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Original article:

Effect of exercise on body circumference measurements in normoglycemic offspring of patients with type2diabetes mellitus

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ABSTRACT

Objectives: It is uncertain if exercise could influence the occurrence of T2DM in offspring of diabetic parents. Therefore this study was designed to assess the effect of exercise on different body circumferences of offspring of T2DM parents compared with offspring of non-diabetic parents.

Design: This study involved purposive selection of 50 offspring of T2DM parents attending University College Hospital, Ibadan and 50 offspring of non-diabetic parents who are undergraduate students of the University of Ibadan, Nigeria. Participants were randomly assigned into four groups using a convenience sampling method: 25 Normal-weight Offspring of Non-Diabetic Parents (NONDP), 25 Normal-weight Offspring of Diabetic Parents (NODP), 25 Overweight Offspring of Non-Diabetic Parents (OONDP) and 25 Overweight Offspring of Diabetic Parents (OODP). Each participant followed a protocol of graded exercise using tummy trimmer everyday spending 30-45 minutes daily for 24 weeks. 3 points body circumferences were measured using measuring tapes. Weight and Body Mass Index (BMI) were estimated using standard methods at baseline, six week, 12 week, 18 week and 24 week, respectively. Data were analyzed using descriptive statistic and repeated ANOVA at $\alpha_{0.05}$.

Results: Atbaseline,therewerereductionincircumferences(cm)inwristcircuference(NONDP:16.88±2.09to14.89±0.93cm,NODP:17.95±4.50to15.51±3.69cm,OONDP:16.74±1.06to15.23±1.08cmandOODP17.65±2.24to16.33±2.62cmarmcircumference(cm)(NONDP:27.28±2.50to24.42±2.2.76,NODP:29.33±13.02to26.26.59±11.85#,OONDP:28.87±2.61to25.70±2.95cmandOODP29.89±4.36to27.42±3.88cmwaistcicumference(cm)(NONDP:76.52±12.49to71.47±13.25cm,NODP:77.0±9.60to73.86+9.34cm,OONDP:81.34±17.90to±76.66+16.83cmandOODP90.05±7.92to86.94±9.27cm after six months of exercise.

Conclusions: Graded exercise alters body circumferences and in all the groups. The clinical importance of graded exercise in prevention of diabetes mellitus among offspring of diabetic parents looks promising.

Key words: Graded exercise, Diabetic parents' offspring, circumferences, BMI,

INTRODUCTION:

Diabetes mellitus, commonly known as diabetes, is a disorder of intermediary carbohydrate, protein and lipid metabolism. It is characterized by hyperglycemia, glucosuria, polydipsia, polyuria, polyphagia and weight loss. It is usually associated by secondary alterations in glucose, fat and protein metabolism, leading to many biochemical

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disorders. It is characterized by peripheral insulin resistance, impaired regulation of hepatic glucose production with declining β-cell function and eventually leading to β-cell failure[1].

Type 2 Diabetes Mellitus (Type 2DM) is characterized by a combination of peripheral insulin resistance and inadequate insulin secretion by pancreatic beta cells. Insulin resistance has been attributed to elevated levels of free fatty acids and pro-inflammatory cytokines in plasma, leads to reduced glucose transport into muscle cells, elevated hepatic glucose production, and pronounced break down of fat[2].

Researchers have found that obesity and diabetes are connected. Individuals who are obese are at high risk of developing T2DM, particular if a close family member is affected with T2DM. Researchers have not yet discovered a specific gene that causes obesity although, several genes are considered to play a role. There seems to be a showing connection between visceral fats (body circumferences) and diabetes, hence anything that will reduce visceral fat will likely reduce diabetes[2].

Diabetes mellitus is a group of metabolic disorders of carbohydrate metabolism in which glucose is underutilized, overproduced or both, leading to hyperglycemia[(3)]. It is characterized by increase in the blood glucose along with alterations in fat and protein metabolism, associated with defects in insulin secretion and or insulin action or both [(4,5,6)]. This metabolic disease is one of the most common endocrine disorders affecting almost 8.5 percent of the world's population [(7)]. It is one of the killer diseases waging war against the survival, growth and development of human beings globally[(8)]. It has assumed epidemic proportion both in developed and developing nations of the world[(8)]. With an increasing worldwide, DM will be a leading cause of morbidity and mortality in the foreseeable future [(9)]. It has become one of the world's most important public health problems [(10)].

Similarly, there is an increased production of superoxide in endothelial cells and oxidative stress, both of which can result in endothelial injury [(11)]. In addition, there is an increased expression of adipokines [(12)], which further fuels the vicious cycle of adipokine-related endothelial dysfunction. The relative importance of impaired insulin release and insulin resistance in the pathogenesis of T2DM has been evaluated in several studies[(13,14,15)] . Pancreatic 3-cell failure, alongside insulin resistance have been considered as the two keys events that lead to the development of Resistin, also called adipocyte secreted factor (ADSF), is a 12.5 kilo Daltons peptide hormone encoded at the RSTN gene [(16)], and is located on chromosome 19 [(17)]. Resistin (or resistance to insulin) was originally discovered in mice in 2001 and named for its ability to resist (interfere with) insulin action [(18)]; at that time, it was proposed as a link between obesity and diabetes mellitus. It is a member of a class of cysteine-rich secreted proteins called "resistin-like molecules-a" (RELM-a), expressed in adipose tissue, heart, lung, and tongue, and "resistin-like molecule-3" (RELM-3); which is expressed in the intestine [(19,20)].

Exercise has been known to ameliorate the effect of diabetes by improving insulin sensitivity and reduced body circumferences. It is the aim of this to work to study the effect of exercise on body circumferences of normoglycemic offspring of patient with type 2 DM.

Methods

The study was carried out in which 3 sites body circumferences(wrist, arm, waist) were measured using non-elastic measuring tape of offspring of patients with type 2 diabetes mellitus and normoglycemic offspring of non- diabetic parents. The parents of the test group were attending the medical out-patient clinic (MOP) of the University College

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Hospital (UCH), Ibadan and Catholic Hospital Oluyoro, Oke-Ofa, Ibadan, South Western, Nigeria. Fifty normoglycemic offspring of non-diabetic parents aged 25 to 50 years were randomly selected using convenience sampling method from general population of Ibadan Community, Ibadan, and South-Western, Nigeria and fifty undergraduate students of University of Ibadan. The latter are normoglycemic offspring of non-diabetic parents with normal BMI served as control subjects. Hundred subjects were randomly selected for the study using convenience sampling method aged between 25 and 50 years.

The participants were divided into four groups as follows:

A – Overweight /Obese offspring of DM parents (OODP) (25 subjects).

B – Normal weight/ Normal Body Mass Index (BMI) offspring of DM parents (NODP) (25 subjects).

C – Overweight / Obese offspring of non-diabetic parents (OONDP) (25 subjects).

D –Normal BMI / weight offspring of non-diabetic parents (NONDP) (25 subjects).

The exclusion criteria are offspring that are already diabetic or has disorders of glucose metabolism.

The study was approved by the University of Ibadan Teaching Hospital Research Ethics Committee (UI /UCH joint IRB) and Catholic Hospital Ethics Committee prior to its implementation

This is by data of body circumference measurements (wrist, arm, waist) were measured using non-elastic measuring tape. This is repeated as follows: Baseline measurement and after 6, 12, 18 and 24 weeks.

Heights of participants were taken using standard hospital-adult vertical rule with sliding arms which had been recalibrated and certified by a Biomedical Engineering technician prior to use. The Omron fat estimator equipment was used to measure the BMI. The study subject stood erect, upright and bare-footed. Those who had extra clothes such as coats and sweater removed them while the Omron equipment measurements were being taken. The readings were recorded in the recording book.

Body mass index (BMI) values for the subject were read off as displayed on the screen of Omron equipment. The BMI values were used to group subject into four categories. Underweight – BMI<18.5kg/m^2 Normal weight – BMI = 18.5 to 24.9 kg/m^2 Overweight- BMI = 25-29.9kg/m^2 Obese –BMI = >30.0 kg/m^2

The subject held his stretched hands forward as if he was riding a motor-bike.

Tummy trimmer, a portable lightweight equipment was selected for the study. It is an in-door anaerobic equipment. It is compact and can fit right in the subject's brief case.

During each phase of exercise the Tummy trimmer, a portable lightweight equipment, is held at the two handles and the sole of the two feet are put inside the pedal rest while the subject assume different positions. The subject will then pull the tummy trimmer's spring towards himself or herself either while lying flat or sitting up on the floor or carpeted hard surface.

Subject sits up with leg straight, leans his or her body backwards until completely lying back with head on floor. He/she returns to sitting position in harmonic fashion. The subject was advised to start slowly and work up to repetitions as she/he feels comfortable with harmoniously.

The subject was advised to lie flat on floor, extend his/her legs straight up in the air. He will be keeping his/her back on the floor and raises lower legs without bending them. The subject was advised to sit erect with legs straight, he/she raises handle to tummy height using arms only.

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Finally, subject was advised to lie flat on the floor while he/she bends knees up to his/her chest. He/She makes a circular motion push feet up and then round towards the floor again. The different positions were observed for exercise period of 30 to 40 minutes (a video clip of the exercise procedure was shown to the subject before the commencement of the exercise).

Each subject was advised:

(1) He/She to undergo the 4 phases of exercise between 30 and 40 minutes daily (either in the mornings or evenings).

(2) He/She to contact the researcher on cell phone anytime when he/she has any problems with the unit.

(3) There were regular cell phone calls made to each of the subjects by the research assistant to ensure compliance with exercise schedule.

(4) The research assistant called them on cell phone and sent s.m.s (Short Message Service) to them to keep return appointments every six weeks. This was done one or two days before appointment schedule.

The data obtained was analyzed using computer statistical programme package SPSS version 15.0. Comparison variables values have probability values of **P** less than 0.05 were considered statistically significant.

RESULTS

CIRCUMFERENCES MEASUREMENTS.

(a) Wrist circumference

The wrist circumferences measurement of participants at 0, 6, 12, 18 and 24 weeks of exercise. There was progressive reduction in the wrist circumference measurements in all the four groups after six month of exercise (Table 1).

The value of wrist circumferences at onset in OODP was 17.65 ± 2.24cm reduced to 16.33 ± 2.62cm after 6 months of graded exercise. In the control group, there was reduction from 16.88 ± 2.09cm in NONDP to 14.89 ± 0.93cm after six months of exercise .Statistical analysis between OODP and NONDP showed statistical significance ($P < 0.05$).

(b) Arm circumference

The arm circumference in all the four groups reduced progressively during six months of exercise (Table 1). In OODP, there is reduction from 29.89 ± 4.36 cm to 27.42 ± 3.88cm after six months of graded exercise.

In the control group, NODP, it reduced from 29.33 ± 13.02cm to 26.26 ± 11.85cm after six months of exercise.

(c) Waist circumference

The waist circumference measurements of participants reduced progressively in all the four groups (Table 1).In ODP (overweight offspring of Diabetic parents) the measurements of 90.05 ± 7.92cm at onset reduced to 86.94 ± 9.27cm after six months of exercise.

In control group, normal weight offspring of Diabetic parents (NODP) it reduced from 77.0 ± 9.60cm to 73.86 ± 9.34cm after six months of exercise..

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Table 1: Body circumference measurements in offspring of diabetic and non-diabetic parents before and after 6months exercise (ng/ml). All values are mean±SE

*Significant at p<0.05 after 24 weeks of exercise.

Body circumference measurements(cm)	Time	OODP	NODP	OONDP	NONDP	F	p
Wrist circumference (cm)	***Onset***	17.65±2.24	17.95±4.50	16.74±1.06	16.88±2.09	1.130	0.341
	6 weeks	17.23±2.33	16.88±3.78	16.34±0.98	16.42±2.19	0.677	0.588
	12 weeks	16.69±2.47	16.17±3.73	15.72±1.07	15.50±0.95	1.301	0.279
	18 weeks	16.32±2.61	15.52±3.70	15.24±1.08	14.90±0.93[a]	1.681	0.177
	24 weeks	16.33±2.62[#]	15.51±3.69[#]	15.23±1.08[#]	14.89±0.93[a#]	1.681	0.177
Arm circumference (cm)	***Onset***	29.89±4.36	29.33±13.02	28.87±2.61	27.28±2.50	0.687	0.562
	6 weeks	28.89±4.07	27.89±12.47	27.21±2.91	26.34±2.27	0.659	0.579
	12 weeks	28.11±4.06	27.60±12.16	26.47±2.98	25.61±2.22	0.749	0.526
	18 weeks	27.42±3.88	26.27±11.85	25.71±2.95	24.42±2.76	0.956	0.417
	24 weeks	27.42±3.88[#]	26.26±11.8[#]	25.70±2.95[#]	24.42±2.76[#]	0.956	0.417
Waist circumference (cm)	***Onset***	90.05±7.92	77.0±9.60[a]	81.34±17.90[a]	76.52±12.49[a]	5.194	0.002*
	6 weeks	89.59±9.85	75.82±9.50[a]	79.12±17.58[a]	74.70±12.39[a]	5.974	0.001*
	12 weeks	88.16±10.02	74.58±9.29[a]	77.90±17.06[a]	72.59±13.30[a]	6.228	0.001*
	18 weeks	86.95±9.28	73.87±9.34[a]	76.67±16.84[a]	71.48±13.26[a]	6.235	0.001*
	24 weeks	86.94±9.27[#]	73.86±9.34[a#]	76.66±16.83[a#]	71.47±13.25[a#]	6.235	0.001*

*Signicifant at p<0.05 [a]Significantly different from OODP

[b]Significantly different from NODP [c]Significantly different from OONDP

[#]Significantly different from Onset

DISCUSSION

Three (3) sites Body Circumference Measurements -the wrist, arm, and waist circumferences were measured using non-elastic measuring tapes. The readings were recorded in the recording book. The body circumference measurements of the participants reduced significantly in all the groups after six months of exercise. This is due to the reduction in the body fat[(2)]. The tummy trimmer which was the instrument apparatus used worked anaerobically

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by utilization of body fat after the depletion of the glycogen stored in the muscle and liver and the shift in energy to the utilization of fat in the tissues[2].

Measurement of subcutaneous fat with measuring Tapes is a simple and inexpensive technique for body visceral fat composition assessment that has been used in the field setting[21,22,23]

The measuring Tape is simple and inexpensive but is susceptible to measurement error[24,25]. Its measurement accuracy is influenced by tension in the skin. Subcutaneous fat thickness has been widely used as a simple body composition assessment method to determine body fat distribution or body density[26,27,28], which has been the most widely used in Japan, predicts body density from[27].

In females, although body fat accumulation is found in the hips or lower limbs in younger women, abdominal fat accumulation tends to increase in postmenopausal women[29].. Although measurement error in body circumferences tends to become greater with increasing obesity level, the influence of the increase in subcutaneous fat thickness on the measurement error was smaller at the abdominal circumferences as compared with other sites[30].

Moreover, in overall assessment of the effect of exercise on the the three sites body circumferences, it is suffice to say that, there is reduction in the waist circumferences which is more prominent and statistically significant in the OONDP and NONDP (control group) than any other groups. The arm circumferences reductions are prominent in NODP and NONDP groups, although this is not statistically significant. The same thing occurred in the wrist groups. However, in waist circumferences it was in OONDP and NONDP that were statistically significant. It is important to note that these reductions in body circumferences in the control group (NONDP) did not have antecedent subtle metabolic derangements or some forms of insulin resistance that usually antedate the development of T2DM many years later[2]. Researchers noted that there is reduction of Adiponectin and elaborations of Leptin in offspring of diabetes many years prior to development of T2DM [31, 32and 33].

Leptin was originally discovered as an afferent satiety signal transmitter to the central nervous system [34]. It is a cytokine, its circulating levels correlate closely with BMI [35]. Plasma concentration of leptin is predominantly defined by body fat mass but will transiently increase following a meal and decrease with fasting [36].Leptin's function to resist obesity and promote leanness led to the choice of the name "leptin" from the Greek root leptos, meaning thin [36]. Rising levels of leptin signal the brain that excess energy is being stored (in the form of fat). This signal brings about adaptations that resist obesity [36]. When this signal is deficient, the brain perceives energy stores to be insufficient, physiological response are to increase appetite and decrease energy expenditure, both of which push energy balance towards energy storage and weight gain [35].

Secretion of adiponectin by fat cells is stimulated by insulin to regulate and control its blood levels [34]. Adiponectin promotes insulin sensitivity and stimulates fat oxidation in liver and skeletal muscle while promoting the storage of TG preferentially in WAT [34]. Besides having clear beneficial effects on insulin action in peripheral tissues, most notably in liver, adiponectin also targets the 3-cells of the pancreas and promotes 3-cell function and survival [36].

The study is similar to the one done by Barbara Sternfield et al, 2004[37] where there were reductions in weight and waist circumference in 3,064 midlife women on physical activity. This study is also similar to the one done by Mayor et al, 2003[38] where exercise induce weight loss preferentially reduced abdominal fat in young obese men. However, there was significant reduction in abdominal and waist circumferences after exercise. Catherine et al,

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2019[39] also ascertain that exercise reduced body circumferences as it was found in self –efficacy and diabetes prevention in overweight south Asian with pre-diabetes.

It is suffice to say that, this study using tummy trimmer as exercise apparatus is the first as far as we know. All searches in literature did not reveal similar study. This study will be a baseline to further studies using tummy trimmer as exercise apparatus.

However, in this study, the body circumference measurements reduced progressively during six months of exercise using tummy trimmer as exercise apparatus. In summary, we found that there were reductions progressively in offspring of T2DM patients which will improve insulin sensitivity in them [36].

Overweight and obesity, together with physical inactivity, are estimated to cause a large proportion of the global diabetes burden (Global Burden of Disease Risk Factors Collaborators, 2015)[39]. Higher waist circumference and higher body mass index (BMI) are associated with increased risk of T2DM, though the relationship may vary in different population [40].

CONCLUSION

Graded exercise using tummy trimmer is an important tool which reduces body circumferences in all the groups studied. The circumference measurements of all the subjects under study also reduced progressively during these periods of exercise. Therefore, since exercise improved body circumferences in all the groups, it should be recommended for offspring of diabetic patients to delay or prevent the onset of diabetes mellitus.

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CONFLICT OF INTEREST

No conflict of interest.

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