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Effects of brisk walking on fasting blood glucose and blood pressure in diabetic patients

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Background: Aerobic exercises have been administered as an adjunct treatment for health conditions; however, the effects of brisk walking on Type 2 diabetes mellitus (T2DM) patients living with hypertension in Ghana are yet to be explored.

Aim: To determine the effects of brisk walking on fasting blood glucose and blood pressure of patients with T2DM living with hypertension in Ghana.

Setting: The National Diabetes Management and Research centre at Korle-Bu Teaching Hospital.

Methods: Males and females above 18 years with T2DM and hypertension were included. Fasting blood glucose, anthropometric measurements and distance walked were measured at baseline and after 8 weeks of intervention. The intervention consisted of brisk walking three times a week for 8 weeks.

Results: Sixty participants completed the intervention. There was a statistically significant reduction of fasting blood glucose (baseline: 8.79 mmol/L (3.55), after intervention: 7.62 mmol/L (2.73) with $p = 0.02$) and blood pressure levels: (systolic blood pressure baseline: 141.12 mmHg (2.91) after intervention 120.75 mmHg (1.21) with $p = 0.00$); diastolic blood pressure (baseline: 80.78 mmHg (1.66), after intervention mmHg 69.38 (1.05) with $p = 0.00$) between baseline and post-intervention.

Conclusion: Eight weeks of brisk walking reduced the levels of fasting blood glucose and blood pressure in patients with T2DM and hypertension.

Contribution: This study will enlighten healthcare workers about the integration of brisk walking as a possible adjunct to control blood glucose and blood pressure levels in patients with T2DM and hypertension.

Keywords: brisk walking; aerobic exercise intervention; fasting blood glucose; blood pressure; Type 2 diabetes; hypertension; Ghana.

Introduction

Hypertension and Type 2 diabetes mellitus (T2DM) are known diseases of lifestyle with common pathophysiological pathways, especially in people who suffer from metabolic syndrome.[1] It is estimated that almost two-thirds of the population with T2DM is also affected by hypertension.[1] Co-existence of the micro and macro vascular risk factors leads to a four-fold increased risk for cardiovascular disease.[2] The magnitude of simultaneous prevalence of T2DM and hypertension depends on age, body mass index (BMI) and ethnicity. In patients with T2DM, hypertension usually presents early and in combination with other cardiovascular risk factors.[3] Currently, the prevalence of T2DM has been increasing in Ghana.[4] A report from a recent population-based study indicates that between 3.3% and 6% of Ghanaian adults are living with diabetes mellitus (DM).[5] Another report from the International Diabetes Federation (IDF) showed that a total of 450 000 Ghanaians were living with the disease as at 2014, and this is estimated to reach 820 000 by 2035 with a mortality rate of 8.6% in adults.[6] A high rate of hypertension was found to be associated with low levels of awareness, drug treatment and blood pressure control.[7] The prevalence of hypertension, blood pressure (BP) ≥ 140/90 mmHg and ≥ 160/95 mmHg, was 25.4% and 15.2%, respectively. Approximately 32.3% of patients with hypertension are aware they have high blood pressure. Only 16.7% of patients living with hypertension had their blood pressure under control (< 140/90 mmHg).[7]

The adoption and maintenance of physical activity are critical foci for blood glucose management and overall health in individuals with T2DM and hypertension.[8] Guidelines for the management of non-communicable diseases recommend that people with diabetes should engage in at least 150 min of moderate to vigorous aerobic exercise per week.[9] A study conducted in the Ho municipality of Ghana concluded that high levels of inactivity, uncontrolled glycaemia and blood pressure exist.[10] Physical activity estimates among participants were 21.3%, 48% and 30.7% for high, moderate and low physical activity respectively. Glycaemic control among the study participants was 33.3%, and blood pressure control was 58.7%. Both glycaemic and blood pressure control were significantly associated with physical activity.[10] Hence, glycaemic and blood pressure control may be modulated by moderate-intensity physical activity.[10]

Regular aerobic exercise has a variety of effects that protect against heart disease and other diseases of the blood vessels, including hypertension. In a critical review of clinical trials, it was found that physical activity reduces blood pressure by 6 mmHg – 7 mmHg for both systolic and diastolic blood pressure, which compares favourably with studies of pharmacological treatment.[11] Physical activities, including circuit weight training, lowered blood pressure and daily activity, produced greater blood pressure reduction than when performed three times per week.[11] It was therefore concluded that physical activity has an independent capacity to lower blood pressure.[11] Studies with large numbers of participants have shown that a 5 mmHg reduction of systolic blood pressure results in 14% decrease of deaths from strokes and a 9% decrease of deaths from coronary heart diseases.[12,13,14] Studies have shown that aerobic exercise reduces systolic and diastolic blood pressure in patients with T2DM and essential hypertension.[15,16] Patients with diabetes who took part in supervised exercises recorded long-term improvements in blood glucose control and insulin sensitivity more than the patients who engaged in home exercises that were not supervised.[17,18] Brisk walking is a popular form of low to moderate-intensity physical activity, which has been linked to a variety of health gains. For example, the amount[19] and pace[20] of regular walking have been associated, respectively, with lower risk of all-cause mortality and coronary attack. Moreover, epidemiological studies investigating the relationships between physical fitness and mortality rates highlight that the greatest public health gains might be achieved from improving the level of physical fitness in sedentary individuals.[21] Intervention studies have demonstrated that brisk walking has the potential to improve fitness in sedentary men and women.[22,23] What is not known, however, is the effects of brisk walking on patients with T2DM living with hypertension in Ghana. Thus, the purpose of this study is to determine the effects of brisk walking on fasting blood glucose and blood pressure of patients with T2DM living with hypertension in Ghana.

Methods

A pre- and post-quasi-experimental design was used. Both male and female adults were recruited using a simple random sampling method. A sample size of at least 59 participants was determined to have 90% power to detect a clinically relevant lowering of at least 1.8% mmol/L in glucose levels after 8 weeks of aerobic exercise training. In this study, the baseline results of the participants were compared with the post-intervention results of the same individual. The study was conducted at the National Diabetes Management and Research Centre (NDMRC) in Korle- Bu Teaching Hospital (KBTH), Accra and the Department of Physiotherapy of the University of Ghana, KBTH Campus. Patients were recruited from NDMRC and the aerobic exercise protocol was conducted at the Department of Physiotherapy of the University of Ghana all in KBTH.

Study population

Sixty male and female outpatients diagnosed with T2DM living with hypertension above the age 18 years who sought medical management at the NDRMC, KBTH were recruited between November 2020 and April 2021. Included patients were ambulant and diagnosed with T2DM and hypertension for more than 6 months who were receiving treatments at the NDMRC who were on their anti-hypertensive medications. The exclusion criteria were patients with uncontrolled T2DM (fasting glucose levels >25 mmol/L) and hypertension (systolic >180 mmHg, diastolic >100 mmHg). Patients who are newly diagnosed with cancer, unstable angina, myocardial infarction and treated within the previous 6 months after diagnosis and patients with neurological problems such as aphasia that result in communication and cognitive impairments were also excluded.

Measured variables

The study and its purpose were explained to all outpatients, and consent was obtained from those patients who volunteered and met the inclusion criteria to participate in the study. The demographic data such as age and gender as well as medication taken and medical regimen such as time of last meal; acute illness was obtained using a data capturing form. The data capturing form, informed by literature and pre-tested through the pilot study, consisted of two parts. **Part A:** comprised personal information such as code, folder number, gender, date of birth, age, address, telephone number, next of kin, level of education and mode of transportation.

Part B: comprised of health information such as diagnosis, medications, anthropometric measurements and blood chemistry.

Approximately 5 mL of blood sample was collected by a Biomedical Scientist at the NDMRC from each participant following an overnight fast. Blood samples were drawn from the cubital vein of the arm using a needle and syringe. Blood was stored in a cooler box and was sent off to the central laboratory of KBTH for testing the fasting blood glucose levels. The test was carried out at baseline and at the end of 8 weeks' intervention. Baseline test results were submitted to the researcher a week after blood samples were sent to the laboratory. The participants' blood pressure was measured daily while resting in a chair according to guidelines using an electronic Omron blood pressure machine that displays both systolic and diastolic blood pressure and heart rate.

Participants were given 5 min rest before taking the measurements and remained still during the measurements. Two measurements were taken by the researcher with a 1-min rest interval. The machine was reset after each participant, and the mean blood pressure reading was used. All measurements were taken on each day of exercise, before each participant engaged in brisk walking and after each bout of exercise.

The anthropometric measurements below were taken by the researcher at baseline and at the end of the intervention (8 weeks). Each participant's body weight was measured using a calibrated bathroom scale at the NDMRC which was zeroed after each participant. All measurements were rounded to the nearest 0.1 kilogram.

A stadiometer (manufactured by IndoSurgicals private company, India) was used to measure height in standing against the wall. A long ruler of the stadiometer was in line with the vertex of the head. All measurements were rounded to the nearest 0.1 centimetre**.** The BMI was calculated using the patient's weight and height. The formula is kg/m^2. The waist-to-hip ratio (WHR) was taken using a tape measure (manufactured by Lokpal industries, China) around the umbilicus and the greater trochanter.

A six-minute walk test (6MWT) developed by the American Thoracic Society in 2002 was conducted by the researcher at baseline and at the end of 8 weeks. Resting heart rate was recorded from Omron portable blood pressure machine (manufactured by Contec Medical Systems company, China) before engaging in 6MWT.

The 6MWT was performed on a walking track that was marked at the physiotherapy department of UG, KBTH. A 30-metre track was marked off in a quiet corridor closer to the emergency department. Intervals of one metre (1 m) were also marked clearly for accuracy. In case any of the participants were unable to complete a full 30 m distance for one lap, chairs were placed in the middle and at the endpoint of 30 m. All participants were given 10-min' rest when they arrived at the hospital outpatient department prior starting the 6MWT. During this time, blood pressure and heart rate were measured. Before the 6MWT started, each participant rated their level of exertion using the rate of perceived exertion (RPE) scale.[24] This scale was used to record the participant's perception of how hard the body is working when exercising. The RPE scale runs from 0 to 10.[24] Participants were asked by the researcher to rate how hard they were working by assigning numbers to how they feel, from 0 to 10. The researcher demonstrated how participants were expected to walk in the marked distance before the test began. Participants were allowed to rest when feeling tired without stopping the clock. At the end of the 6MWT or when the participants indicated that they could not go further, the test was stopped and the distance covered measured and recorded. At the end of the test, each participant was asked to rate their level of exertion. Heart rate and blood pressure levels were measured immediately at the end of the activity and after 6 min rest. Figure 1 shows the sequential steps followed by the researcher to assess the participants before engaging in the 8 weeks brisk walking intervention.

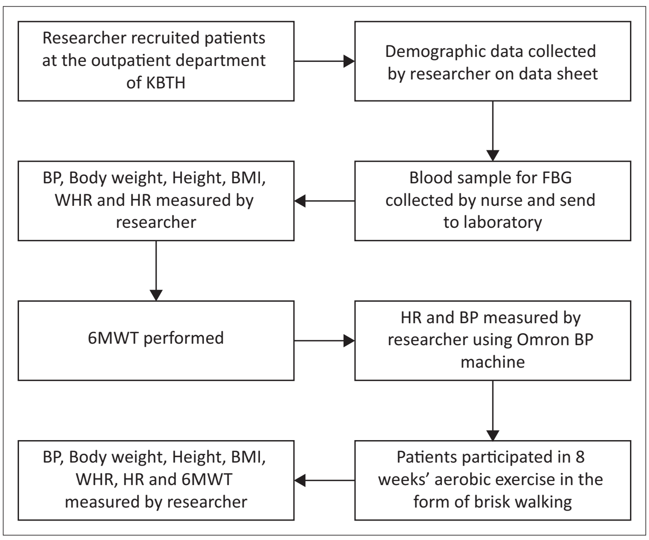
Intervention

Aerobic exercise protocol

On the day of exercise, heart rate and blood pressure were measured before and after exercise. Each participant engaged in a supervised brisk walking (aerobic exercise) intervention three times per week on Mondays, Wednesdays and Fridays. The intervention commenced a week after the 6MWT was carried out. An open space between the physiotherapy department and the emergency unit was used for brisk walking. Time was used as an outcome measure while walking. Participants were encouraged to walk at a minimum time of 6 min and built their walking time steadily until they could walk for 12 min in the 1st week. All participants walked (at a pace of about 100 steps per minute) for 12 min in the 1st week to the end of the 4th week, the time was increased to 15 min on the 5th week to the end of the 6th week. Time was increased again from 15 min to 20 min in the 7th week until the last day of the intervention (week 8, day 3). Heart rate and blood pressure were measured after the participant rested for 5 min. A research assistant, who is a qualified physiotherapist and had undergone training assisted with the supervision of participants when performing brisk walking. After the end of 8 weeks, all the baseline tests mentioned under procedure were re-evaluated by the researcher. Participants walked in groups of 4–6 participants, with a total of 16–20 participants in a day.

Data analysis

STATA series 11 statistical package (StataCorp LLC, Texas, United States) was used to analyse the data. Statistics



KBTH, Korle-Bu Teaching Hospital; BP, blood pressure; HR, heart rate; 6MWT, six-minute walk test; BMI, body mass index; WHR, waist-to-hip ratio; FBG, fasting blood glucose.

FIGURE 1: Sequential steps of the study.

pertaining to changes in fasting blood glucose levels, blood pressure levels, distance walked during the 6MWT were summarised using mean and standard deviation at a 95% confidence interval. Categorical data were summarised using frequency, percentage and possible cross tables. A paired *t*-test was used to compare 8 weeks of blood glucose with baseline as well as to compare 8 weeks of systolic and diastolic blood pressure with averages of week 1 and week 8. Similar analysis was employed for calculating the distance walked during the 6MWT and the reported RPE. Testing was done at the 0.05 level of significance.

Ethical considerations

Ethical clearance to conduct this study was obtained from the Faculty of Health Sciences Research Ethics Committee of the University of Pretoria (No. 779/2019) and the Korle Bu Teaching Hospital Scientific and Technical Committee (KBTH-STC/IRB/00015/2020). Informed consent of the participants was obtained before recruiting them into the study. Only patients who gave their consent participated in the study.

Results

A total of 60 participants who were on their glucose and blood pressure-lowering medications completed the aerobic exercise protocol. As shown in Table 1, the majority of participants were females in their middle age, living with diabetes and hypertension for more than 5 years and did not have formal education with the majority of them coming to the study site with public transport. There was no loss to follow up on participants.

TABLE 1: Description of the study population.

Demographics	Frequency (n = 60)	%
Gender		
Male	8	13
Female	52	87
Age (years)		
18–24	1	2
25–49	9	15
50 and above	50	83
Medications		
Nifedipine	34	57
Amlodipine	26	43
Metformin	49	82
Glimepiride	11	18
Years of diagnosis		
< 1	7	12
1–5 years	17	28
> 5 years	36	60
Disease diagnosed first		
Type 2 diabetes mellitus	48	80
Hypertension	12	20
Educational status		
Primary	13	22
Secondary	12	20
Tertiary and above	8	13
None	27	45
Mode of transport		
Public transport (taxi and trotro)	53	88
Private (owned) transport	7	12

There was a statistically significant reduction (p = 0.02) between the mean of the baseline and the mean after the end of the 8th week of intervention in the fasting blood glucose levels and blood pressure (Table 2). However, medications that the participants were on remained the same throughout the 8 weeks of intervention. There was no record of adverse events of angina, restlessness or hypoglycaemic events as participants were advised to sit or rest if they felt tired at any point.

Participants increased the distance walked compared with baseline with and the rated exercised to be comfortable when using the RPE. This change was statistically significant, p = 0.00. Body mass index did not change after the end of the 8 weeks of aerobic exercise, p = 0.26. Waist-to-hip ratio decreased, and this change was statistically significant, p = 0.01. The increased distance over the 6-min test was ~60 m.

Discussion

The findings of this study showed that there was a significant difference between fasting blood glucose levels, blood pressure and 6MWT at baseline and at the end of 8 weeks of doing supervised brisk walking. Reduction in blood glucose levels may be because of the conversion of blood glucose to glycogen to produce energy during the exercise that facilitates muscle glucose uptake and thus lowers blood glucose levels.[25,26] The majority of patients with T2DM and hypertension may experience improved glycaemic control in response to a range of pharmacological and dietary

TABLE 2: Fasting blood glucose and blood pressure of study participants at baseline and after the intervention.

Variable (n = 60)	Baseline Mean ± s.d.	After intervention Mean ± s.d.	95% CI		P**
			Before	After	
FBG (mmol/L)	8.79 ± 3.55	7.62 ± 2.73	7.87–9.71	6.91–8.32	0.02*
SBP (mmHg)	141.12 ± 2.91	120.75 ± 1.21	135.35–146.98	118.33–123.17	0.00*
DBP (mmHg)	80.78 ± 1.66	69.38 ± 1.05	77.46–84.11	67.28–71.48	0.00*

Note: Participants increased the distance walked compared to baseline with a decreased rate of perceived exertion (RPE). This change was statistically significant, p = 0.00 in Table 3.

FBG, fasting blood glucose; SBP, systolic blood pressure; DBP, diastolic blood pressure; s.d., standard deviation; CI, confidence interval.

*, Indicates statistical difference; **, $p < 0.05$.

TABLE 3: Exercise capacity and anthropometric measurements of study participants at baseline and after intervention.

Variable (n = 60)	Baseline Mean ± s.d.	After intervention Mean ± s.d.	95% CI		P**
			Before	After	
Resting heart rate (bpm)	74.20 ± 9.78	73.37 ± 9.74	71.67–76.73	70.85–75.88	0.73
6MWT (m)	359.55 ± 79.85	421.02 ± 65.56	338.92–380.18	404.08–437.95	0.00*
Borg scale (peak RPE)	7.17 ± 0.87	5.19 ± 0.97	6.94–7.39	5.72–6.22	0.00*
BMI (kg/m^2)	33.17 ± 8.23	32.97 ± 7.66	31.04–35.29	30.96–34.94	0.26
WHR (m)	0.85 ± 0.07	0.83 ± 0.06	0.83–0.87	0.81–0.85	0.01*

6MWT, six-minute walk test; RPE, rate of perceived exertion; BMI, body mass index; WHR, waist-to-hip ratio; bpm, beats per minute; s.d., standard deviation; CI, confidence interval.

*, Indicates statistical significance; **, $p < 0.05$.

interventions as well as physical activity.[27] Lack of adequate encouragement for the patients, education, inaccessibility of sports sites[28] and problems caused by the pathophysiology of the disease are among the barriers to exercise[29] among these patients. Despite the various obstacles to motivating patients to exercise, a structured exercise programme that involved warm up, ergonomic cycling and cool down, three times a week for a period of 8 weeks is reported to contribute to better control of their blood glucose levels.[30] The mean systolic blood pressure reduced from 142 mmHg to 135 mmHg while the mean diastolic blood pressure also reduced from 89 mmHg to 84 mmHg post exercises. The baseline and 8 weeks post-exercise average blood glucose level was 8.0 mmol/L and 5.2 mmol/L, respectively.[30] However, this current study seems to suggest that regular brisk walking improves blood glucose levels and blood pressure. There is a minimal requirement of equipment yet very effective and less costly. Walking as an aerobic exercise and research about the effects of aerobic exercise on blood glucose in patients with diabetes has reported similar results;[30,31,32,33] hence the patient group can incorporate brisk walking in their activities of daily living to achieve the reported results.

The findings of this study also showed a significant reduction in blood pressure following the 8 weeks' intervention. The paired *t*-test was used to compare baseline systolic blood pressure levels directly with the final readings of systolic blood pressure levels after 8 weeks of undergoing aerobic exercises three times weekly. The test showed that there was a significant difference between systolic blood pressure levels after 8 weeks of intervention. Post-exercise hypotension may be the reason for the reduction in systolic blood pressure. This is because during repeated sessions of exercise, there is a regular decrease in the peripheral vascular resistance in diastolic blood pressure.[34] Effective aerobic exercise has been shown to elicit adaptations to both the molecular and macroscopic levels. These adaptations profoundly impact the two most affected organ systems (musculoskeletal and cardiovascular) enabling more efficient oxygen delivery, endurance capacity and improved performance.[34] Meanwhile, previous research also reported that exercise training altered the balance between vasodilatation and vasoconstriction-related cytokines, such as nitric oxide[35] prostacyclin and thromboxane,[36] thereby increasing the diameter of the blood vessels and increasing blood flow. This is in line with other findings that reported that aerobic exercise is able to reduce both systolic blood pressure in both male and female patients with hypertension.[37,38] Aerobic exercise is one of the non-pharmacological treatment methods recommended by European and American hypertension guidelines to reduce blood pressure.[39] It is reported that aerobic exercise is able to reduce both systolic and diastolic blood pressure in both male and female patients with essential hypertension.[38] The paired *T*-test showed a difference between diastolic blood pressure at baseline and diastolic blood pressure at the end of the 8 weeks of undergoing aerobic exercises. Baseline and final readings of diastolic blood pressure levels may have changed because of consistent participation in aerobic exercise, which may have led to the reduction in peripheral vascular resistance.[35] The exercise produced further reduction of blood pressure especially during diastole. These results indicate that brisk walking can be used as a potent non-pharmacological tool for the treatment of hypertension in patients with T2DM. It could be acknowledged that aerobic exercise in a form of brisk walking plays a critical role in the reduction of systolic and diastolic blood pressure in patients with T2DM living with hypertension.[40] However, blood pressure could also be influenced by other factors relating to regular social interactions, especially group interactions as participants had supervised sessions.

The results of this study showed that there was no statistically significant difference in body weight, even though there was a small reduction at the end of 8 weeks of intervention compared to baseline. Body mass index at the end of 8 weeks of brisk walking (aerobic exercise) also showed a trend of reduction when compared to baseline measurements; however, this finding was not statistically significant. Waist-to-hip ratio, however, showed a decrease at the end of intervention compared to baseline, and the difference was statistically significant ($p = 0.01$). This implies that the 8 weeks of consistent brisk walking caused reduction of fat around the waist of the participants, even though body weight and BMI were not statistically significant. These results are similar to a study that suggested that healthcare providers can introduce rehabilitation programmes such as brisk walking to empower patients to alleviate disease complications and reduce individual and social costs of chronic and cardiovascular diseases.[41] This finding is also in conformity with a study that concluded that visceral fat reduction was significantly related to weight reduction during aerobic exercise intervention.[42] Although a significant visceral fat reduction may occur without a significant weight loss, aerobic exercise, such as brisk walking, light jogging or stationary ergometer usage, is required for visceral fat reduction. However, there is a dose–response relationship between aerobic exercise and visceral fat reduction in obese persons with metabolic-related disorders such as T2DM and hypertension.[41,42] According to Tuomilehto et al., aerobic exercise for more than 4 h on a weekly basis could reduce the fasting blood glucose in patients with T2DM without weight loss.[43] Relatively low weight loss is reported to reduce the risk of T2DM.[44] Another study reviewed the effect of regular exercise and concluded that total, visceral and subcutaneous fat decrease occurs following the regular exercise and improved diabetes via glycaemia control and increase of free fatty acids oxidation without weight loss.[45] However, the decrease in BMI may be seen by the combination of endurance exercise and aerobic training.[46] Some studies have reported that lifestyle modifications including exercises have positive effects on weight loss, waist circumference, fasting blood glucose and blood pressure when patients adhere to prescribed medications.[44,47,48] Aerobic exercise improves human body fat metabolic enzyme activity, accelerates fat decomposition and utilisation and effectively inhibits fat synthesis.

Therefore, a suitable aerobic exercise intervention gradually eliminates fat accumulation in the body and improves glucolipid metabolism and insulin resistance.

Heart rate results showed no statistical significance at the end of 8 weeks of intervention, $p > 0.05$. The distance walked using a 6MWT and Borg scale were statistically significant, with $p = 0.00$ and $p = 0.00$, respectively. This implies that participants improved in their aerobic capacity and endurance to walk better than they started and hence improved the ability of patients in the 6MWT and enhanced their functional exercise capacity. The 6MWT is used as cost-effective method to measure exercise capacity. It has been proven to be useful as a prognostic indicator in the treatment of hypertension among patients with T2DM. This finding is in line with a study that revealed that 6MWT and Borg scale values changed significantly after 3 months of exercise.[49] The intensity of exercises was rated to be comfortable when RPE was used for participants in this study. This study supports that 6MWT indicates maximum sustainable exercise that might be related to its predictive value in patients with chronic conditions. The findings of this study suggest that there may be some improvement in endothelial function that may contribute to improvements in blood flow and muscle function.

Conclusion

The findings of this study showed a statistically significant reduction in fasting blood glucose and blood pressure after 8 weeks of brisk walking. There was an increase in distance walked when comparing baseline and post-intervention assessments. Waist-to-hip ratio also decreased after intervention and hence brisk walking could be considered as a part of the management strategies of patients with T2DM.

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Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Authors' contributions

B.O. was principal investigator as this project was for her master's degree; she was involved in the conceptualisation of the proposal, data collection, data analysis and write-up.

C.R.d.B-B. was a co-supervisor who guided the principal investigator in conceptualisation, interpretation of analysed data, putting the draft manuscript and guided to the final product.

J.Q. was a co-supervisor who assisted the principal investigator in data collection, analysis and writing of the manuscript and approved the final product.

M.N. was the main supervisor who was responsible for guiding the student and mentoring the two co-supervisors in the process of postgraduate supervision. Involved in guiding the process from conceptualisation, data collection and analysis interpretation, drafting a manuscript and approving a final product.

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Data availability

Data are kept safe in the university repository and available from the principal investigator, B.O., upon request.

Disclaimer

The views and opinions expressed in this article are those of the authors and do not necessarily reflect the official policy or position of any affiliated agency of the authors.

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