

Impact of a 12-week aerobic exercise training program on anthropometric and metabolic parameters of a group of type 2 diabetes Cameroonian women aged ≥ 50 years

Yves Dahjio^{1*}, Jean Jacques N. Noubiap^{2,3*}, Marcel Azabji-Kenfack⁴, Mickael Essouma⁵, Gabriel Ekali Loni⁶, Arnold Ewane Onana⁶, Mesmin Dehayem⁶, Angeline Mvom⁶, Maurice Njock Tadjore¹, Eugene Sobngwi^{5,6,7}

¹National Youth and Sports Institute, Yaoundé, Cameroon; ²Department of Medicine, Groote Schuur Hospital and University of Cape Town, Cape Town, South Africa; ³Medical Diagnostic Center, Yaoundé, Cameroon; ⁴Department of Physiological Sciences and Biochemistry, ⁵Department of Internal Medicine and Specialties, Faculty of Medicine and Biomedical Sciences, University of Yaoundé I, Yaoundé, Cameroon; ⁶National Obesity Center, Yaoundé Central Hospital, Yaoundé, Cameroon; ⁷Laboratory for Molecular Medicine and Metabolism, Biotechnology Center, University of Yaoundé I, Yaoundé, Cameroon

Contributions: (I) Conception and design: Y Dahjio, MN Tadjore, E Sobngwi; (II) Administrative support: E Sobngwi, MN Tadjore; (III) Provision of study materials or patients: E Sobngwi; (IV) Collection and assembly of data: Y Dahjio, M Azabji-Kenfack, GE Loni, AE Onana, M Dehayem, A Mvom, E Sobngwi; (V) Data analysis and interpretation: Y Dahjio, JJ Noubiap, M Essouma; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

*These authors contributed equally to this work.

Correspondence to: Prof. Eugene Sobngwi, MD, MPhil, PhD. National Obesity Center, Yaoundé Central Hospital and Faculty of Medicine and Biomedical Sciences, University of Yaoundé I, Yaoundé, Cameroon. Email: sobngwieugene@yahoo.fr.

Background: We examined whether aerobic exercise could have an impact on anthropometric and metabolic parameters of type 2 diabetes mellitus (T2DM) Cameroonian women aged ≥ 50 years.

Methods: We enrolled 23 T2DM Cameroonian women aged ≥ 50 years regularly followed at the National Obesity Center of Yaounde, Cameroon, in a 12-week aerobic exercise program monitored by a pedometer. Exercise intensity was progressively set between 55% and 75% of maximum heart rate. We measured weight, body mass index (BMI), fat, lean mass, visceral fat, maximum oxygen uptake, glycaemia and insulin tolerance index at baseline, after six and twelve weeks. A mixed ANOVA model was used to evaluate changes of outcome measures over time.

Results: Total body weight was significantly reduced after 12 weeks ($P < 0.05$), waist circumference after 6 and 12 weeks ($P < 0.05$). There was an increase of the lean mass from 6 weeks ($P < 0.001$) and a reduction of the mean visceral fat at 12 weeks ($P < 0.001$). At the end of the program, the mean glycaemia was significantly decreased ($P < 0.05$), and the maximum oxygen uptake was enhanced ($P < 0.05$).

Conclusions: The 12-week aerobic exercise program improved the anthropometric and metabolic parameters as well as the aerobic capacity of T2DM Cameroonian women aged ≥ 50 years.

Keywords: Aerobic exercise; anthropometric parameters; metabolic parameters; aerobic capacity

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Introduction

Type 2 diabetes mellitus (T2DM) has reached epidemic proportion worldwide, as a result of population growth and ageing, urbanization, and increasing prevalence of obesity and physical inactivity (1). Estimates from the International Diabetes Federation (IDF) indicate that the number of adults with diabetes mellitus in the world will expand by 55%, from 381.8 million in 2013 to 591.9 million in 2035 (2). The largest increase of the prevalence of diabetes will occur in sub-Saharan Africa, with a projected growth of 109.6%, from 19.8 million in 2013 to 41.5 million in 2035 (2).

T2DM is associated with an adverse cardiometabolic profile including hypertension, dyslipidemia, and obesity (3). Alongside pharmacologic treatment, lifestyle modifications including diet, weight management and exercise are important features of the management of T2DM. Physical activity (resistance, or aerobic exercise, or both) has been shown to improve the control of glycaemia along with other cardiovascular risk factors such as hypertension and obesity, and is associated with reduced morbidity and mortality in T2DM patients (4). Thus, the American Diabetes Association recommends at least 150 minutes/week (50–70% of the maximal heart rate) of moderate intensity exercise, and at least thrice-a-week sessions of aerobic exercise to reduce glycaemia and the cardiovascular risk (5).

Cameroon is a low-income country situated in Central Africa. In 2013, the IDF estimated the nation prevalence of diabetes among adults aged 20 to 79 years at 4.8% (2). Glycemic control in known diabetes patients is often very poor; a population based survey in the country showed that only one in four known diabetic patients had optimal fasting blood glucose levels (6). Strategies for an efficient management of diabetic patients in Cameroon are urgently needed. We conducted a pilot study to examine whether a 12-week aerobic exercise program could improve anthropometric and metabolic parameters of a group of T2DM women aged ≥ 50 years followed at the National Obesity Center (NOC) of the Yaoundé Central Hospital. Findings may contribute to designing and implementing routine aerobic exercise program for diabetic patients in the country.

Methods

Ethics statement

The study was granted approval by the National Ethical Review Board of the Cameroon Ministry of Public Health.

Written informed consent was obtained from all the participants. The study was conducted in accordance with the Helsinki Declaration.

Setting, participants and procedure

We conducted a prospective cohort study during three months from February to May 2009. T2DM women aged ≥ 50 years old followed at the NOC were invited to participate in the study. We excluded patients with overt diabetic macro and/or microvascular complications, cardiovascular diseases, comorbid conditions such as cancers or auto-immune diseases. Participants were enrolled in a 12-week aerobic exercise program. During this period, thrice-a-week sessions of physical activity lasting a mean time of 45 minutes each were held, under the supervision of trained personnel. Each session was divided into three periods as follows: warm-up, activity (brisk walking and light running), and cool-down. Step counting was done with a NESTLE pedometer. Aided by pulse recording, activity's intensity was progressively augmented from 55% to 75% of an individual's maximal heart rate obtained from the Fox-Haskell formula (7). Details on the session are provided in Appendix. Participants' diet was closely monitored by a dietician at the NOC. The program was held at the National Institute for Youth and Sport (NIYS). This academic institution which is located in Yaoundé at few kilometers from the NOC, is in charge of the academic training of sports and youth affairs professionals in Cameroon. Anthropomorphic and metabolic parameters during the study were recorded at the NIYS, while the glucose tolerance test was carried out at the NOC.

Outcome variables

Anthropometric and metabolic parameters were measured at baseline, after six weeks of exercise, and at the end of the training program (at 12 weeks), whereas cardiorespiratory and biochemical measurements were carried out only at baseline and after the training program. We measured height and waist circumference to the nearest 0.5 cm, and weight in light clothes to the nearest 0.1 kg, and we then calculated the body mass index (BMI) as weight in kg/height² in m². Metabolic parameters including fat mass, lean mass and visceral fat were also measured to the nearest 0.1%, using the TANITA BC-420 MA impedancemeter.

The maximum oxygen uptake (VO₂ Max) was indirectly

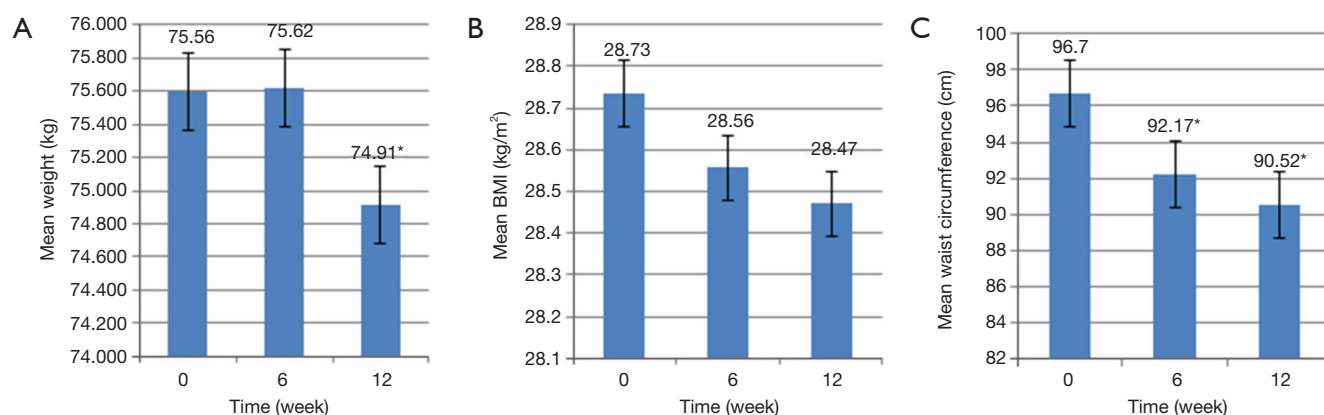


Figure 1 Variations of anthropometric parameters over time. BMI, body mass index. *, P<0.05.

Table 1 Body composition of participants at baseline, after 6 and 12 weeks

Variable	Before exercise (mean ± SD)	After 6 weeks (mean ± SD)	After 12 weeks (mean ± SD)
Fat mass (%)	37.36±6.11	36.37±6.01	36.87±5.52
Lean mass (%)	62.68±6.14	63.44±5.98**	65.82±6.08**
Visceral fat (%)	8.91±2.62	8.69±2.52	7.56±2.23**

SD, standard deviation; **, P<0.001 with reference to the initial value.

evaluated using the Cooper test, and estimated by the formula: where VO_2 Max is the maximum oxygen volume consumed by unit of body weight and by unit of time and expressed in mL/kg/min and d the maximum distance performed by a subject, expressed in km (8).

Glycaemia and insulin sensitivity were monitored at baseline and at the end of the program. Insulin sensitivity was assessed using the KITT method after the short insulin tolerance test as previously described (9).

Statistical analysis

Data was entered, coded and analyzed using the Statistical Package for Social Science (SPSS) version 20.0 for Windows (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp.). Continuous variables were expressed as mean with standard deviation (SD). The ANOVA test was used to assess changes of outcome measures over time. A P value <0.05 was considered statistically significant.

Results

A total of 23 women were enrolled in the study. Their mean age was 56.1 (SD 5.3) years, and the mean duration of diabetes was 8.43 (SD 5.98) years. As shown in *Figure 1*, we found a significant reduction of 0.8 kg of the mean total body weight after 12 weeks (P<0.05), and of waist circumference after 6 and 12 weeks (P<0.05). There was an increase of the lean mass from 6 weeks until the end of the program (P<0.001), and a reduction of the mean visceral fat after 12 weeks (P<0.001) (*Table 1*). The mean glycaemia was significantly decreased by 32.7 (SD 2) mg/dL from the beginning to the end of the program (P<0.05), while insulin sensitivity was not significantly affected (*Figure 2*). Compared to baseline, the maximum oxygen uptake was enhanced by 1.85 mL/kg/min at the end of the program [P<0.05, *Figure 3*].

Discussion

This study was designed to assess the impact of an aerobic exercise training program monitored by a step counter, on anthropometric and metabolic parameters of T2DM Cameroonian women aged ≥50 years. After a 12-week period of exercise, most of the anthropometric and metabolic characteristics of participants were significantly improved, as well as their aerobic capacity.

Previous prospective studies have reported a significant reduction of overall and visceral adiposity markers (weight, waist circumference, visceral fat, and fat mass) after an aerobic training program (10,11) as we observed in this study. Several biological mechanisms could explain this reduced adiposity. For example, excess glucose need in the

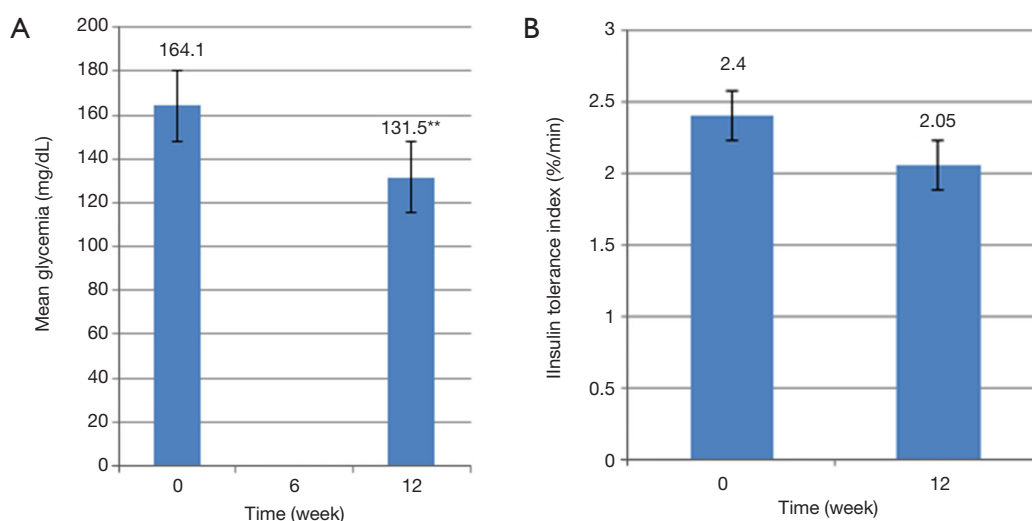


Figure 2 Variations of glycemia and insulin sensitivity before, and after exercise. **, $P < 0.001$.

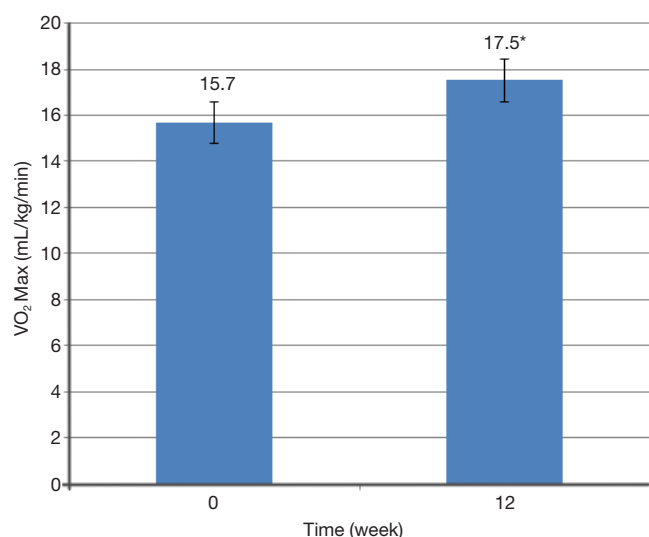


Figure 3 Aerobic capacity of participants before, and after exercise. *, $P < 0.05$.

muscular tissue which is the main “actor” during exercise augments metabolic activities and nutrient exchange (12). Lipid molecules may therefore be converted to glucose during this period through enzymatic pathways. Furthermore, the white adipose tissue which is concerned with an adverse cardiometabolic activity, makes up to 20–25% of the total body weight (13). Total body weight loss is thus certainly accompanied with a reduced white adipose tissue mass. However, this seems to be minor in reducing adiposity during physical activity (11). By restoring

muscular fibers through a good blood flow, the aerobic exercise could have induced the increase of the lean mass observed in this study (14).

Another observation of this study was the markedly decreased glycaemia at the end of the program. This has already been noted by other authors (11). Glucose and glycosylated hemoglobin can be reduced by the only exercise (3,4). Four main mechanisms could explain that result: excess glucose uptake and utilization by the muscle tissue, increased glycogenolysis, increased neoglucogenesis and increased insulin sensitivity. Because of “physiologic muscle hyperemia” and of increased intracellular glucose transporters during exercise, excess glucose and oxygen uptake occurs (11,15). Glycogenolysis restores glucose in the circulation from glycogen, and neoglucogenesis brings more glucose in the circulation from other substrates. Insulin sensitivity may be increased by exercise, especially in the muscular tissue, and mediate glucose uptake (12). We could not verify that hypothesis, as in one work by Jung *et al.* (10). Our study was not designed for a dose-response relationship between insulin sensitivity and aerobic exercise, same as the concerned study of Jung *et al.* This can explain the lack of an observed effect of aerobic exercise on insulin sensitivity in these studies. In fact, another study by Jung *et al.*, showed improved insulin sensitivity after a vigorous aerobic exercise program compared to a moderate aerobic exercise program. To observe the effect of moderate aerobic exercise on insulin sensitivity, more time is usually required. The underlying mechanism of improved insulin sensitivity when the

aerobic capacity is most increased (during exercise) may be the activation of the AMP-kinase pathway (11).

Our participants also showed an increased aerobic capacity after the training period. This is consistent with the results of a meta-analysis of randomized controlled trials assessing the impact of step counting on T2DM patients' aerobic capacity (16). The pedometer could have accounted for this. It has been shown to increase T2DM patients' physical capacity, especially when there is a self-set physical activity goal (16). Physical capacity is expressed by the maximum oxygen uptake which carries its highest value during exercise, in order to meet the muscle needs (12,17). Increase in aerobic capacity could also have driven previous observations (16). In fact, increase in VO_2 Max is closely related to increase in metabolic activities of the cells (12), and therefore to reduced blood levels of nutrients such as glucose and lipids. It is also associated with improvement of the cardiac autonomic function in T2DM patients (18). Furthermore, an increased aerobic capacity is the reflect of a potential good productive capacity at work (17). However, diabetics usually have a reduced exercise capacity which worsens their disease (19). A good training program is thus useful to overcome this situation, as well as to prevent diabetes in healthy populations (20).

There are some limitations that should be taken into consideration when interpreting these data. The small cohort size could be explained by the fact that it was a preliminary study. We cannot separate the effect of exercise per se from that driven by increased aerobic capacity on anthropometric and metabolic parameters in this study. But it was not designed for that purpose.

Conclusions

This preliminary study showed that the 12-week aerobic exercise could positively impact on anthropometric and metabolic parameters of T2DM Cameroonian women aged ≥ 50 years, even on their aerobic capacity. Our findings call for further studies to better assess the possible benefit of an aerobic exercise program among various diabetic populations in Cameroon, and explore ways for implementation in routine management of patients in the country.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: The study was granted approval by the National Ethical Review Board of the Cameroon Ministry of Public Health. Written informed consent was obtained from all the participants. The study was conducted in accordance with the Helsinki Declaration.

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The 12-week aerobic exercise training program for a group of T2DM Cameroonian women aged ≥ 50 years

- (I) First phase (six sessions)
 - (i) Aim: psychic, sensory and motor adaptations
 - (ii) Intensity: $\leq 55\%$ of the maximal heart rate
 - (iii) Periods of a session (48 minutes)
 - ❖ Warm-up (10 minutes)
 - ♦ Walking on site with elevated knee
 - ♦ Round of the horizontal arm
 - ♦ Flexion-extension movements of upper limbs and of lower limbs
 - ♦ Body stretching and joint relaxation
 - ❖ Activity (28 minutes)
 - ♦ Two series of twice repeated walking at a moderate pace, separated by a four-minute interval of recovery, each walking period being separated from the other by two minutes of active recovery
 - ❖ Cool-down (10 minutes)
 - ♦ Stretching, softening and relaxation at the sitting position
- (II) Second phase (five sessions)
 - (i) Aim: cardiovascular, respiratory and musculoskeletal adaptations
 - (ii) Intensity: $\leq 60\%$ of the maximal heart rate
 - (iii) Periods of a session (61 minutes)
 - ❖ Warm-up (10 minutes)
 - ♦ Walking on site
 - ♦ Knee elevation, each hand touching the opposite thigh
 - ♦ Bending the torso towards the knees
 - ♦ Round of the horizontal arm
 - ♦ Airport signal
 - ♦ Hands elevation and standing on tiptoe
 - ♦ Stretching
 - ❖ Activity (41 minutes)
 - ♦ Three series of walking at a moderate pace for 10 minutes, with a $3\frac{1}{2}$ minutes-period of recovery in between series
 - ❖ Cool-down (10 minutes): stretching, softening, relaxation and practical advices
- (III) Third phase (four sessions)
 - (i) Aim: Maintenance of cardiovascular, respiratory and musculoskeletal capacity.
 - (ii) Intensity: $\leq 65\%$ of the maximal heart rate.
 - (iii) Periods of a session (60 minutes)
 - ❖ Warm up (12 minutes)
 - ♦ Five minutes of walking at a moderate pace
 - ♦ Two minutes of active recovery
 - ♦ 5 minutes of stretching
 - ❖ Activity (38 minutes)
 - ♦ Two series of twice repeated walking at a moderate pace, separated by a four-minute interval of recovery, each walking period being separated from the other by two minutes of active recovery
 - ❖ Cool-down (10 minutes)
 - ♦ Stretching, softening and relaxation
- (IV) Fourth phase (five sessions)
 - (i) Aim: lower tolerance thresholds aerobic endurance type of long-term effort to sub-critical power.
 - (ii) Intensity: set between 65% and 70% of the maximal heart rate
 - (iii) Periods of session (55 minutes)
 - ❖ Warm-up (12 minutes)
 - ♦ Five minutes of brisk walking followed by two minutes of active recovery
 - ♦ Five minutes of stretching
 - ❖ Activity (33 minutes)
 - ♦ Three series of walking at a moderate pace for 10 minutes, with a $3\frac{1}{2}$ minutes-period of recovery in between series
 - ❖ Cool-down (10 minutes)
 - ♦ Stretching, relaxation and softening
- (V) Fifth phase (six sessions)
 - (i) Aim: lower tolerances for type effort aerobic endurance submaximal power
 - (ii) Intensity: set between 70% and 75% of the maximal heart rate
 - (iii) Periods of a session (59 minutes)
 - ❖ Warm-up (12 minutes)
 - ♦ Five minutes of brisk walking and two minutes of active
 - ♦ Five minutes of stretching
 - ❖ Activity (37 minutes)
 - ♦ Two series of thrice repetition of trot running separated by a $3\frac{1}{2}$ minutes-period of recovery; each repetition being separated from the other by two minutes of light walking
 - ❖ Cool-down (10 minutes)
 - ♦ Stretching, softening, and relaxation.
- (VI) Sixth phase (five sessions)
 - (i) Aim: improvement of aerobic resistance
 - (ii) Intensity: set between 70% and 75% of the maximal

heart rate

(iii) Periods of a session (70 minutes)

- ❖ Warm-up (15 minutes)
 - ♦ Walking on tiptoe and on heels
 - ♦ Airport signal
 - ♦ Small round arms
 - ♦ Trot on site
 - ♦ Torso torsion and lower limbs flexion
 - ♦ Stretching
- ❖ Activity (45 minutes)
 - ♦ Running (30 minutes)

Two series of twice repeated small trot running separated by a five-minute interval of semi-active recovery, each small trot running activity being separated from the other by a two-minute interval

- ♦ Strengthening activity (15 minutes)
 - Muscle strengthening (dorsal and abdominal

muscles)

- ❖ Cool-down (10 minutes)
 - ♦ Stretching, relaxation and softening

(VII) Seventh phase (four sessions)

- (i) Aim: aerobic endurance improvement and moderate intensity activity lasting a long time
- (ii) Intensity: set at 75% of the maximal heart rate
- (iii) Periods of a session (60 minutes)

- ❖ Warm-up (15 minutes)
 - ♦ Stretching and walking at a moderate pace
- ❖ Activity (35 minutes)
 - ♦ Brisk walking
- ❖ Cool-down (10 minutes)
 - ♦ Stretching, relaxation and softening

N.B.: dance was integrated in the activity period of every session as from the fifth week.