

Influence of obesity on spatiotemporal gait parameters among female students from Jouf University, Saudi Arabia

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Abstract

Study aim: The aim of the current study is to explore the effect of obesity on spatiotemporal parameters of gait in obese young female students.

Material and methods: A cross-sectional study with fifteen obese female university students (mean age = 20.3 ± 1.6 , mean BMI = 36.2 ± 4.6) and fifteen normal weight female university students (mean age = 20.9 ± 2 , mean BMI = 22.6 ± 2.4) was conducted. The spatiotemporal gait parameters were evaluated using GAITRite® walkway (Frankline, USA, Model No. TR30RAM090 with software version 4.89C2).

Results: Independent sample t-test showed statistical significant differences in some spatiotemporal gait parameters between normal and obese subjects with statistically significant reductions of single-limb support time, step length, stride length, and velocity in the obese subjects rather than normal subjects ($p = 0.031, 0.015, 0.039$, and 0.002 , respectively). Moreover, there were statistically significant increases of step time, stride time in the obese subjects rather than the normal subjects ($p = 0.038, 0.017$, respectively).

Conclusion: These results suggested that obesity is a factor that adversely affects the spatiotemporal gait parameters in the obese young female. This may be contributed to decrease the joints' mobility and increase the incidence of joint osteoarthritis. So, it is recommended to encourage the sufficient physical activity and weight reduction among obese female students.

Key words: Obesity – Spatiotemporal gait parameters – Young female – GAITRite® System

Introduction

Obesity described as an irregular collection of exaggerated body lipids which may be having harmful effects to health. There is no single cause of obesity, but most studies considered the imbalance in the number of calories used, secretion of excessive insulin or insulin resistance, and hereditary factors as some of the bio-physiological reasons of obesity [9, 18, 22]. Some investigators refer to obesity as environment adoption of an unhealthy lifestyle, characterized by decreased physical activity and high calories. Obesity has extended to an epidemic stage in developed countries especially in children [37]. Also, females are more expected to be obese more than males, because of intrinsic hormonal alterations [16]. According to the (WHO), if body mass index equals or larger than 25 kg/m^2 ,

It considered as overweight, if body mass index equals or larger than 30 kg/m^2 , It considered as obese [10].

In the developed countries, musculoskeletal disorders for example rheumatism, osteoarthritis, arthritis are a major burden on the subjects and healthcare organizations. People with musculoskeletal disorders have pain, functional disabilities, and poor quality of life [32]. There is evidence to indicate that musculoskeletal disorders are related to many risk factors like age, body mass index, nature of education, monthly income and parentage. The relationship between musculoskeletal conditions and the degree of obesity (body mass index) is of specific interest. Some studies have shown that obesity is associated with many musculoskeletal abnormalities which ranged from arthritis to joint ache [28, 29]. Experiments and studies have shown that the weight reduction in obese people is associated with relieving pain in the lower back, knee,

ankles, and feet [29, 40]. A study performed by DeVita et al. [12] showed that decrease the knee force in relation to the weight loss and increase the walking quality. This indicated the importance of studying the effect of obesity on the different components of gait quality. Musculoskeletal abnormalities due to obesity are common in women than men. Women are at more risk for evolving pain-related disability and chronic pain due to increase body weight [14, 19]. This attracts the attention of researchers to focus on female subjects when studying the effect of obesity on walking abilities.

The incidence of increasing weight (obesity) doubled in over 70 countries from 1980 to 2015. Obesity and overweight are quickly growing problems all over the world, and it was assessed that in 2015 there were 603.7 million grown persons and 107.7 million teenagers with obesity worldwide [11]. Obesity has a significant health distress leading to an epidemic rate in both developing and developed countries [43]. Obesity is likely to affect more than one third of the population. Globally, overweight and obesity is considered the main cause of more than 2.8 million deaths. If these secular trends continue, 20% or more of the world's population may be affected by excessive obesity by 2030; while 38% of them will be overweight [27].

The diffusion of obesity in Gulf Countries between children and teenagers ranges from 5% to 14% in men and from 3% to 18% in young women [5]. Data from other Middle Eastern countries are rare; though, there is overpowering evidence to propose increased obesity. For instance, in Kuwait, current surveys have found that 48% of women and 30% of men were weighty, whereas in Saudi Arabia, 44% of the women population and 28% of the male populace were found to be obese. Nevertheless, 71% of female and 66% of males were described as overweight. There are quite high degrees of overweight and obesity in Saudi Arabia which have been considerably increasing along the years [1, 3, 35]. According to world atlas data, Saudi Arabia has been listed as one of the highly obese countries in the world which were caused by physical inactivity and fast food consumption. The statistics reveal that the rate of obesity is constantly rising in Saudi Arabia. Saudi females have been found to have an advanced obesity rate than males and the general rate is estimated to reach 59.5% by 2020 [6]. The main factors that donate to obesity in Kingdom of Saudi Arabia as of the following: marital status, physical inactivity, family history of obesity, diagnosis of diabetes, hypertension, education, age, bad eating habits, genetic factors, and sleep disturbance. The costs of obesity include ischemic heart disease, diabetes, cardiovascular diseases, hypertension due to lack of mobility of obese subjects and decrease the functional efficiency [4]. Finding solutions for subjects' obesity may have a valuable effect in improving the overall functional ability of different

body systems and protect the body against the previously mentioned diseases. One of the functional mobility assessments is gait which it is a tool that give feedback about the functional ability of subjects [41]. So, the study try to investigate the effect of obesity on the mobility of Saudi young female subjects through the examination of spatio-temporal gait parameters.

Most of the previous studies were performed on the gait assessment of obese children rather than the adults [30, 31, 42]. Furthermore, most of the studies were performed in gait assessment focused on the assessment of kinetic and joint angles parameters rather than the spatiotemporal parameters [33, 34]. In addition, there is lack of studies that performed on obese subjects using the GAITRite system which is specialized in measuring the spatiotemporal parameters of walking [2, 25, 26]. So, the main aim of the current study was to detect the effect of obesity on the spatiotemporal parameters (step time, stride time, single limb support time, step length, stride length, speed, and cadence) of gait in Saudi female students using the GAITRite system. The study's null hypothesis specified that there is no statistical significant difference in the gait spatiotemporal parameters between obese and non-obese female students.

Materials and methods

Participants

Fifteen young obese university students (age = 20.3 ± 1.6 yr, Mass = 57 ± 7.4 kg, Height = 156.6 ± 4.8 cm, BMI = 36.2 ± 4.6) and fifteen normal weight young university students (age = 20.9 ± 2 yr, Mass = 23.7 ± 3 kg, Height = 158.6 ± 4.7 cm, BMI = 22.6 ± 2.4) were selected from College of Applied Medical Sciences, Jouf University, Saudi Arabia. Each participant written an agreement (consent form) which was obligatory before examination and the process was clarified in details for each subject. For the inclusion criteria of this study, all participants should be female, aged from 20–30 years, and the two groups of female students (normal and obese) not engaged in any specific physical activity. For the exclusion criteria, all participants shouldn't be pregnant at any stage; have no any surgical history or suffering from any musculoskeletal abnormalities (such as leg length discrepancy) or any degree of optical, vestibular, equilibrium, and balance disturbances that affect the performance of lower extremity. Moreover, all subjects shouldn't take any kind of drugs that affect the balance in the previous 24 hours before the examination. The current study was approved by the review board of ethical committee of College of Applied Medical Sciences, Jouf University (NO. 06-03-42) in compliance with Declaration of Helsinki.

Study design

This evaluation cross sectional study was performed to distinguish the differences in spatiotemporal parameters (step time, stride time, single limb support time, step length, stride length, speed, and cadence) of gait between both groups (normal and obese) of female students.

Instrumentations

GAITRite® System with pressure sensor (Frankline, USA, Model No. TR30RAM090 with software version 4.89C2) was used for spatiotemporal gait analysis and providing simple identification and documentation of gait problems. Participants walked along walkway that linked to computer software for data analysis (Fig. 1). The device consisted of an 8.1 m length and 0.89 m width electronic mat with 27,648 sensors embedded in it. The sensitive area of the walkway is 0.61 m wide and 7.32 m long approximately. The rate of sample was 80 Hz and the collected data were analyzed using reliable gait analysis software. The test retest reliability of the GAITRite device was detected by Cho et al. [8]. In addition, validity and reliability of the device was detected by Bilney et al. [7] which proved that validity and reliability for GAITRite® is acceptable for measuring spatial and temporal parameters. The system starts recording automatically when the subject's foot contacts the platform and the data is stored.

Procedure

The study was performed at the physical therapy lab. In College of Applied Medical Sciences, Jouf University. Females' body height and mass were measured using a medical scale and measuring tape. The body mass Index (BMI) was calculated for each participant from the weight and height. The participants wore comfortable clothes to avoid any movement restriction during the measurement.

The spatiotemporal gait data will be collected from the dominant leg (preferred kicking leg) by walking barefoot across the walkway of the GAITRite device (the order of the feet that strike the walkway is randomize). Familiarization trials will be conducted to allow each subject to strike the center of the platform during the normal walking. Three repetition trials will be done by barefoot (without shoes) [17] and the average of these three trials were calculated. The subject walked with normal walking speed across the walkway mat sensor with self-preferred walking speed and started with two foot-steps before contact the center of the platform (Fig. 2) once the examiner asks the subject to start walking. In the current study, the spatiotemporal gait parameters (step time, stride time, double limb support time, step length, stride length, velocity, and cadence) during walking will be detected for the dominant leg. The data collected from the mat sensor transferred to the lab top of the device for processing. The Data filtered and calculated by the GAITRite software version 4.89C2 and demonstrated as printed file. The sample size of 30 participants produced the analysis power of 85% with an alpha level of 0.05.

Statistical analysis

Statistical Package for Social Sciences (SPSS) version 20.0 was used. The exploration of data and descriptive statistics were performed as preliminary check to certify data normality in each group suing Shapiro-Wilk test. Inter-rater reliability test (in the single session and between the three collected measurements) of each variable of interest was detected using the interclass correlation coefficient (ICC). Independent sample t-test was conducted to identify the demographic data and spatiotemporal differences (step time, stride time, single limb support time, step length, stride length, speed, and cadence) between both groups (normal and obese groups).

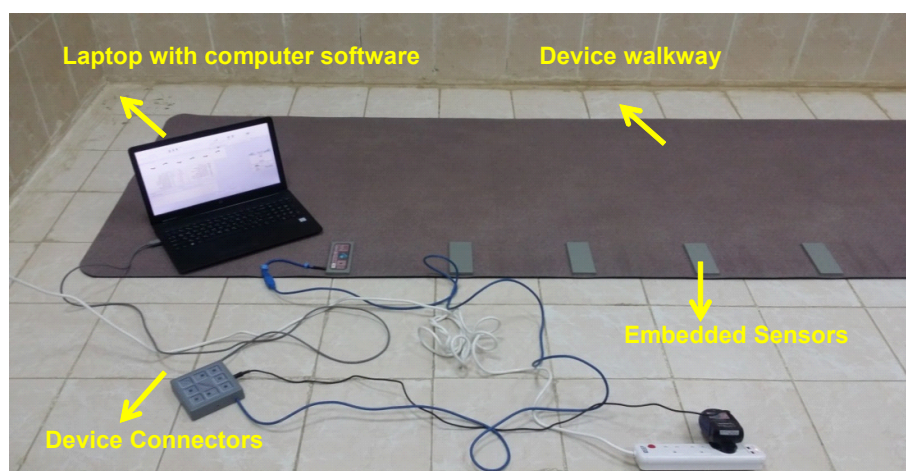


Figure 1. The different parts of GAITRite® device

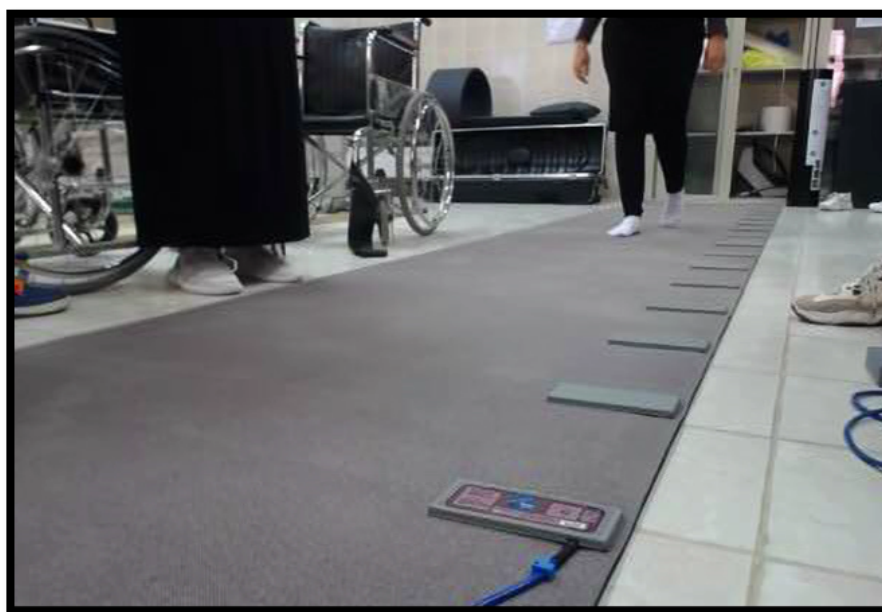


Figure 2. Subject walking with normal walking speed across the walkway

Results

Data reliability and consistency (between three collected measurements)

As revealed in the earlier section, The inter-rater reliability and uniformity in single session were detected by computing interclass correlation coefficient (ICC) for each variable of interest in each group with excellent category ($P \geq 0.8$) as presented in Table 1.

Descriptive analysis

Spatiotemporal gait parameters of both groups were sensibly detected and entered SPSS for processing, exploring,

Table 1. Intra-class correlation coefficient (ICC) for spatiotemporal gait parameters of each group

Variables	ICC of normal	ICC of obese
Step time	0.880	0.964
Stride time	0.895	0.954
SLS	0.857	0.957
Step length	0.800	0.902
Stride length	0.885	0.965
Cadence	0.884	0.938
Velocity	0.930	0.861

Abbreviations: ICC – Inter-class correlation, SLS – Single Limb Support Time.

and analysis. The mean and SD of each interested variables are calculated as shown in Table 2. Shapiro-Wilk test approved the consistency and homogeneity of each group ($P < 0.05$). The equality of variance assumed by Levene's Test for each variable of interest during the comparison between groups was greater than 0.05.

Independent t-tests

The Independent sample t-test showed no statistical significant differences in the age and body height between the normal and obese female students ($p = 0.368$, $p = 0.344$, respectively) except in the weight and body mass index (BMI) ($p = 0.000$, $p = 0.000$, respectively). The Independent sample t-test showed statistical significant differences in the spatiotemporal gait parameters (step time, stride time, single limb support time, step length, stride length, and velocity) between both groups ($p < 0.05$) except the cadence which showed no statistical significant difference between both groups ($p > 0.05$) as represented in Table 2. The mean values of step length, stride length, single limb support time, and velocity of obese female students showed statistical significant reductions rather than the mean values of normal female subjects ($p < 0.05$). The mean values of step time and stride time were significantly higher than that of normal female students ($p < 0.05$). Although, there was no statistical significant difference in the mean values of cadence between obese and normal female students, the mean value of cadence in normal subjects was higher than that of obese subjects ($p > 0.05$).

Table 2. Means and SD of each variables of interest between both groups using independent t – test

	Normal female	Obese female	p-value	t-value
Step time [sec]	0.53 ± 0.02	0.56 ± 0.04*	0.038	–2.18
Stride time [sec]	1.07 ± 0.06	1.14 ± 0.09*	0.017	–2.53
SLS [sec]	0.44 ± 0.02	0.41 ± 0.03*	0.031	2.27
Step length [cm]	65.35 ± 8.95	58.59 ± 4.64*	0.015	2.59
Stride length [cm]	123.28 ± 6.84	117.21 ± 8.42*	0.039	2.17
Velocity [cm/sec]	114.87 ± 9.96	104.07 ± 6.63*	0.002	3.50
Cadence [steps/min]	111.06 ± 6.77	107.47 ± 7.17	0.170	1.41

Abbreviations: SLS – Single Limb Support. * – significantly different than normal ($p < 0.05$).

Discussion

The analysis of spatiotemporal parameters of gait is regularly used clinical investigation tool for locomotion to detect outcome measures, which are important for the applicability of scientific research in therapeutic use [13]. The variations in spatiotemporal parameters were according to gender, and in the current study the female subjects were chosen for analysis as they have a higher total body fat than males, especially at the regions of the hip and thigh [20]. The study sample was selected as 15 obese female university students and 15 normal weight female university students to detect the spatiotemporal gait parameters differences between both groups.

The age of female subjects ranged from 20–30 years, an available and active age group in which any locomotor deficiency or movement abnormalities may lead to greater functional limitation and affect the economic production of this society [24]. The gait pattern changes with the age and motor development [15]. In adult, the gait parameters can change with the change of the body height which considered an important and influential factor for gait changes. The body height affects the spatiotemporal gait parameters. The body height can affect the stride length, speed, and cadence of the subjects [38]. In this current study no statistical significant difference was found between the both groups with respect to height ($P > 0.05$), indicating that the both groups varied only in weight and BMI. It can be proved that differences in gait spatiotemporal parameters did not be affected by the body height but by the BMI only in this study. Statistical significance difference was detected in BMI in the current study which inferred that the changes in spatiotemporal gait parameters not returned to the change of the body height but by the difference in the BMI of both groups' participants.

The current study proved the reduction of spatiotemporal parameters of walking in obese female university students in comparison with the normal weight female students. The study results showed statistical significant reduction in the step length, stride length, velocity, and single limb support time of obese female students rather than the normal subjects. Although, there was a reduction in the cadence of obese participant rather than the normal subjects but it was not statistically significant, this may be returned to the small sample size was selected. Also, there was a statistical significant increase of step time and stride time of obese subjects in comparison with the normal female subjects. The inverse relationship between the gait velocity and the step and stride times was proved by a study conducted by Lai et al. [23] using three dimensional motion analysis system which indicated that the obese male and female adults with BMI $33.06 \pm 4.2 \text{ kg/m}^2$ in comparison with non-obese male and female adults with BMI $27.6 \pm 8.6 \text{ kg/m}^2$ walked slowly and had a short step and stride length. They also consumed more time in double support and stance phase of walking. These results agree with the results of our study. In addition, the increase of double limb support in obese persons indicated the reduction of single limb support time.

The study conducted by Silva-Hamu et al. [39] verified the presence of statistical significant decrease of the gait velocity, step length, stride length, and cadence in obese women aged in comparison with eutrophic (normal weight) women but the sample of this study was selected with wide range of age from 20–60 years and using three dimensional gait analysis system, the results of this study confirmed the results of our study in the presence of the statistical significant reduction of velocity, step length, stride length. The cadence in our study showed no statistical significant reduction, although the cadence reduced in obese person than the normal subjects, this may be returned to the small sample size selected that didn't clarify the significant difference between both groups or may

be a compensation from the obese subjects to the reduction of velocity. Another study demonstrates the effect of gait velocity on the other spatiotemporal gait parameters which indicated a dependency relation among them. In general, increasing the gait velocity may tend to increase step length and cadence, but the opposite is true. This study was performed on four groups of old age women which indicated that the older women groups (75–79 and ≥ 80 years) walked with reduced average gait velocity, step length, and cadence, and were above average for the variables step and gait cycle time. These results were similar to the results of obese young female students which indicated that increase obesity among young female may give the same gait variability and decrease the walking efficiency as in the old age women with normal BMI [21].

The reduction of step length and stride length with increasing the gait cycle time in obese subjects may be returned to the lack of lower limb joint mobility. A research showed that the reduction of gait velocity with increasing the stride time and decreasing the step and stride length may return to the reduction of knee and ankle mobility in obese subjects, this may return to increasing the BMI, the body inertia tends to increase. This may put great demand on the muscles of the lower extremities [39]. Also, research work was conducted by Rosso et al. [36] about the effect of BMI on gait properties of young male (obese and non-obese) adult who found a reduction in spatiotemporal parameters of gait in obese subjects. In addition, a positive correlation between BMI and kinematic gait parameters changes in both frontal and transverse planes of motion indicated the greater load on the lower limb joint to control the body sway and upright stability.

The voluntary participation and availability time of female university students were the main limitations in detecting the sample size and the type of examined activity. The data was collected from only two types of BMI (normal and obese) according to availability of the sample. The gathered data was also limited to the normal walking activity rather than the other activity such as running and fast walking. Also, the study only investigated the spatiotemporal parameters of gait instead of the other gait kinetic and kinematic data. Consequently, further researches should be applied on different type of BMI rather than only two types and in different activities rather than the normal walking only. In addition, the other information related to gait (kinetic and kinematic data) should be involved.

Conclusion

Spatiotemporal variations were ascertaining between obese and normal weight young female students. There were no significant differences between the both groups in age and height except in BMI which has a great impact in

reducing the gait efficiency. The young obese females have a gait delay by increasing the time of step and stride. On the other hand, the step length and stride length reduced in obese subjects who tend to cause a reduction in gait velocity. Moreover, the obese persons were unable to maintain their body weight over one lower extremity that cause a decline in single limb support time. So, the overall reduction in the gait efficiency of obese subjects sends warning messages by encouraging young females to keep the proper body weight and involve in various physical activities.

Conflict of interest: Authors state no conflict of interest.

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