16 (SD 35.19) minutes per day; engaged in vigorous activities related to agriculture or gardening for 15.84 (SD 32.54) minutes per day; practised dancing or sports for 34.62 (SD 62.86) minutes per day; climbed an average of 2.2 (SD 3.4) flights of stairs per day; spent 40.94 (48.34) minutes per week walking to go shopping; and devoted 62.64 (SD 57.93) minutes each week to vigorous household cleaning tasks. The cohort's mean energy expenditure over 14 days was 4031.78 (SD 3986.86) MET-min/14 days. We found that 26 patients (48%) were classified as Q1, 15 patients (28%) were classified as Q2, 8 patients (15%) were classified as Q3, and 5 patients (9%) were classified as Q4. Patients without PAD exhibited a median (Q1–Q3) energy expenditure of 4249.70 (2101.95–6630.48) MET-min/14 days, compared with 2832.06 (1507.40–3877.35) MET-min/14 days in individuals with PAD. A Mann–Whitney U test revealed a statistically significant difference between the two groups ($U = 203.000$; $Z = -2.767$; $p = 0.006$). The distribution of time spent on activities and energy expenditure by group is presented in Table 3.

Table 3. Distribution of time spent on activities and energy expenditure by groups according to the presence of peripheral arterial disease.

Variable	PAD		No PAD		<i>p</i> -Value
	Median	IQR	Median	IQR	
Walking (min/day)	60.0	30.0–60.0	60.0	42.5–105.0	0.240
Gardening/Agriculture (min/day)	0.0	0.0–0.0	0.0	0.0–45.0	0.056
Sports/Dance (min/day)	0.0	0.0–45.0	0.0	0.0–60.0	0.977
Climb stairs (floor/day)	2.0	0.0–3.0	0.0	0.0–4.50	0.947
Shopping on foot (min/week)	20.0	0.0–30.0	40.0	12.5–95.0	0.046 *
Household cleaning (min/week)	60.0	0.0–60.0	60.0	17.5–120.0	0.096
MET-min/14 days	2832.06	1507.40–3877.35	4249.70	2101.95–6630.48	0.006 *
Variable	Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)	
Q1: <3060	17	59	9	36	
Q2: 3060–5000	10	35	5	20	
Q3: 5001–7550	2	7	6	24	
Q4: >7550	0	0	5	20	

IQR: interquartile range; MET: metabolic energy turnover; Q: quartile by energy expenditure; * p -value < 0.05.

We evaluated the relationship between energy expenditure and PAD using Spearman's correlation coefficient. The results revealed a significant negative correlation between the two variables ($\rho = -0.380$, $p = 0.005$), indicating that as PA levels increase, the likelihood of presenting PAD tends to decrease.

In the unadjusted logistic regression model, higher PA levels were significantly associated with a lower probability of PAD (OR = 0.616; 95% CI: 0.435–0.873; $p = 0.006$). This model showed a significant overall effect ($\chi^2 = 11.150$; $p = 0.001$), with moderate explanatory capacity (Cox & Snell $R^2 = 0.187$; Nagelkerke $R^2 = 0.249$) and an overall classification accuracy of 68.5%. However, the Hosmer–Lemeshow test indicated poor calibration ($\chi^2 = 19.433$; $p = 0.013$). After adjustment for age, BMI, HbA1c, and duration of DM, the association remained statistically significant and of similar magnitude (OR per 1000 MET-min/14 days = 0.621; 95% CI: 0.392–0.983; $p = 0.042$), suggesting that the relationship was not materially influenced by these clinical covariates. The adjusted model demonstrated acceptable calibration (Hosmer–Lemeshow $p = 0.278$) and improved explanatory capacity (Cox & Snell $R^2 = 0.242$; Nagelkerke $R^2 = 0.322$), with an overall classification accuracy of 69.0%, sensitivity of 76.2%, and specificity of 61.9%. Detailed regression coefficients (β), ORs, 95% CIs, and p -values for all variables included in the adjusted model are presented in Table 4.

Table 4. Detailed regression coefficients (β), odds ratios (ORs), 95% confidence intervals (95% CIs), and p -values for all variables included in the adjusted model.

Variable	β	OR	95% CI	p
Age (years)	−0.057	0.945	0.864–1.034	0.216
BMI (kg/m ²)	0.072	1.075	0.892–1.296	0.447
HbA1c (%)	−0.247	0.781	0.379–1.608	0.503
Diabetes duration (years)	0.048	1.049	0.994–1.107	0.083
Physical activity (per 1000 MET-min/14 days)	−0.476	0.621	0.392–0.983	0.042 *

Physical activity was entered into the model per 1000 MET-min/14 days to improve the interpretability of the regression coefficient and odds ratio. This rescaling does not affect the model fit or statistical significance.
* $p < 0.05$.

Additionally, spending more than 60 min walking daily was associated with lower odds of prevalent PAD (OR = 0.056; $p = 0.021$). Other forms of PA, such as gardening, practising other sports or dancing, climbing stairs, walking to go shopping, and performing household cleaning tasks, showed no significant associations with PAD. The overall classification accuracy of the model was 69.0%, with a sensitivity of 76.2% and a specificity of 61.9%. These results suggest that higher levels of PA are associated with a lower prevalence of PAD, particularly prolonged walking, at least in our cohort.

Finally, ROC curve analysis demonstrated that the logistic regression model showed good discriminative ability for identifying prevalent PAD, with an area under the curve (AUC) of 0.840 (95% CI: 0.737–0.943; $p < 0.001$). This result indicates that the model showed acceptable discriminative ability within this sample and can correctly distinguish between patients with and without PAD in 84% of cases; however, as the model was developed and evaluated in the same dataset without internal validation, this AUC represents the apparent performance and should be interpreted with caution.

To determine an exploratory threshold for the probability of PAD based on energy expenditure, we selected a threshold of 0.38 in the predicted probability from the logistic regression model. This cut-off enabled discrimination between positive and negative cases with a balance between sensitivity (93%) and specificity (64%). Calculating the corresponding value at this cut-off using the inverse logistic formula yielded a threshold of 4322 MET-min/14 days. Although the proposed cut-off value should be considered exploratory and requires validation in independent cohorts due to sample size limitations.

4. Discussion

Physical activity is a fundamental component in the management of patients with DM because of its well-established health benefits. However, our descriptive analysis revealed that the study population was generally physically inactive, with 48% of participants exhibiting energy expenditures below 3060 MET-min/14 days. This finding may be attributable to the advanced age of our population, whose mean age was close to 70 years.

Although the VREM questionnaire encompasses both leisure activities and household tasks, we did not observe a significant increase in overall PA levels. This finding may be linked to the fact that many of the study participants benefit from home assistance programmes, which provide domestic support, including cleaning and shopping, thereby reducing the need to perform these activities themselves. Furthermore, the long duration of DM and the presence of concomitant complications such as retinopathy and neuropathy—affecting 19% and 56% of the sample, respectively—may have also limited the participants' ability to engage in their usual daily activities.

However, higher levels of physical activity were associated with a lower prevalence of PAD in our sample: a greater energy expenditure was inversely associated with prevalent PAD (OR = 0.621; 95% CI: 0.392–0.983; $p = 0.042$). These findings are consistent with previous studies that have linked inactivity with lower ABI values [23,26,27]. However, given the cross-sectional design of the study, causality cannot be established.

We found that only walking for more than one hour per day was associated with lower odds of prevalent PAD; that finding was independent of clinical and sociodemographic factors such as BMI, age, or the duration of DM. However, this threshold was derived for exploratory analytical purposes and should not be interpreted as a clinically validated recommendation. Confirmation in larger prospective studies is required. On the other hand, Stein et al. observed a significant association with any regular leisure-time PA [26].

The ROC curve analysis suggested that the multivariable model demonstrated good discriminative performance for distinguishing between patients with and without PAD (AUC = 0.840). This indicates that, within the study sample, the model shows an adequate ability to distinguish and classify individuals according to PAD status based on PA and clinical covariates. An exploratory probability cut-off of 0.38, corresponding to approximately 4322 MET-min/14 days, optimised the balance between sensitivity and specificity; however, this threshold should be interpreted cautiously, as it was derived from the same dataset used to develop the model. Therefore, its clinical applicability remains limited, and the reported discriminative performance is likely optimistic and may not be reproduced in independent populations. External validation is therefore required before any potential clinical application.

Promoting an adequate level of PA, particularly regular and sustained walking, may represent an effective preventive strategy against PAD in individuals with DM. Given that PAD is associated with an increased risk of DFUs, amputations, and cardiovascular mortality, its prevention via non-pharmacological interventions should be systematically integrated into the management of these patients.

In agreement with Perks et al. [28], our results highlight the need to establish specific and tailored intervention strategies for this patient group to improve PA and reduce sedentary behaviour, since the presence of PAD in individuals with DM is associated with lower levels of PA during leisure time, increased periods of inactivity, and poorer physical function, regardless of sociodemographic and clinical characteristics.

Our findings support the potential role of a simple, validated physical activity questionnaire as an adjunctive clinical tool to help identify individuals with diabetes who may warrant further vascular assessment, particularly in settings where routine ABI screening is not systematically implemented.

The principal limitation of this study lies in the assessment of PA, which was based on self-reported questionnaires. This method may be subject to recall bias or social desirability bias. Other authors [29] have advocated for the use of electronic activity monitoring devices, such as pedometers or accelerometers, to investigate how daily step counts may help identify patients with PAD. These devices enable a more accurate evaluation of physical behaviours in individuals with PAD, thereby overcoming the limitations associated with traditional questionnaire-based assessments. Nevertheless, questionnaire-based assessments remain attractive for routine clinical practice because they are inexpensive, easy to administer, and do not require specialised equipment or data processing. Future studies combining objective physical activity monitoring with vascular assessment would help validate the associations observed in the present study and further define the clinical utility of questionnaire-based screening approaches [30–32].

The relatively small sample size and the number of variables included in the multivariable regression model may have increased the risk of overfitting, potentially limiting the stability, precision, and generalisability of the estimated odds ratios. Therefore, the multivariable analysis should be considered exploratory, and the adjusted estimates should be interpreted with caution until confirmed in larger, adequately powered prospective studies. Another significant limitation of this study is the cross-sectional design, which precludes establishing temporal relationships between physical activity and PAD. Therefore, reverse causality cannot be excluded, as individuals with PAD may engage in lower levels of physical activity due to functional limitations such as claudication. The lower levels of physical activity observed in participants with PAD may represent not only a potential risk marker but also a consequence of the disease itself. Accordingly, our findings should be interpreted as demonstrating an association rather than a causal relationship, and prospective longitudinal studies are required to clarify the temporal direction of this association.

Finally, because participants were recruited from specialised clinical settings and diabetes associations, the prevalence of PAD in our cohort was higher than that typically reported in unselected diabetic populations. Therefore, the proposed physical activity threshold may not be directly applicable to other clinical settings and requires external validation.

The principal strength of this study lies in its multicentre design, which increases the diversity of the study sample. Moreover, the use of the VREM questionnaire—encompassing not only structured leisure-time exercise but also tasks related to household care and gardening—allows for a more comprehensive assessment of daily active behaviour beyond structured exercise. Another strength is the use of objective vascular assessment, including ABI, TBI, TcPO₂, and distal pulse examination. Furthermore, the study addresses a clinically relevant question by evaluating a simple screening tool that could facilitate the identification of individuals requiring objective vascular assessment. Finally, the methodological structure of this investigation, wherein independent researchers were responsible for data collection and analysis, reduces the risk of observer and analytical bias.

Future longitudinal studies with larger sample sizes and objective assessments of PA are needed to clarify the temporal relationship between physical activity and PAD.

5. Conclusions

In this exploratory cross-sectional study, lower physical activity levels measured using the VREM questionnaire were associated with a higher prevalence of PAD in individuals with DM. Although objective vascular assessment remains essential for the diagnosis of PAD, a simple questionnaire-based assessment of physical activity may represent a useful adjunctive tool for identifying individuals who could benefit from further vascular evaluation. These findings require confirmation in larger prospective studies before clinical implementation.

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Abbreviations

The following abbreviations are used in this manuscript:

PAD	peripheral arterial disease
VREM	Minnesota Leisure-Time Physical Activity Questionnaire
MET	metabolic equivalent of task
ROC	receiver operating characteristic
AUC	area under the curve
NO	nitric oxide
PA	physical activity

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