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Effects of Interrupting Prolonged Sitting with Physical Activity Breaks on Obesity and Blood Glucose Level Regarding Their Association with Metabolic Health in Adults

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ABSTRACT

Background: Physical activity [PA] is an important element of diabetes care and is a crucial recommendation to all patients**.** The individuals should replace extended periods of inactivity with repeated bouts of low-intensity physical activity throughout the day, in addition to conventionally scheduled moderate-to-vigorous level physical activity.

Aim of the work: To measure the effects of interrupting prolonged sitting with physical activity breaks on obesity and blood glucose level regarding their association with adult metabolic health.

Patients and Methods: We studied 156 adult Egyptian people aged 18 years old or above with type 2 diabetes, prediabetes, impaired fasting glucose level, or obesity who presented to Al-Azhar University Hospitals and all subjected to history taking, age, sex, body mass index [BMI], neck circumference, waist circumference, cutting sitting before or after 5 hours, activity min. below or above 150 min. per week evaluation, blood pressure, heart rate [HR], random blood sugar [RBS] and glycosylated hemoglobin [HbA1c] assessment.

Results: It was found that significant decrease in age, blood pressure, waist circumference, HbA1C and random blood sugar in patients with cutting setting < 5 hours when compared with patients of cutting setting ≥ 5 hours, but no significance between cutting setting hours in sex, heart rate, BMI and neck circumference. Significant decrease in patient's activity min. > 150 min. per week in age, heart rate, neck circumference, waist circumference, random blood sugar and HbA1C when compared with patient's activity min. < 150 min., but no statistically significant between activity min. in sex, blood Pressure and BMI.

Conclusion: It was concluded that cutting of prolonged sitting with short bouts of activity enhances blood glucose level rather than BMI.

Keywords: Prolonged Sitting; Physical Activity; Obesity; Diabetes Mellitus.

INTRODUCTION

Changing one's lifestyle can prevent around half of the deaths caused by cardiovascular diseases, which are the main cause of mortality. Lifestyle variables are the most significant contributors to the genesis of these diseases. When it comes to the causes of mortality, only tobacco is more harmful than food and degree of activity, as a result, it has long been advised that the main strategy for managing and avoiding metabolic disorders and cardiovascular disease is physical activity [1].

A sedentary lifestyle is one in which there is little or no PA, this is typically used to describe repetitive activities that don't need much physical effort over long stretches of time, such reading or working in an office, as well as other routines like watching television, using a mobile device, or using a computer monitor [2].

Enhancing physical exercise and both reducing and interrupting sedentary behavior are ascertained in public health. Any sitting or reclined position throughout the daytime that requires an energy expenditure of 1.5 metabolic equivalents or less is considered sedentary behavior like sitting in the office. It is advisable to reduce sedentary time and breaking up extended periods of sitting during working hours [3].

In the general population, being overweight or obese is linked to increased sedentary time and decreased PA [4, 5]. In those who are overweight or obese, higher levels of physical activity participation are associated with positive self-perceptions of their health, self-efficacy, social support, and enjoyment of exercise. There is some evidence linking increased sedentary time to office jobs, the severity of obesity, and the number of comorbidities [6]. Higher levels of total daily sitting time are associated with an increased risk of cardiovascular disease and diabetes and mortality, as well as cardio metabolic risk indicators [such as fasting glucose and triglycerides] [7]. Elevated postprandial hyperglycemia and hyperlipidemia are important markers of cardiometabolic illness and may be useful targets for therapies aimed at preserving cardio-metabolic health [8].

Chronic, non-communicable diseases are the main threat to world health. According to a recent world health organization [WHO] global status report about chronic disease, non-communicable diseases like obesity, diabetes and cardiovascular disease now cause around two-thirds of all deaths globally [9]. A major cardiovascular disease risk factor and other chronic illnesses is metabolic syndrome [10, 11].

To date, a limited number of related researches that have measured the effects of interrupting prolonged sitting with physical activity breaks on obesity and blood glucose level regarding to their association with metabolic health in adults.

Accordingly, there was scope for our literature as an important source of data that goes into creating, updating, and improving public health guidelines.

PATIENTS AND METHODS

Patients

The current study was done on 156 adult Egyptian people presented to Al-Azhar University Hospitals, with ages ranging from 18 – 80 years with mean ± SD [35.6 ± 13.5] and the number of males 73 but females are 83 in the period from November 2022 to October 2023. Every participant was made aware of the purpose of the research, and all were consented to participate.

This study included adults aged 18 years and older who were obese, had impaired fasting glucose levels, or were diagnosed with pre-diabetes or type 2 diabetes; the intervention used to break up sitting involved any activity that exceeded simply standing, such as walking or any form of exercise.

This study excluded individuals for several reasons, including those for whom standing was the primary method of intervention to break up sitting, participants whose information was obtained from a previous study, and individuals from special populations such as those with neurologically disabling conditions, chronic obstructive pulmonary disease, and peripheral arterial disease, as the study's objective was not to assess the impact of physical activity breaks on rehabilitation; additionally, adults with type 1 diabetes were also excluded.

Methods

Every participant in the study was subjected to a series of assessments to gather comprehensive data. This included a detailed history-taking process that emphasized medical histories related to diseases such as diabetes, hypertension, and smoking. A thorough metabolic examination was conducted, starting with the evaluation of Body Mass Index [BMI], which classifies adults as underweight, overweight, or obese based on a simple weight-for-height index calculated using the formula BMI = Weight [in kg] / [Height in meters] ^{2}. Additionally, neck and waist circumferences were measured in centimeters.

Participants were also assessed based on their activity levels, specifically regarding sitting time and any activities above standing, such as walking in the room. It was required that participants had engaged in these activities as part of their lifestyle for at least the previous three months [12]. The study considered activity levels in terms of minutes per week, aiming to distinguish between those who engaged in activities below or above 150 minutes per week. [13].

Other parameters collected included age in years, sex [male or female], and vital statistics like blood pressure measurements [systolic and diastolic] and heart rate per minute. Blood pressure and pulse rate were measured using a device manufactured by Shenzhen Mindary Bio-Medical Electronics Co., Ltd., China, which is recognized for its reliability. These readings represented an average taken over the last three months in conjunction with measurements of activity and sitting hours [14].

Furthermore, random blood sugar levels were assessed using a rapid check fine test apparatus at the end of the three months of either prolonged sitting or increased activity. This process was standardized, ensuring all participants had been following the same lifestyle practices during that period. Lastly, HbA1c levels were determined using the EDTA method for all participants, also at the conclusion of the three-month assessment period.

Statistical analysis: Data were analyzed using the Statistical Program for Social Science [SPSS] version 24, employing the Kolmogorov–Smirnov test. Qualitative data were expressed as frequency and percentage, while quantitative data were represented as median and inter-quartile range [IQR]. The median is defined as the middle number, determined by ordering all data points and selecting the central value; if there are two middle numbers, the mean of those two is used. The IQR, which measures statistical dispersion, is the difference between the 75th and 25th percentiles of the data. To analyze differences between groups, the Mann Whitney U test was employed for comparisons involving abnormally distributed data, and the Chi-square test was used for non-parametric data. A p-value of less than 0.05 was considered significant, while a p-value greater than 0.05 was regarded as insignificant.

RESULTS

Table [1] provides a description of laboratory data for all studied patients. The mean age of the patients was 35.6 ± 13.5 years, with ages ranging from a minimum of 18 years to a maximum of 80 years. For systolic blood pressure [SBP], the mean was 120.5 ± 14.7 mmHg, with a minimum of 90 mmHg and a maximum of 190 mmHg. The mean diastolic blood pressure [DBP] was 75.5 ± 10 mmHg, with a range from 60 mmHg to 100 mmHg. The mean heart rate [HR] was 87.3 ± 13.4 beats per minute, ranging from 59 to 149 beats per minute. The mean body mass index [BMI] of the patients was 29.6 ± 5.4 kg/m², with minimum and maximum values of 17 kg/m² and 44 kg/m², respectively. The neck circumference [NC] had a mean of 40.5 ± 6.7 cm, ranging from 25 cm to 60 cm. The mean waist circumference [WC] was 101.2 ± 17.7 cm, with a range from 61 cm to 160 cm. The random blood sugar [RBS] mean was 142.8 ± 57.4 mg/dl, with minimum and maximum values of 90 mg/dl and 400 mg/dl, respectively. Finally, the mean hemoglobin A1C [HbA1C] was 6.3 ± 1.3%, ranging from a minimum of 4.7% to a maximum of 16%.

Table [2] shows the description of cutting sitting hours and activity min. in all studied patients. As regard cutting setting hours per day, it was ≥ 5 hours per days in 70 patients [44.9%] and < 5 hours per days in 86 patients [55.1%]. As regard activity min. per week, it was < 150 min. per week in 51 patients [32.7%] and > 150 min. per week in 105 patients [67.3%] of the studied patients.

Table [3] presents findings on various health metrics related to patients based on their cutting setting hours. It highlights that patients with a cutting setting of less than 5 hours experienced statistically significant decreases in systolic blood pressure [SBP] and diastolic blood pressure [DBP], with p-values of 0.031 and 0.003, respectively; their SBP was a median of 120 mmHg [IQR = 110–120 mmHg] and DBP was a median of 70 mmHg [IQR = 70–80 mmHg], in contrast to those with a cutting setting of 5 hours or more, who had a median SBP of 120 mmHg [IQR = 110–130 mmHg] and DBP of

80 mmHg [IQR = 70–80 mmHg]. Additionally, there were significant decreases [p-value < 0.001] in age, waist circumference [WC], random blood sugar [RBS], and hemoglobin A1C [HbA1C] for patients with cutting settings under 5 hours, where the medians were 28 years [IQR = 25–34.25], 95 cm [IQR = 85–100], 120 mg/dl [IQR = 106.5–135.5], and 5.6% [IQR = 5.2–6%], respectively, compared to those with cutting settings of 5 hours or more, who had medians of 36.5 years [IQR = 30–50.25], 105.5 cm [IQR = 98.75–115], 140 mg/dl [IQR = 116.5–181.5], and 6% [IQR = 5.5–7.5]. Lastly, there were no statistically significant correlations found between cutting setting hours and heart rate [HR] [p-value = 0.194], body mass index [BMI] [p-value = 0.222], sex [p-value = 0.295], or neck circumference [NC] [p-value = 0.599].

Table [4] presents results indicating statistically significant decreases [p-value = 0.017] in age, heart rate [HR], neck circumference [NC], waist circumference [WC], random blood sugar [RBS], and hemoglobin A1C [HbA1C] among patients with weekly activity greater than 150 minutes, with medians of 30 years [IQR = 25.5–38], 87 beats per minute [IQR = 76–80], 40 cm [IQR = 34.5–43], 95 cm [IQR = 88.5–110], 120 mg/dl [IQR = 110–145.5], and 5.6% [IQR = 5.2–6%], respectively, compared to those with activity less than 150 minutes, who had medians of 34 years [IQR = 28–50], 90 beats per minute [IQR = 84–100], 41 cm [IQR = 40–47], 100 cm [IQR = 95–115], 133 mg/dl [IQR = 133–186], and 6% [IQR = 5.5–6.9]. Additionally, there were no statistically significant correlations found between weekly activity and sex [p-value = 0.465], systolic blood pressure [SBP] [p-value = 0.406], diastolic blood pressure [DBP] [p-value = 0.087], or body mass index [BMI] [p-value = 0.050].

Table [5] reveals statistically significant decreases in age [p-value = 0.001], systolic blood pressure [SBP] [p-value = 0.002], diastolic blood pressure [DBP] [p-value = 0.002], neck circumference [NC] [p-value = 0.002], and waist circumference [WC] [p-value = 0.025] among female patients, who presented medians of 29 years [IQR = 25–36], 120 mmHg [IQR = 110–120], 70 mmHg [IQR = 60–80], 40 cm [IQR = 34–43], and 98 cm [IQR = 85–110], respectively, compared to male patients, whose medians were 35 years [IQR = 28–46], 120 mmHg [IQR = 115–130], 80 mmHg [IQR = 70–80], 41 cm [IQR = 39–46.5], and 100 cm [IQR = 91–115]. Additionally, there were no statistically significant correlations found between gender and heart rate [HR] [p-value = 0.744], body mass index [BMI] [p-value = 0.112], random blood sugar [RBS] [p-value = 0.598], hemoglobin A1C [HbA1C] [p-value = 0.726], cutting setting hours [p-value = 0.295], or activity minutes [p-value = 0.465].

Table [1]: Description of demographic, clinical and laboratory data in all studied patients

[n = 156]	Minimum	Maximum	Mean	±SD
Age [years]	18	80	35.6	13.5
SBP [mmHg]	90	190	120.5	14.7
DBP [mmHg]	60	100	75.5	10.0
HR [beat/min]	59	149	87.3	13.4
BMI [kg/m^2]	17	44	29.6	5.4
NC [cm]	25	60	40.5	6.7
WC [cm]	61	160	101.2	17.7
RBS [mg/dl]	90	400	142.8	57.4
HbA1C [%]	4.7	16	6.3	1.9

Table [2]: Description of cutting sitting hours and activity min. in all studied patients

		Studied patients [n = 156]	
Cutting setting hours [per day]	**≥ 5 hours**	70	44.9%
	< 5 hours	86	55.1%
Activity min. [per week]	**< 150 min.**	51	32.7%
	> 150 min.	105	67.3%

Table [3]: Correlation between cutting setting hours per day and other studied data in all studied patients

		Cutting setting hours per day				Stat. test	P-value
		≥ 5 hours [N = 70]		< 5 hours [N = 86]			
Age [years]	**Mean**	36.5		28		**MW = 1626**	**< 0.001 HS**
	±SD	[30 - 50.25]		[25 - 34.25]			
Sex	**Male**	36	51.4%	37	43%	X^2 = 1.09	0.295 NS
	Female	34	48.6%	49	57%		
SBP [mmHg]	**Median**	120		120		**MW = 2421.5**	**0.031 S**
	IQR	[110 - 130]		[110 - 120]			
DBP [mmHg]	**Median**	80		70		**MW = 2223**	**0.003 S**
	IQR	[70 - 80]		[70 - 80]			
HR [beat/min]	**Median**	90		88		MW = 2646.5	0.194 NS
	IQR	[79.75 - 98.25]		[76.75 - 93.25]			
BMI [kg/m^2]	**Median**	30		28.5		MW = 2667.5	0.222 NS
	IQR	[26 - 34.25]		[25 - 33]			
NC [cm]	**Median**	40		40		MW = 2863	0.599 NS
	IQR	[37 - 44]		[35.75 - 45]			
WC [cm]	**Median**	105.5		95		**MW = 1783**	**< 0.001 HS**
	IQR	[98.75 - 115]		[85 - 100]			
RBS [mg/dl]	**Median**	140		120		**MW = 1840**	**< 0.001 HS**
	IQR	[116.5 - 181.5]		[106.5 - 135.5]			
HbA1C [%]	**Median**	6		5.6		**MW = 1932.5**	**< 0.001 HS**
	IQR	[5.5 - 7.5]		[5.2 - 6]			

Table [4]: Correlation between activity min. per week and other studied data in all studied patients

		Activity min. per week				Stat. test	P-value
		< 150 min. [n = 51]		> 150 min. [n = 105]			
Age [years]	**Mean**	34		30		**MW = 2047**	**0.017 S**
	±SD	[28 - 50]		[25.5 - 38]			
Sex	**Male**	26	51%	47	44.8%	X^2 = 0.53	0.465 NS
	Female	25	49%	58	55.2%		
SBP [mmHg]	**Median**	120		120		MW = 2464.5	0406 NS
	IQR	[110 - 130]		[110 - 130]			
DBP [mmHg]	**Median**	80		80		MW = 2245.5	0.087
	IQR	[70 - 80]		[70 - 80]			
HR [beat/min]	**Median**	90		87		**MW = 1769.5**	**0.001**
	IQR	[84 - 100]		[76 - 90]			
BMI [kg/m^2]	**Median**	31		28		MW = 2160.5	0.050
	IQR	[27 - 34]		[25 - 34]			
NC [cm]	**Median**	41		40		**MW = 1901**	**0.003**
	IQR	[40 - 47]		[34.5 - 43]			
WC [cm]	**Median**	100		95		**MW = 2008**	**0.011**
	IQR	[95 - 115]		[88.5 - 110]			
RBS [mg/dl]	**Median**	133		120		**MW = 2016**	**0.012**
	IQR	[112 - 186]		[110 - 145.5]			
HbA1C [%]	**Median**	6		5.6		**MW = 1874**	**0.002**
	IQR	[5.5 - 6.9]		[5.2 - 6]			

Table [5]: Correlation between gender and other studied data in all studied patients

		Gender				Stat. test	P-value
		Males [n = 73]		Females [n = 73]			
Age [years]	**Mean**	35		29		**MW = 2084**	**0.001**
	±SD	[28 - 46]		[25 - 36]			
SBP [mmHg]	**Median**	120		120		**MW = 2163.5**	**0.002**
	IQR	[115 - 130]		[110 - 120]			
DBP [mmHg]	**Median**	80		70		**MW = 2196**	**0.002**
	IQR	[70 - 80]		[60 - 80]			
HR [beat/min]	**Median**	90		89		MW = 2938	0.744
	IQR	[77.5 - 95]		[78 - 98]			
BMI [kg/m^2]	**Median**	28		31		MW = 2582.5	0.112
	IQR	[26 - 33.5]		[26 - 35]			
NC [cm]	**Median**	41		40		**MW = 2142**	**0.002**
	IQR	[39 - 46.5]		[34 - 43]			
WC [cm]	**Median**	100		98		**MW = 2398.5**	**0.025**
	IQR	[91 - 115]		[85 - 110]			
RBS [mg/dl]	**Median**	126		120		MW = 2881.5	0.598
	IQR	[110 - 160]		[111 - 150]			
HbA1C [%]	**Median**	5.8		5.8		MW = 2931	0.726
	IQR	[5.3 - 6.95]		[5.4 - 6]			
Cutting setting hours	**≥ 5 hours**	36	49.3%	34	41%	$X^2 = 1.09$	0.295
	< 5 hours	37	50.7%	49	59%		
Activity min.	**< 150 min.**	26	35.6%	25	30.1%	$X^2 = 0.53$	0.465
	> 150 min.	47	64.4%	58	69.9%		

DISCUSSION

Sedentary behaviors have become the dominant lifestyle due to shifts in transportation choice, occupational requirements, building design, and the prevalence of digital entertainment, which collectively promote increased sitting and decreased activity [15, 16]. It is generally advised that all people with diabetes engage in physical activity as a crucial part of their management. It has been suggested that people should incorporate many bouts of low-intensity physical activity throughout the day to cut down on extended periods of sitting in addition to the conventional scheduled moderate-to-vigorous level physical activity [17]. This recommendation is supported by evidence that, regardless of physical activity level, sedentary behavior is associated with dose-dependent increases in body weight, deteriorating glycemic control, and cardio metabolic morbidity [7].

Additionally, other research indicates that replacing extended periods of inactivity with short bursts of physical activity improves both acute postprandial and whole-day glucose levels, with improvements in blood glucose levels lasting until the following morning. [12] Due to increased insulin sensitivity brought on by contraction and/or energy deficit [18] and/or a higher dependence on insulin-independent contraction-mediated glucose clearance [19].

In the present study, it was found that there was statistically significant decrease of age, blood pressure, WC, RBS and HbA1C with no statistically significant differences of heart rate, BMI and NC in patients with cutting setting < 5 hours per day when compared with patients of cutting setting ≥ 5 hours per day. Also, there were statistically significant decreased of heart rate, NC, WC, RBS and HbA1C with no statistically significant differences of blood pressure and BMI in patient's activity min. > 150 min. per week when compared with patients of activity min. < 150 min. per week. Our results agreed with **Ostman *et al.*** [20] who has out an exercise training meta-analysis encompassing 16 studies with 23 intervention groups and 77,000 patient hours. Every study included participants who had a baseline clinical diagnosis of metabolic syndrome, compared sedentary controls to exercisers, and measured the incidence of hospitalization and death. The length of exercise training varied from eight weeks to a year, also they found that analysis comparing aerobic exercise training to control groups revealed reductions in BMI, waist circumference, systolic and diastolic blood pressure, fasting blood glucose, triglycerides, and low-density lipoprotein.

Moreover, our results agreed with **Myers *et al.*** [21] who found that in their observational research linking patterns of physical exercise to investigations of metabolic risk that are cross-sectional or observational by nature have limitations since they cannot show cause and effect. It was demonstrated that some of these research flaws included the possibility that those who are inherently healthier are more likely to exercise or that their genetic makeup makes them more fit regardless of behavioral or lifestyle considerations. However, this research has yielded important insights into the relationships among physical activity patterns, metabolic risk, and associated illnesses. Also, our results were concomitant with the results of **Dempsey *et al.*** [22] and **Patterson *et al.*** [7] who stated that observational evidence indicates that greater total time spent sedentary and, more specifically, sedentary time accumulated in prolonged uninterrupted bouts, increases the risk of getting diabetes, cardio-vascular disease, and all that cause mortality. Recent experimental research indicates that interrupting sedentary time with simple resistance exercises during the day improves postprandial glycaemia by 21% to 39% [23, 24].

Furthermore, our results were consistent with those of **Cooper et al.** [25]. They revealed that longer periods of inactivity were linked to a higher risk of diabetes, as well as worse metabolic and inflammatory profiles in people with type 2 diabetes. Numerous studies have examined the short-term cessation of sedentary behavior with physical activity and found improvements in waist circumference, insulin levels, postprandial glucose, and cholesterol [26, 12].

Our results showed that there were statistically significant decreased of blood pressure, NC and WC in female patients when compared with male patients with no statistically significant differences of heart rate, BMI, RBS and HbA1C in female patients when compared with male patients. Our results agreed with **Myers *et al.*** [21] Who examined the effectiveness of exercise training in management of metabolic syndrome in 621 inactive but otherwise healthy participants. The subjects participated in a 20-week fitness program that included three sessions per week of training on a cycle ergometer under supervision. Both before and during the research period, the existence of the metabolic syndrome and the group of related risk variables were identified. The individuals' metabolic profiles, which included blood pressure, triglycerides, HDL cholesterol, fasting plasma glucose, and waist circumference, were significantly improved because of exercise training. It was also discovered that there were no racial or gender disparities in the effectiveness of exercise in management of metabolic syndrome.

Conclusions: Collectively, our study suggests that more active people either have fewer instances of developing the metabolic syndrome, a lower prevalence of risk factors for the metabolic syndrome, or both. Interrupting extended sitting with physical activity breaks improves blood glucose level rather than BMI. These data support the idea that fulfilling the lowest criteria for activity of 150 min. /week of activity is linked to a lower prevalence of the metabolic syndrome, even though the levels of activity have been measured and characterized differently and that greatly associated with improving metabolic health.

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