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Original Article

Mini-trampoline rebound exercises: A 'self-care' initiative for glycated hemoglobin, body mass index and emotional distress for mildly obese females with non-insulin dependent type 2 diabetes

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1. Introduction

The prevalence of type 2 diabetes (T2D) is common in individuals presenting clinically with diabetes and is generally associated with incorrect diet and obesity [1]. Epidemiological studies show a sedentary lifestyle and obesity with high energy dense food leads to excess body fat which exacerbate the metabolic activities of diabetes [2]. Diabetes in general is the impairment of β-cell function with hereditary and environmental factors influencing the etiology leading to a chronic metabolic condition [3]. It is recommended that a triad of medication, dietary counselling and physical activities be encouraged to regulate blood glucose to prevent or minimize complications of diabetes and improve the individual's quality of life (QoL) [4]. Poor glycemic control can also place an emotional and physical burden on the affected individual leading to diabetes-related emotional distress [5,6]. This has a negative impact to adherence to diabetes 'self-care' programs and creates a vicious cycle leading to sub-optimal glycemic control and perpetuates the poor QoL [7,8]. This leads to individuals with diabetes having a higher risk of depression and emotional distress than the general population with women being at higher risk for psychosocial comorbidity compared to men [9].

The management of diabetes is a multidisciplinary approach with skilled healthcare professionals and will need continuous medical care and co-operation of the affected individual to engage in self-management and lifestyle changes. It is therefore imperative that all health professionals managing T2D seek and prescribe interventions that are safe and effective for these individuals. The challenge however to manage T2D is that the relevant lifestyle changes of the individual are not under the control of the relevant health professionals. Literature recommends and supports exercises for at least 30 min a day, five times per week as a means of facilitating the regulation of blood-sugar levels and reduce blood pressure [10]. In reality this may not be possible or achievable as diabetic individuals are reluctant to exercise for fear of making their condition worse or getting fatigued during exercises. There are also limited studies and specifically less emphasis investigating the link between exercises and psychological health status in T2D [11]. Based on this alternate strategies or modes of exercises are required to manage T2D. To promote a patient-centered and 'self-care' approach for T2D there is a shift to augment diabetic medication with alternate therapies such as increasing physical activities and exercises. It would therefore be beneficial if alternate, easy or recreational exercises are explored to manage diabetes and encourage 'self-care' to avoid or delay diabetes related complications. Jumping or bouncing on a mini-trampoline, called rebound exercises, is a relatively new exercise and is used for recreational activities, aerobic benefits and advocated as a simple way to attain exercise training effects [12]. The benefits of rebound exercises is that minimal effort is required as the elastic surface of the trampoline, springs and gravity facilitates the "bouncing" movements. These exercises minimize the negative impact-forces associated with other more strenuous lower limb full-weight bearing exercises. It is known that the use and side effects of hypoglycemic medications can cause weight gain which could potentially be reduced by engaging in rebound exercises for diabetics who have no contra-indications to exercise [13]. Recent reports show an increase of

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abuse and violence against women and when exercising outdoors which may require women to exercise in a safe environment. Rebound exercises can easily be done at home or in an open space and therefore has potential for females to obtain positive physiological and psychological effects when engaging in this form of exercise. Since there are no documented studies for the safety and impact of rebound exercises for glycated hemoglobin (HbA_{1c}), body mass index (BMI) and diabetes-related emotional distress for mildly obese females with T2D these outcome measures are unknown. This study explored the safety and impact of rebound exercises with counselling for HbA_{1c}, BMI and emotional distress for this population.

2. Methods

2.1. Design and sample selection

This randomized pre-test, post-test study recruited mildly obese females presenting with T2D from a public health diabetic clinic attached to the Aminu Kano Teaching Hospital (AKTH) in Kano, Northwestern Nigeria. Ethical approval was obtained from the University of KwaZulu-Natal Biomedical Research Ethics and AKTH Ethics Committees which conformed to the Helsinki Declaration of 1975 (revised 1983). The period of study was July 2016 to December 2017 with signed informed consent obtained from participants. On entry participants received detailed information of the procedures, risks, and benefits of the study with anonymity assured and all data coded. The inclusion criteria were moderately obese females (body mass index of 30.0–34.9kg/m2), diagnosis of T2D $\leq$ 5 years, glucose levels of 6.0 mmol/L to 13.0 mmol/L and an emotional distress score $\geq$ 40 using the Problem Areas in Diabetes (PAID) survey. Glucose levels for inclusion were relevant as clinically a value below 6.0 mmol/L can lead to hypoglycaemia during exercises and above 13.0 mmol/L with ketones is a contra-indication to exercise. Patients with hypertension, cardiovascular disease, macro-and microvascular diabetic complications, weak or deformities of the lower limb, cardiothoracic or abdominal surgery within the previous 6 months, history of spine, hip, knee or ankle fractures were excluded. Other exclusion criteria were pregnancy, lactation, retinopathy, nephropathy, use of insulin or participation in other exercise programs during the study.

2.2. Randomization and exercise procedure

Physicians in the diabetic clinic identified and screened participants to ensure no contra-indications for exercises. Those satisfying the inclusion criteria were randomized equally into a control and exercise group by means of an online computer-generated randomization schedule. The control group received counselling while the exercise group engaged in rebound exercises and received counselling. The counselling for both groups included the benefits of physical activities and exercises, ways to identify, avoid or minimize risk factors and complications associated with diabetes. Information on diet was presented by a dietician who emphasized the consumption of a Mediterranean diet of low saturated and high polyunsaturated fatty acids, high intake of fiber and vitamins and the importance of polysaccharides and cereals instead of simple sugars. Participants were also informed of the importance of complying with medication and the benefits of a healthy lifestyle. Participants in the exercise group had to complete a 6-min walk test along a straight passage with no obstructions as an additional safety measure to ensure cardio-respiratory fitness [13]. The exercises were conducted in a rehabilitation gymnasium attached to the AKTH. The mini-trampoline (Portable 2013 Model Half-Fold Cellerciser®, Utah, USA) was fitted with handlebars for support and safety with supervised jumping on the mid portion with feet slightly apart and knees in full extension. Jump frequency was signaled by an electronic metronome set at an initial minimum of 90 per minute and gradually progressed to a maximum of 150 per min. Each foot strike equaled one step or jump with step height, defined as the distance between the foot at maximum height of jump and the surface of the trampoline ranging from 10 to 15 cm. Duration of exercises were 15 min followed by 15 min of counselling which was a summary of the presentation given to the control group. Frequency of the control and exercise groups was three times per week on alternate days for 12 weeks. All relevant data were recorded at baseline, 6 and 12 weeks. Heart rate reserve (HRR) was maintained at moderate intensity of 40–65% and calculated using the Karvonen equation (220-age) [17]. A heart rate monitor (Polar Electro Oy, Kempele, Finland) was used to monitor values throughout the exercises with a 30% increase above baseline values of systolic or diastolic blood pressure an indication to stop the exercises. Throughout the exercise program participants were monitored for subjective fatigue, dyspnea, respiratory distress, profuse sweating or unsteady gait which were signs of maximum exertion [12]. Participants were taught to correlate the intensity of exertion using the Borg Scale of Perceived Exertion with the relevant values while exercising [18]. All data and values were recorded by senior exercise therapists and research assistants who were blinded to the aims of the study. Data were recorded at baseline, 6 and post-12weeks of intervention. As an ethical requirement, on completion of the study participants in the control crossed-over and engaged in rebound exercises. All participants continued with their hypoglycemic medication of metformin and sulfonylureas during the study.

2.3. Assessment of emotional stress

The Problem Areas in Diabetes (PAID) is a self-administered questionnaire which assesses diabetes-specific emotional distress having an internal consistency of alpha = 0.92 d [6,14,15]. The questionnaire was distributed by a research assistant for each participant pre-and post-12weeks of the interventions.

2.4. Anthropometric measures and blood chemistry analyses

Body mass and height measurements were conducted according to standard protocols using a calibrated digital weighing scale (Tanita Corporation, Tokyo, Japan) and a portable stadiometer (*Seca*® Company, Hamburg, Germany) respectively [16]. Body mass index (BMI) was calculated by dividing weight (kilograms) by the square of height (meters). Body fat analysis was by Bioelectrical Impedance using a body fat analyzer (HBF-514C, OMRON Corporation, Tokyo, Japan). Heart and blood pressure rates were measured using a calibrated Omron BP742, 5-Series (Omron Healthcare Inc., Illinois, USA). Blood samples were taken by venepuncture in the morning after a 12-h fast. The sample were transferred to tubes containing ethylene-di-amine-tetra-acetic acid and centrifuged for 15 min at 2300 rpm to separate plasma from blood cells. These were aliquoted and stored at −70 °C with analysis for HbA_{1c} using mini-column ion-exchange chromatography (TECO Diagnostics, California, USA).

2.5. Statistical analysis

Power analyses and sample size was determined using software (Pass15.0.3 NCSS, LLC USA). Data were analyzed using the IBM SPSS (Version 21.0, SPSS Inc., Chicago IL, USA) with normality assessed numerically and graphically and depicted by means of tables and a bar graph [19]. Mann-Whitney *U* test was used to determine

differences between groups and Wilcoxon Signed Ranks test for detecting changes in outcomes from baseline to post-intervention in each group. Statistical tests were two-tailed with $p < 0.05$ indicating significance.

3. Results

A total of 63 mildly obese females were recruited during the study period with nine excluded for not satisfying the inclusion criteria. The remaining 54 participants were randomized equally into a control and rebound exercise group. Four participants in the exercise and 4 in the control group did not complete the study as shown in the Consort flow in Fig. 1. Adherence to groups was the number of participants completing all sessions for the 12 weeks which was 85% (n = 46). At baseline there was no significant differences between the groups as shown in Table 1. Post-rebound exercises a significant improvement ($p < 0.05$) was noted for emotional distress based on the PAID scores, HbA_{1c}, BMI and systolic blood pressure ($p = 0.046$) with no significant changes in the control as seen in Table 2. Post-12 weeks, between-group comparisons indicated significantly lower HbA_{1c} for the rebound exercise group compared to the control as shown in Table 3. Perceived exertion was 43% (n = 10) scoring 11; 48% (n = 11) scoring 12 and 9% (n = 2) scoring 13 (see Fig. 2).

4. Discussion

This study was designed to determine the safety of moderate intensity rebound exercises and its impact on HbA_{1c}, BMI and diabetes-related emotional distress for non-insulin dependent mildly obese females having T2D. Eighty-five percent of the participants completed the exercises and perceived exertion scores indicated they coped with the intensity and duration of exercises with no adverse effects. This supports rebound exercises being safe for this population. Data reflect an improvement for HbA_{1c}, BMI and diabetes-related emotional distress post-exercises which correlate with other aerobic exercises [20]. However, the results from this study differed to the study by Chudyk & Petrella who observed improvements in HbA_{1c}, but no reduction in BMI following their exercise programme for T2D [21]. The researchers postulate that the improvement of BMI values in this study may relate to the nature and dynamics of rebound exercises which can be explained as follows. Physiologically T2D can also relate to deficiencies in insulin receptors impairing glucose uptake by reducing glucose transporter (GLUT 4) translocation. Studies show that following aerobic exercises there is an increase in GLUT 4 translocation to skeletal muscle which restore the defects of insulin [22]. It is possible that post-rebound exercises the continuous vertical body propulsions increase cardio-respiratory values and together with the concomitant metabolic activities of body and adipose cells these facilitate GLUT 4 translocation. Therefore, when engaging in rebound exercises, energy and oxygen supply to working muscles increases and simultaneously the body maintains these to the brain and other vital organs. During the initial 5–10 min of exercises, muscle glycogen is the main source of energy. As the duration of exercises increase glucose and non-esterified fatty acids are utilized and with the continuation of the exercises, non-esterified fatty acids become the major fuel. The accumulative effects of these metabolic reactions with the repetitive vertical propulsion of the body possibly facilitate an '*insulin-like*' action for glycaemic control [23]. Additionally, the elastic nature of muscles, tendons, enhanced neurological responses and reflex processes occurring in muscles renders rebound exercises, with its low-impact elastic surface, springs and gravity-assisted movements an alternate mode of cardio-respiratory exercise compared to jogging and treadmill exercises. The repeated "bouncing" alternates G-forces from 0 to 4 Gz by vertical acceleration and deceleration with an increase in heart, respiratory and blood flow and repetitive loading and unloading of muscles creates a "training" effect thereby increasing energy expenditure and improving BMI data [22,23]. Together with participants adhering to counselling for diet and reducing the intake of fatty foods these would also improve BMI values. It is therefore conceivable that by engaging in rebound exercises, females with T2D especially those who are mildly obese, and have no contra-indications to exercise would benefit from this exercise.

Studies show that anxiety, depression and a sedentary lifestyle affects the QoL of a diabetic with physical activities improving stress and psychological well-being of these individuals [24,25]. The results of this study correlate with other studies that confirm that general health improved with a decrease in stress, anxiety, depression with improvements for QoL for T2D following exercise training [26,27]. An additional benefit for participants in this study was the group interaction, social contact and peer support which all have a positive motivation to engage in exercises [28]. It is also possible that females performing rebound exercises in a confined

Table 1
Participants' socio-demographics and baseline clinical characteristics.

Variables	All patients	MRG	COG	p-value
	N = 46(SD)	N = 23(SD)	N = 23(SD)	
Age (years)	41.2 (17.3)	36.5 (10.6)	34.6 (9.6)	0.653
Weight (kg)	92.0 (31.0)	95.1 (31.0)	90.1 (18.1)	0.498
Height (cm)	174.0 (25.1)	173.5 (24.5)	174.0 (21.3)	0.829
BMI (kg/m^2)	35.1 (5.1)	34.4 (3.2)	32.9 (6.1)	0.878
DSD (years)	3.08 (4.0)	4.01 (4.0)	3.50 (4.0)	0.574
HbA_{1c} (%)	9.09 (5.40)	9.30 (5.40)	8.90 (4.00)	0.664
PAID score (%)	42.3 (21.3)	43.0 (20.0)	42.3 (21.3)	0.320
Systolic BP (mmHg)	124.5 (19.1)	121.1 (25.2)	119.8 (20.3)	0.769
Diastolic BP (mmHg)	80.9 (16.5)	84.5 (13.9)	82.2 (19.2)	0.065
Marital status, n (%)				
Married	43 (93.5)	22 (95.7)	21(91.3)	–
Single	3 (6.5)	1 (4.3)	2 (8.7)	–
Employment status -N (%)				
Employed	34 (73.9)	16(69.6)	18(78.3)	–
Unemployed	12 (26.1)	7 (30.4)	5 (21.7)	–

Abbreviations: MRG, mini-trampoline rebounding group; COG, control group; BMI, body mass index; DSD, duration since diagnosis of diabetes; HbA_{1c}, glycated hemoglobin; PAID, problem areas in diabetes; BP, blood pressure. Data are medians (range) unless otherwise indicated. P values are for the non-parametric test (Mann-Whitney U).

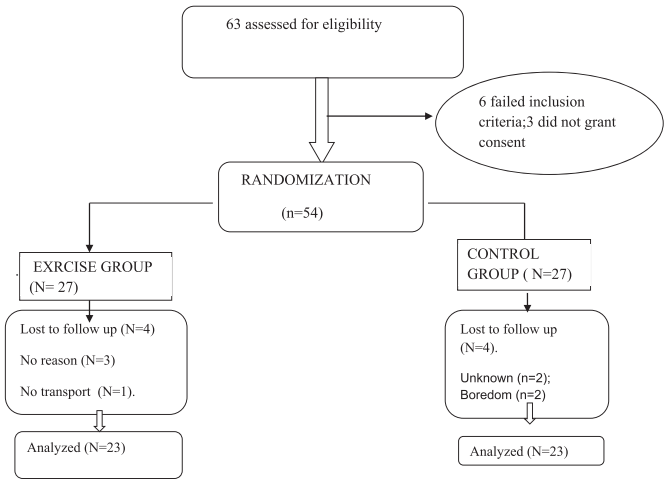

Fig. 1. CONSORT flow of study.

Table 2
Responses following 12-weeks of interventions.

Variables	MRG		P-value	COG		P-value
	Baseline	Post		Baseline	Post	
Weight (kg)	95.1 (31.0)	87.6 (20.5)	0.055	90.1 (18.1)	92.9 (19.3)	0.081
BMI (kg/m^2)	31.0 (3.20)	29.4 (2.30)	0.003*	32.8 (5.10)	31.86 (4.90)	0.060
HbA_{1c} (%)	9.30 (5.40)	6.85 (5.80)	0.019*	9.00 (4.00)	8.10 (3.00)	0.247
Systolic BP (mmHg)	121.1 (25.0)	110.0 (10.0)	0.046*	119.8 (20.0)	120.4 (20.0)	0.931
Diastolic BP (mmHg)	84.5 (20.0)	83.1 (15.0)	0.861	82.2 (20.0)	81.6 (20.0)	0.389
PAID score (%)	43.0 (20.0)	32.5 (15.0)	0.005*	42.3 (21.3)	40.7 (7.50)	0.292

Abbreviations: MRG, mini-trampoline rebounding group; BMI, body mass index; HbA_{1c}, glycated hemoglobin; BP, blood pressure; PAID, problem areas in diabetes.
Data are presented as medians (range). P values are from the results of Wilcoxon signed ranks test.
*indicates statistical significance.

Table 3
Between-Group Comparison of Outcome Variables at follow-up.

Variables	MRG	COG	P value
	n = 23	n = 23	
Weight (kg)	87.6 (20.5)	92.9 (19.3)	0.008*
BMI (kg/m^2)	29.4 (2.30)	32.0 (4.90)	<0.05*
HbA_{1c} (%)	6.85 (5.80)	8.10 (3.00)	0.008*
Systolic BP (mmHg)	110.0 (10.0)	120.4 (20.0)	0.008*
Diastolic BP (mmHg)	83.1 (15.0)	81.6 (20.0)	0.146
PAID score (%)	32.5 (15.0)	42.3 (7.50)	<0.05*

Abbreviations: MRG, mini-trampoline rebounding group; COG, control group; BMI, body mass index; HbA_{1c}, glycated haemoglobin; BP, blood pressure; PAID, problem areas in diabetes. Values are presented as medians (range). P values are for Mann-Whitney *U* test.
*indicates statistical significance.

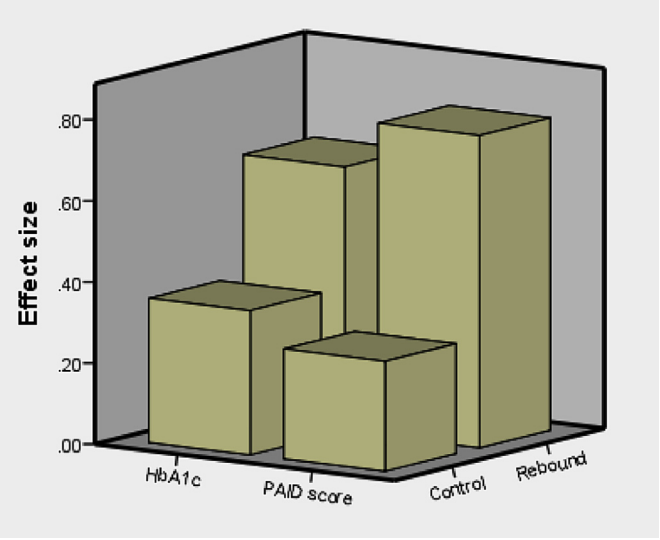

Fig. 2. Effect size for HbA_{1c} and PAID score from baseline and 12 weeks for participants in both groups.

or safe environment may contribute to less psychological stress thereby improving these scores.

Although not a specific outcome for this study, it was noted that systolic blood pressure also improved significantly which was a similar finding by Olsen et al. [29]. They found that post-aerobic exercises there were changes to venous return and stroke volume affecting systolic blood pressure which increased with exercises, peaked at 12 min at a heart rate of 160 beats per minute with diastolic pressure almost remaining constant [29]. There is evidence that when engaging in rebound exercises the bouncing movements of the body cause fluctuating positive and negative gravitational forces which alter central, thoracic blood volumes and central venous pressure [30]. This may explain the improved systolic pressure following rebound exercises with the improvement decreasing the hypertensive state of the body and potentially improving emotional distress. Additionally, anecdotal reports from participants indicated they enjoyed the "*euphoria*" following bouncing and together with lower emotional distress and ease of rebound exercises these could have contributed to the high adherence and positive benefits noted in this study. Studies have shown that educating healthcare professionals of alternate ways to manage T2D improves diabetic care and those presenting with diabetes must be encouraged to change their lifestyle with diet and exercises being relevant for this condition [31,32].

5. Limitation of the study

Although participants had to notify the researchers of changes to their diet or medication there may be instances where these were not reported. Secondly, although participants engaging in other exercise programs were excluded but there could have been participants who may have engaged in vigorous physical activities at home or in their occupation which could have been omitted as this was not recorded during the study.

6. Conclusion and recommendations

This study supports rebound exercises with counselling for mildly obese T2D females who have no contra-indications to exercise. Post-rebound exercises showed improvements for HbA_{1c}, BMI and diabetes related emotional distress scores. Physicians and other health professionals could recommend these exercises as a 'self-care' and patient centered initiative for T2D. However further studies with a larger sample size, longer duration of rebound exercises and decreased use of T2D medication during the period of study are recommended. The long-term view is to reduce and replace the use of diabetic medication with exercises and alternate therapies to prevent the side-effects and damage to major organs by using chronic diabetic medication.

Conflicts of interest

The authors declare no conflicts of interest and did not get funding for this study.

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