El efecto del ejercicio con pelota de golf sobre el índice tobillo-brazo en la diabetes mellitus: un estudio piloto

The Effect of Golf Ball Foot Exercise on Ankle Brachial Index in Diabetes Mellitus: A Pilot Study

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Abstract

Introduction: Insulin dysregulation in diabetes mellitus (DM) contributes to peripheral circulation disturbances, which can be quantified using the Ankle-Brachial Index (ABI). Regular foot exercise is essential for enhancing blood flow and preventing vascular complications. This study aimed to evaluate the effect of foot exercise using a golf ball on ABI in patients with type 2 DM (T2DM).
Methods: A quantitative, one-group pre and post-test design was employed. A total of 137 T2DM patients, aged 36–59 years, were recruited from four primary health centers in Surabaya, Indonesia. All participants had fasting blood glucose levels above 126 mg/dL in the preceding month. The intervention comprised foot exercises using a golf ball performed twice daily for 5 minutes over 14 consecutive days. ABI measurements were obtained before and after the intervention, and Wilcoxon signed-rank test was used to analyze the data.
Results: A total of 137 participants (mean age 53.4 ± 5.3 years, 69% female) completed the 14-day intervention. The median ABI significantly increased from 0.94 (IQR: 0.3) pre-intervention to 1.08 (IQR: 0.2) post-intervention ($p < 0.001$), indicating improved peripheral arterial function. Binary logistic regression showed that participants had greater odds of achieving a normal post-intervention ABI (OR 14.9; 95% CI, 3.3–66.4; $p < 0.001$) after intervention. Gender-stratified analyses confirmed significant ABI improvements in both males and females ($p < 0.001$).
Conclusion: A 14-day foot exercise regimen using a golf ball effectively improved ABI in T2DM patients, suggesting a potential reduction in the risk of peripheral arterial disease..

Keywords

Diabetes; exercise therapy; feet; golf balls; ankle brachial index.

Resumen

Introducción: La desregulación de la insulina en la diabetes mellitus (DM) contribuye a alteraciones de la circulación periférica, que pueden cuantificarse mediante el índice tobillo-brazo (ITB). El ejercicio regular de los pies es esencial para mejorar el flujo sanguíneo y prevenir complicaciones vasculares. Este estudio tuvo como objetivo evaluar el efecto del ejercicio de los pies con una pelota de golf sobre el ITB en pacientes con DM tipo 2 (DM2).
Métodos: Se empleó un diseño cuantitativo de un grupo, con preprueba y posprueba. Se reclutaron 137 pacientes con DM2, de entre 36 y 59 años, de cuatro centros de atención primaria en Surabaya, Indonesia. Todos los participantes presentaron niveles de glucemia en ayunas superiores a 126 mg/dl durante el mes anterior. La intervención consistió en ejercicios de los pies con una pelota de golf, realizados dos veces al día durante 5 minutos durante 14 días consecutivos. Se obtuvieron mediciones del ITB antes y después de la intervención, y se utilizó la prueba de rangos con signo de Wilcoxon para analizar los datos. Resultados: Un total de 137 participantes (edad media de 53,4 ± 5,3 años, 69 % mujeres) completaron la intervención de 14 días. La mediana del ITB aumentó significativamente de 0,94 (RIC: 0,3) antes de la intervención a 1,08 (RIC: 0,2) después de la intervención ($p < 0{,}001$), lo que indica una mejora de la función arterial periférica. La regresión logística binaria mostró que los participantes tenían mayor probabilidad de alcanzar un ITB normal después de la intervención (OR: 14,9; IC del 95 %: 3,3-66,4; $p < 0{,}001$). Los análisis estratificados por género confirmaron mejoras significativas del ITB tanto en hombres como en mujeres ($p < 0{,}001$). Conclusión: Un régimen de ejercicios de pies de 14 días utilizando una pelota de golf mejoró eficazmente el ITB en pacientes con diabetes de tipo 2, lo que sugiere una posible reducción del riesgo de enfermedad arterial periférica.

Palabras clave

Diabetes; terapia de ejercicios; pies; pelotas de golf; índice tobillo-brazo.

Introduction

Globally, the prevalence of diabetes mellitus (DM) has risen dramatically, with projections estimating up to 650 million affected individuals by 2030 in the absence of effective preventive measures. Type 2 DM constitutes over 80% of all cases (International Diabetes Federation, 2021; Sun et al., 2022). In Indonesia, approximately 19.46 million people were affected by DM in 2021—a marked 81.8% increase from 2019—with East Java, particularly Surabaya, accounting for a high burden of cases (International Diabetes Federation, 2021). East Java Province is included in the top 10 for the highest number of DM patients in Indonesia, with the city of Surabaya having the largest number of DM patients (Ministry of Health Indonesia & Unit, 2018; Surabaya City Health Office, 2022). DM is frequently accompanied by severe complications such as microvascular disease—including retinopathy, nephropathy, and neuropathy—which can lead to diabetic foot ulcers (DFU) and peripheral arterial disease (PAD) (Farida et al., 2022; Pradeepa & Mohan, 2017; Venguidesvarane et al., 2020)(Meena & C., 2019). In Indonesia, among individuals with type 2 DM, the prevalence is estimated at 5–15%, with PAD constituting a notable risk factor (Pemayun & Naibaho, 2017; Yunir et al., 2021).

PAD, characterized by reduced blood flow to the extremities due to arterial narrowing, is especially common in type 2 DM patients as a result of vascular damage and circulatory disturbances (E. M. Dewi et al., 2022; Thomas et al., 2021). Diabetic neuropathy further impairs the ability to detect foot injuries, thus increasing the likelihood of DFU (Jais, 2023; Wang et al., 2022). Moreover, over 50% of patients with critical limb ischemia (CLI) also have DM, and because many individuals with PAD remain asymptomatic, screening with the ankle-brachial index (ABI) is essential (Ghirardini & Martini, 2024; Takahara, 2021) (Thomas et al., 2021).

In line with the Indonesian national program for DM control—which seeks to reduce risk factors associated with DM-related morbidity, disability, and mortality—foot exercises are advocated as a key component of diabetic foot care (Astuti et al., 2023; Ping et al., 2021). Comprehensive foot care entails regular examinations, proper washing and drying, the use of moisturizers, appropriate footwear, and timely first aid to prevent wounds (Jais, 2023; Lin et al., 2020). Evidence from experimental studies indicates that DM foot exercises can significantly improve foot sensitivity; for instance, one study reported an increase in the sensory score from 1.67 to 2.36 following twice-weekly exercises (Astuti et al., 2023).

Additionally, foot exercises have been shown to enhance blood circulation, alleviate stress on the feet, and improve the health of foot tissues, thereby reducing the incidence of DFU and the impact of PAD (Hicks et al., 2019; Noor et al., 2017; Thomas et al., 2021). Improved muscle strength and injury prevention through regular foot exercise have been associated with a lower incidence of foot ulcers, reinforcing its role in diabetes management in Indonesia (Astuti et al., 2023; Ping et al., 2021). Preventive strategies that integrate foot exercise and proper foot care are widely recommended by medical professionals to mitigate DFU and other related complications (Huda et al., 2020; Jais, 2023). Notably, the use of golf balls in DM foot exercises represents an innovative alternative to protect against peripheral vascular disorders, with the ABI serving as an initial screening measure. For example, passive stretching combined with golf ball rolling—administered in three sets of 30 seconds over three consecutive days—resulted in a significant enhancement in muscle flexibility (mean difference: 10.4 ± 1.9; $p < 0.001$) compared to controls (Shetty & Roman D'souza, 2018).

Although rarely utilized, golf balls offer a unique therapeutic modality owing to their dimpled surface, which produces vibrations that enhance blood flow to the soles, thereby optimizing nutrient and oxygen delivery to nerves and improving nerve function (Ryu et al., 2024; Shetty & Roman D'souza, 2018). Complementary studies on roller massage have demonstrated short-term improvements in the range of motion—such as a 4.3% increase in hip flexion immediately following 5 to 10 seconds of hamstring rolling (Halperin et al., 2014)(Sullivan et al., 2013) —and similar benefits have been observed in alleviating plantar fasciitis-related pain through golf ball-based exercises (Ryu et al., 2024). This study therefore aims to evaluate the effect of foot exercises using golf balls on the ankle-brachial index (ABI) in patients with diabetes mellitus.

Method

Design and Sample

This study is a one-group pre and posttest design where we only employed one group of subjects to see the effects of intervention (Knapp, 2016; Marsden & Torgerson, 2012). The participants in this study were patients with Type II Diabetes from four primary health centers in Surabaya city who received routine therapy for their disease. The regions in which the participants were recruited represented four areas with high density of type II Diabetes patients. The inclusion criteria for this study were DM patients aged 36-59 years and had fasting blood glucose values above 126 mg/dL in the past month. This study was conducted between May and July 2022.

The sample size formula in this study was based on the modified Slovin approach (Ryan, 2013) , which considers the normal standard value (λ) at a certain confidence level ($\alpha = 0.05$) and an assumed population proportion of 50% ($p = 0.5$). This calculation resulted in a sample size of 125 participants. After accounting for an anticipated dropout rate of 10%, the minimum required sample size was determined to be 137 participants. The cluster sampling technique was carried out to recruit each participant based on the region or location of the four primary health centers.

Procedures

Each and every participants was given an explanation of the research objectives, study procedures and potential benefits received by the participants. The research took place during the Covid-19 era so that participants had to be able to show proof of a vaccine certificate of at least dose 2, wash their hands, maintain distance and wear masks. Each participants received one golf ball distributed by the researcher.

After identifying the target population of DM patients registered at primary health centers and confirming that they met the inclusion criteria, the participants were grouped into natural clusters based on the working areas of the health centers, namely neighborhood units (RW). Once the cluster list was established, a random selection of DM patients was conducted within several RW using a simple lottery method with numbered draws. All DM patients within the selected clusters who met the eligibility criteria were then recruited as study participants. Furthermore, the intervention was implemented through an appointment system while adhering to health protocols, including mask-wearing, physical distancing, and ensuring proper room ventilation. Participants were also added to a WhatsApp group to facilitate home-based monitoring.

The researcher then showed the procedure required by the participants to practice. The steps were 1) Asking the participant to sit in the most comfortable position on the chair with the participant's feet resting on a solid and non-slippery floor (without a mat), 2) then the golf ball was placed under the participants' feet and then asked to press on the ball while making a clockwise rotation to the left and right alternately. The pressure of the golf ball stimulates the soles of the feet by increasing blood flow to the soles of the feet through vibrations created between the concave part (dimple of the ball) on the surface of the golf ball and participants' plantar feet surface (Halperin et al., 2014; Shetty & Roman D'souza, 2018; Sullivan et al., 2013). This would optimize the flow of nutrients and oxygen to the nerves and improving nerve function (Davis et al., 2014; Ryu et al., 2024; Shetty & Roman D'souza, 2018). Each movement in the golf ball exercise was performed for 5 minutes twice a day in the morning and evening for 14 days (Gabriel et al., 2024; Syeda et al., 2023). Home monitoring was carried out regularly every day via video calls or video messages reported by participants to researchers.

Assessments

Before the intervention, each participants filled out demographic questionnaires in which information about age, gender, education, family income and length of duration of diabetes mellitus were collected. The ankle-brachial index (ABI) measurement procedure was conducted using a single-blind technique, in which the assessor was unaware of whether the measurement occurred during the pre- or post-intervention phase. This was achieved by encoding participant data with randomly assigned codes and scheduling ABI measurements at random times, without disclosing the intervention status to the assessor. The procedure then continued with measuring ABI by dividing the systolic pressure of dorsalis pedis artery and systolic pressure of the brachial artery (Taylor-Piliae et al., 2011; Thomas et al., 2021) as measured by a sphygmomanometer digital (E. M. Dewi et al., 2022) version with voice type B869.

Direct recording of measurement results was carried out by a digital sphygmomanometer (voice type B869), which reduces subjective interpretation. The digital sphygmomanometer (model B869) underwent regular calibration both prior to and throughout the study in accordance with the manufacturer's specifications, and all measurements were conducted by qualified personnel following established standard operating procedures. The ABI assessments were conducted following a minimum of 10 minutes of rest in a supine position, within an environment maintained at a stable room temperature of approximately 22–24°C, while carefully applying the digital sphygmomanometer cuff to avoid undue pressure during the measurement process (Aboyans et al., 2012; Muntner et al., 2019). Interpretation of ABI measurement is obtained as follows: ABI score> 0.9 - 1.4 is normal, ABI score <0.6 - 0.8 is borderline perfusion, ABI score <0.5 is indicated in severe ischemia and ABI score <0.4 is indicated as critical leg ischemia (Aboyans et al., 2012; Farida et al., 2022; Thomas et al., 2021).

Ethics

All research activities in this study were conducted in accordance with established scientific principles and adhered to ethical standards in nursing research. Ethical approval was obtained from the Health Research Ethics Commission of the Faculty of Dentistry, Airlangga University (Approval No. 222/HRECC.FODM/V/2022). The intervention posed no foreseeable risks to participants; however, researchers maintained a rigorous commitment to ethical and humanistic considerations to uphold the dignity and rights of all individuals involved.

Data analysis

Ordinal and categorical variables were presented as frequencies and percentages The study utilized primary data collected directly from participants, which was subsequently analyzed using SPSS software version 23 (SPSS Inc., Chicago, IL, USA). The non-parametric Wilcoxon Signed Rank test was employed to assess differences in Ankle Brachial Index (ABI) within paired samples, with a significance threshold set at ≤0.05. Odds ratios and confidence intervals were calculated using binary logistics regression where post intervention ABI classification as the dependent variable.

Results

Between May and July 2022, a total of 137 participants were recruited from four regions of Surabaya. All participants provided informed consent and successfully completed the 14-day follow-up period.

Table 1. Distribution of demographic characteristics for all participants

Characteristics	Total (n = 137)	%
Age in Year - Mean±SD	53.4±5.3	range (36 - 59)
36-45 year (late adulthood)	22	16%
46-59 year (early elderly)	115	84%
Gender		
Female	95	69%
Male	42	31%
Level of Eucation		
No Formal education	9	7%
Elementary education	44	32%
Secondary education	52	38%
Higher education	32	23%
Family Income		
Below RMW	49	36%
Average RMW	22	16%
Above RMW	66	48%

Diabetes Duration - Mean±SD		
Below 5 year	47	34%
Above 5 year	90	66%
Blood Pressure mmHg- Mean±SD		
(Pre Intervention)		
SBP- Brachial	147.1±22.1	range (102 - 208)
DBP-Brachial	91.3±14.3	range (63 - 125)
SBP- Ankle	146.8±32.5	range (92 - 223)
DBP- Ankle	101.7±16.6	range (55 - 144)
MAP-Brachial	109.7±15.2	range (78 - 147.3)
MAP-Ankle	116.7±20.1	range (73.7 - 164.3)
ABI (Baseline)	1.0±0.3	
ABI > 1.4	13	9%
ABI 0.9 - 1.4	65	47%
ABI < 0.9	59	43%
Blood Pressure mmHg- Mean±SD		
(Post Intervention)		
SBP- Brachial	137.6±17.8	range (105 - 194)
DBP-Brachial	89.2±11.9	range (65 - 122)
SBP- Ankle	154.7±26.1	range (110 - 228)
DBP- Ankle	99.7±16.1	range (55 - 145)
MAP-Brachial	105.3±12.6	range (80 - 145)
MAP-Ankle	118.0±17.5	range (76 - 172.7)
ABI (Post intervention)	1.13±0.2	
ABI > 1.4	12	9%
ABI 0.9 - 1.4	113	82%
ABI < 0.9	12	9%

SBP, systolic blood pressure; DBP, diastolic blood pressure;

RMW (regional minimum wage) approximately USD 255 monthly

The mean age of the cohort was 53.4 ± 5.3 years, with a predominance of females (69%). As presented in Table 1, the distribution of demographic characteristics indicates that the majority of participants (84%) were within the 46–59 year age range. More than half had completed secondary or higher education, while 7% had no formal education. Table 1 also illustrates the distribution of ankle, brachial, and mean arterial blood pressures alongside Ankle Brachial Index (ABI) values before and after the intervention. Following the intervention, the proportion of participants with a normal ABI (0.9–1.4) increased by 35%, whereas the percentage of individuals with an ABI <0.9 declined markedly from 43% to 9%.

Table 2a. ABI Difference Between Pre and Post Intervention

ABI - median (IQR)	***(n=137)***	***P***
Pre Intervention*	0.94 (0.3)	< 0.001 (a)
Post Intervention*	1.08 (0.2)	

(a). Non Parametric Wilcoxon Sign Rank test (*paired*); ABI ankle brachial index

Table 2a summarizes the changes in the Ankle Brachial Index (ABI) among 137 participants before and after the intervention. The ABI values are expressed as medians with interquartile ranges (IQR). Prior to the intervention, the median ABI was 0.94 (IQR = 0.3), which increased to a median of 1.08 (IQR = 0.2) post-intervention. The Wilcoxon Signed Rank test indicated that this increase was statistically significant (P < 0.001). These findings suggest that the intervention was associated with a significant improvement in arterial performance as measured by ABI.

Table 2b. Binary Logistic Regression of Pre and Post Intervention

	ABI Post Intervention		
Pre Intervention	**Normal** (ABI 0.9-1.4)	**Abnormal** (ABI<0.9 or >1.4)	**OR and P Value**
Normal (ABI 0.9-1.4)	65	2	14.9 (95%CI 3.3 - 66.4) P = 0.000
Abnormal (ABI<0.9 or >1.4)	48	22	

ABI, ankle brachial index; OR, odds ratio, CI, confidence interval

Table 2b presents a binary logistic regression analysis investigating the association between baseline and post-intervention Ankle Brachial Index (ABI) for 137 participants. ABI values were categorized as "normal" (0.9–1.4) or "abnormal" (<0.9 or >1.4). The regression model indicates that participants with a normal pre-intervention ABI were significantly more likely to exhibit a normal ABI following the intervention, with an odds ratio (OR) of 14.9 (95% CI, 3.3–66.4; P < 0.001). This strong association suggests that intervention with golf ball exercise could potentially increase the favorable outcomes.

Table 3. ABI Difference between male and female participants

	Male (n=42)	***P***	***Female (n=42)***	***P***
ABI - median (IQR)		< 0.001 (a)		< 0.001 (a)
Pre Intervention*	0.92 (0.5)		0.94 (0.4)	
Post Intervention*	1.06 (0.2)		1.09 (0.2)	

(a). Non Parametric Wilcoxon Sign Rank test (*paired*)

In comparing the male and female participants, we performed a stratified analysis by gender as summarized in Table 3. For male participants (n = 42), the median ABI increased from 0.92 (IQR: 0.5) at baseline to 1.06 (IQR: 0.2) after the intervention, with the change achieving statistical significance (P < 0.001) as determined by the paired Wilcoxon Signed Rank test. Similarly, female participants (n = 42) experienced a significant enhancement in ABI, with the median value rising from 0.94 (IQR: 0.4) pre-intervention to 1.09 (IQR: 0.2) post-intervention (P < 0.001).

These results indicate that the intervention was effective in improving ABI values—a marker of vascular function—in both male and female cohorts, with statistically significant gains observed in each group. The comparable improvements across genders underscore the potential of the intervention in positively influencing arterial health regardless of gender differences.

Table 4. The Difference of ABI Before and After Intervention Between Male and Female

Characteristics	Male (n = 42)	P	Female (n = 95)	P
Blood Pressure mmHg- Mean±SD				
SBP- Brachial				
Pre Intervention	156.6±22.4	0.000	142.9±21.6	0.000
Post Intervention	143.6±18.9		134.9±16.7	
DBP-Brachial				
Pre Intervention	98.1±12.6	0.021	88.2±14.0	0.748
Post Intervention	92.6±12.3		87.7±11.5	
SBP- Ankle				
Pre Intervention	156.0±33.9	0.579	142.8±31.3	0.000
Post Intervention	158.9±28.2		152.9±25.1	
DBP- Ankle				
Pre Intervention	105.8±17.2	0.019	99.9±15.9	0.982
Post Intervention	98.7±18.1		100.1±15.2	
MAP-Brachial				
Pre Intervention	117.6±14.3	0.000	106.5±14.9	0.007
Post Intervention	109.6±12.9		103.4±12.1	
MAP-Ankle				
Pre Intervention	122.5±20.9	0.111	114.2±19.3	0.027
Post Intervention	118.8±19.2		117.7±16.8	

SD, standard deviation; SBP, systolic blood pressure; DBP, diastolic blood pressure; MAP, mean arterial pressure

Table 4 presents a gender-stratified analysis of blood pressure parameters measured at the brachial and ankle levels, as well as the corresponding mean arterial pressures (MAP), before and after the intervention. For male participants, the intervention was associated with significant reductions in brachial systolic blood pressure (SBP), with values decreasing from 156.6 ± 22.4 mmHg pre-intervention to 143.6 ± 18.9 mmHg post-intervention (P < 0.001). Similarly, brachial diastolic blood pressure (DBP) also decreased significantly (P = 0.021) as well as the brachial MAP (P < 0.001). In contrast, while the ankle SBP in males showed an increase, this change was not statistically significant (P = 0.579). However, the ankle DBP decreased significantly from 105.8 ± 17.2 mmHg to 98.7 ± 18.1 mmHg (P = 0.019), and the ankle MAP exhibited a nonsignificant reduction from 122.5 ± 20.9 mmHg to 118.8 ± 19.2 mmHg (P = 0.111).

For female participants, a significant increase was observed in brachial SBP (P < 0.001), while ankle SBP was observed to be significantly increasing (P < 0.001). In contrast, brachial and ankle DBP remained unchanged (P = 0.748 and P = 0,982). The brachial MAP in females also decreased significantly from 106.5 ± 14.9 mmHg to 103.4 ± 12.1 mmHg (P = 0.007). Interestingly, the ankle SBP in females increased significantly from 142.8 ± 31.3 mmHg to 152.9 ± 25.1 mmHg (P < 0.001), while the ankle DBP remained unchanged (P = 0.982).

Table 5a. Binary Logistic Regression of Pre and Post Intervention (Male)

Pre Intervention	*ABI Post Intervention*	OR

	Normal (ABI 0.9-1.4)	Abnormal (ABI<0.9 or >1.4)	
Normal (ABI 0.9-1.4)	19	2	2.9 (95%CI 0.5 - 17.4) P = 0.228
Abnormal (ABI<0.9 or >1.4)	16	5	

ABI, ankle brachial index; OR, odds ratio, CI, confidence interval

We continued the analysis of finding the clinical significance of golf ball exercise in each gender. Table 5a presents a binary logistic regression analysis among male participants to assess the association between baseline and post-intervention ABI status. Among those with normal baseline ABI (0.9–1.4), 19 remained normal post-intervention while 2 shifted to an abnormal category (<0.9 or >1.4). Conversely, of those with abnormal baseline ABI, 16 achieved normal ABI and 5 remained abnormal.

Table 5b. Chi-square test of Pre and Post Intervention (Female)

Pre Intervention	*ABI Post Intervention*		P Value(b)
	Normal (ABI 0.9-1.4)	**Abnormal** (ABI<0.9 or >1.4)	
Normal (ABI 0.9-1.4)	46	0	0.000
Abnormal (ABI<0.9 or >1.4)	32	17	

(b) Chi-square test; ABI, ankle brachial index; OR, odds ratio, CI, confidence interval

The odds ratio (OR) for a normal post-intervention ABI in males with a normal baseline was 2.9 (95% CI: 0.5–17.4; P = 0.228). On the other hand, in female participants the association between baseline and post-intervention ABI status was statistically significant (P = 0.000), indicating a strong relationship between initial ABI classification and subsequent outcomes in this population (Table 5b).

Discussion

This study evaluated the effect of a golf ball foot exercise regimen on the Ankle Brachial Index (ABI) in patients with diabetes mellitus (DM). Key findings demonstrated that a 14-day program, with exercises performed twice daily, resulted in a significant increase in ABI. Subgroup analyses by gender revealed similar improvements in both male and female participants. Patients with DM are predisposed to chronic complications resulting from vascular damage and increased blood viscosity (Conte et al., 2019; Thomas et al., 2021; Venguidesvarane et al., 2020), with peripheral vascular issues being among the most common complications (Conte et al., 2019; Takahara, 2021). In type 2 DM, chronic hyperglycemia leads to increased reactive oxygen species (ROS) production and reduced nitric oxide (NO) bioavailability, causing endothelial dysfunction and impaired arterial elasticity, which facilitate atherosclerotic plaque formation (Mandal et al., 2022; Tan et al., 2022; Volpe et al., 2018). These vascular changes compromise systemic circulation, particularly in the lower extremities, thereby elevating the risk of foot trauma and related complications (American Diabetes Association, 2022; Farida et al., 2022). Previous studies have reported notable improvements in ABI following foot exercise interventions in DM patients (Farida et al., 2022; Venguidesvarane et al., 2020). Moderate-intensity exercise has the potential to improve endothelial function, insulin sensitivity, and peripheral blood flow and improve vascular function in patients with DM, which in turn help prevent common vascular complications. (Ilias et al., 2025; Ramadhan et al., 2025). However, to date, the specific impact of golf ball training on ABI in Indonesian DM patients has not been investigated. Consequently, although lower limb training appears beneficial, further research is required to confirm the efficacy of golf ball-based interventions in this setting.

The physiological basis of the golf ball intervention is attributed to the mechanical stimulation produced when a dimpled golf ball is rolled across the plantar surface. This action stimulates localized nerve fibers, resulting in muscle contractions and enhanced glucose uptake, thereby promoting the utilization of blood sugar for energy production (Halperin et al., 2014; Shetty & Roman D'souza, 2018; Stambolieva et al., 2017; Sullivan et al., 2013). Moreover, the repetitive motion inherent in the treatment is thought to improve blood circulation in the lower extremities (R. Dewi et al., 2024; Shetty & Roman D'souza, 2018; Shuang et al., 2024). In one study, a protocol combining passive stretching with golf ball rolling—performed for 30 seconds per set over three sets for three consecutive days—yielded a significant improvement in muscle flexibility compared with a control group ($p < 0.001$), with flexibility scores improving from 14.9 ± 4.5 to 4.5 ± 4.3, reflecting an average change of 10.4 ± 1.9 (Shetty & Roman D'souza, 2018). Additionally, roller massage has been shown to increase the range of hip flexion by 4.3% immediately after 5 to 10 seconds of hamstring rolling in patients with DM (Sullivan et al., 2013). In this study, a 14-day program, with exercises performed twice daily, resulted in a significant increase in ABI. A two-week regimen of single-leg exercise enhanced in vivo oxidative metabolism in individuals with type 2 diabetes, whereas no such improvement was observed in non-diabetic matched controls (Scalzo et al., 2022). Multiple studies have indicated that even brief exercise programs lasting under two weeks can provide benefits for individuals with vascular disorders and peripheral artery disease (PAD), including enhanced circulation and greater tolerance to pain (Hallak et al., 2023; Iimura et al., 2022; Soyoye et al., 2021). Future investigations should take into account extending the intervention period and incorporating follow-up assessments after the program to determine the sustained impact of golf ball foot exercises over the long term.

In this study, the majority of participants were female. Elevated diabetes mellitus prevalence among women has been associated with decreased estrogen levels, particularly during menopause (Mauvais-Jarvis et al., 2017; Paschou & Papanas, 2019). Furthermore, estrogen and progesterone influence circulating insulin levels (Merino & García-Arévalo, 2021; Ramadhan et al., 2025; Yan et al., 2019). According to International Diabetes Federation data from 2021, the global prevalence of diabetes among individuals aged 20–79 years is 10.5%, affecting approximately 536.6 million people with a nearly equal distribution between males and females (International Diabetes Federation, 2021). However, no study to date has specifically examined the effect of hormonal factors on the efficacy of golf ball foot exercises in patients with diabetes mellitus. Therefore, further research is warranted to elucidate the impact of hormonal influences on the therapeutic response to this intervention.

The limitation of participant age to the 36–59 year range in this study was intended to minimize physiological variability commonly observed in older adults, including the presence of multiple comorbid conditions (Divo et al., 2014; Jaul & Barron, 2017; Ngcobo, 2025), declines in both motor and cognitive abilities (Fastame et al., 2023; Manderson et al., 2025; Ward et al., 2020), and an increased risk of falls (Giovannini et al., 2022; Xiong et al., 2024), all of which could potentially interfere with the execution of foot exercise interventions and compromise the precision of Ankle Brachial Index (ABI) assessments (Bareiro et al., 2024; Espeland et al., 2015). Future research could involve older adult populations by employing customized intervention strategies and incorporating peripheral nerve function screening beforehand, considering the greater incidence of vascular and neuropathic complications typically observed in this age group.

Implications and limitations

This study provides valuable insights into the potential of foot exercise interventions using golf ball treatment to prevent vascular complications in patients with diabetes mellitus (DM). The observed increase in the ankle-brachial index (ABI) suggests improved peripheral blood circulation, which may reduce the risk of lower extremity ischemia and diabetic foot ulcers—common complications in DM resulting from impaired blood flow. From a nursing perspective, these findings support the implementation of simple foot exercises as an effective, cost-efficient, and easily deployable non-pharmacological intervention in both clinical settings and home-based self-care. Furthermore, these results underscore the importance of patient education and health promotion strategies to encourage routine foot exercise, thereby maintaining vascular function and mitigating long-term complications.

Nurses play a pivotal role in instructing patients on the benefits, proper techniques, and appropriate frequency of these exercises to maximize therapeutic outcomes.

This study employed a one-group, pre-posttest, pre-experimental design that presents several limitations. Foremost, the absence of a control group restricts the ability to attribute observed changes in ABI solely to the golf ball foot exercise intervention, as other factors such as alterations in physical activity or enhancements in diabetes management may have contributed. Additionally, as a pilot study with a relatively small sample size, the findings may have limited generalizability to the broader population. Nonetheless, in this study we have performed serial measurement of ABI before and after intervention and thus paired test used accordingly incorporating its benefit to the analysis. In addition, the participants were drawn from various regions in Surabaya city, providing a diverse representation. Importantly, no prior studies have specifically assessed the effect of golf ball exercise on ABI values in DM patients in Indonesia, underscoring the novelty and exploratory nature of these results. Furthermore, the absence of standardized instructional videos that participants can replay, along with the lack of structured checklists for daily reporting, may increase the risk of bias due to variations in movement execution. Ultimately, the lack of screening procedures for peripheral neuropathy should be addressed in future research to improve the study's validity.

Conclusions

The results indicate that performing foot exercises using a golf ball, performed twice daily for five minutes over 14 consecutive days, significantly improves ABI values in patients with diabetes mellitus (DM). Normalization of ABI in these patients may reduce the risk of peripheral arterial disease (PAD) and subsequent amputation. There has been no previous study has specifically examined the effect of golf ball exercises on ABI values in Indonesian DM patients, rendering the present investigation a pilot study. These findings reinforce the potential of simple, inexpensive, and effective non-pharmacological interventions to support vascular health in the diabetic population. Moreover, sustained compliance with this intervention could be facilitated through integration into health center programs, supported by family involvement and supervision by healthcare professionals, along with the development of standardized guidelines for golf ball foot exercises.

Acknowledgements

We would like to express our gratitude to the Primary Health Center as the research location in Surabaya City which has helped and provided policies during the research process, all participants involved in this research.

Financing

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

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