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Three-dimensional gait analysis for spatiotemporal parameters in obese children

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Abstract: ***Background***: *Obese children are challenged while moving excess mass and performing task requiring power and speediness as gait.* ***Purposes***: *To investigate the differences in spatiotemporal gait parameters measured by 3D motion analysis between obese children non-obese children.* ***Materials and methods***: *twenty children of both sexes participated in this study were assigned into two groups ten obese children as study group and ten age matched non obese children as control group. Spatio-temporal parameters were assessed for all subjects by Three-dimensional gait analysis including step (length, time and width), stride length, cadence, speed, stride time.* ***Results***: *A significant decrease was noted in stride and step lengths, and walking speed mean values in the study group and a significant increase in stride time, step (time and width) mean values. On the other hand, non-significant difference was found in cadence between both groups.* ***Conclusion***: *an objective evidence of changes in spatiotemporal gait parameters between obese and non-obese children using 3D gait analysis.*

Key words: *Gait, CP, spatiotemporal parameters.*

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I. INTRODUCTION

Obesity in childhood is a serious medical problem affecting children and adolescents. In children, weight changes with age, sex and height [1, 2]. Therefore, the children are considered obese or overweight when they are beyond the normal weight for their age and height. Obesity and overweight can be measured by Body Mass Index (BMI) [3].

Calculation of children BMI, described as a percentile that obtained from either a percentile calculator or a graph. Interpretation of a child's BMI must be relative to other children of the same age and sex, as height and weight are continuously changing during growth and development [4]. *"Overweight* "is described as children and adolescents ages 2 to 18 years with a BMI between the 85th and 94th percentiles, and *"obese* "as BMI at or greater than the 95th percentile[5].

Incidence of obesity and overweight has increased noticeably over the past three decades. Even with managing obesity and overweight, high incidence was reported by the National Health and Nutrition Examination Survey (NHANES), as 17% of children and adolescents with a BMI above the 95th percentile for age and gender [6].

Obesity and overweight high prevalence has serious health consequences [7,8], such as type II diabetes, hypertension, left ventricular hypertrophy, dyslipidemia, atherosclerosis, metabolic syndrome, sleep disorders [9,10] as well as psychological effects. Obesity during childhood also noticeably rises the risk of being an obese adult. Adults who were obese during childhood may be at risk of developing mentioned diseases and coronary heart disease than those who were not obese during childhood [11].

Moreover, obese children may have a limited capacity to be physically active [12, 13, 14]. A high BMI does not have a negative influence on the locomotor system in general but risk of falls and subsequent injury are increased with obesity [15]. The stress within the bones, joints, and soft tissues are increased due to excess weight, resulting in impairment of musculoskeletal function such as abnormal mechanics of the body [16]. Obese children faced great challenge while moving excess body mass during tasks requiring power, speed or agility [17,18,19]. Kinematic spatiotemporal parameters variations as cadence, speed, stride length and stance, and swing phase duration were reported in obese adults, [20, 21].

Analysis of obese children gait revealed alterations in spatiotemporal parameters (STPs) as seen in obese adults, but with longer stance phase duration, gait cycle, and reduced cadence and a flatter foot pattern during heel contact [22,23].

STPs provides objective measures of walking; by describing where, when, how long and how rapidly the person is in contact with ground. All parameters are recorded using pressure mat, force platform and three dimensional motion analysis camera system. Temporal data are collected by using foot switches (on/off device assembling foot contact timing) [24].

Purpose of the study:

The study aimed to define effects of excess body weight on gait parameters through the comparing spatiotemporal parameters in obese and non-obese children while self-paced.

II. SUBJECT, MATERIAL & METHOD

This work is a part of research project funded by gait laboratory of Childhood Abilities Programs (CAP) clinic, Jeddah – Saudi Arabia.

Subjects:

Ten obese children were joined in this study.Their age ranged from six to ten years and ten age matched non obese children, procedures were clarified to all children and their parents, parental consent was signed prior to each child's participation in the study. (Appendix 1).

Inclusive criteria:

The patients were included based on the following criteria:

- Have a BMI equal or above 95th percentile.
- Able to walk independently.
- Able to respond well to instruction

Exclusion criteria

Patients were excluded if they had:

- Deformities of the lower limb such as flat foot
- Any neurological disorders affect gait
- Previous orthopaedic surgery in the lower limbs.

Design of study:

Ten obese children were assigned to the study group and ten age matched non-obese children were assigned as a control group.

Spatio-temporal parameters were assessed for all subjects by Three-dimensional motion including step (length, time & width), stride (length & time), cadence, and speed.

Assessment Materials:

1- BMI

Growth charts of the Centre for Disease Control and Prevention (CDC) are the most frequently used indicator to measure size and growth patterns of children and adolescents [4]. The BMI-for-age growth chart for both boys and girls (**Figure 2)**, which are displayed the variation in BMI with age. Along those lines of CDC Growth Chart, there are two cut-off values to define and evaluate children overweight and obesity. They are 85th and 95th percentiles, which refer to *"Overweight"* described as children and adolescents ages 2 to 18 years with a BMI between the 85th and 94th percentiles, and *"obese"* as BMI at or greater than the 95th percentile[5, 6].

2- Three-dimensional motion capture Vicon motion analysis system

Three-dimensional motion capture uses an eight-camera Vicon motion analysis system (Oxford Metrics Ltd., Oxford, UK). Ground reaction forces had been recorded at a rate of 1200 Hz by one AMTI force plate (OR6-5-1000; Advanced Mechanical Technology, Inc., Newton, MA) camouflaged in an eight meters pathway were used to collect kinematic data from reflective dots at 100 Hz **Fig. (1)**.

Figure (1): Eight-camera Vicon motion analysis system for 3-D gait analysis

Assessment Procedure:
1- Measurement of BMI
2- Three-dimensional motion capture Vicon motion analysis system

Each patient underwent 3D gait analysis and physical examination. After static calibration of gait lab, anthropometric measurements were applied including; mass, height, leg length, knee and ankle circumferences. Later, sixteen reflective markers Reflective markers (14mm spheres) were placed bilaterally by gait lab expertise on the following landmarks based on the requirements of the lower body Plug-in-Gait model; the anterior superior iliac spine, posterior superior iliac spine, lateral (thigh, femoral epicondyle, shank, and malleolus), second metatarsal head, and the calcaneus **Fig. (2)**.

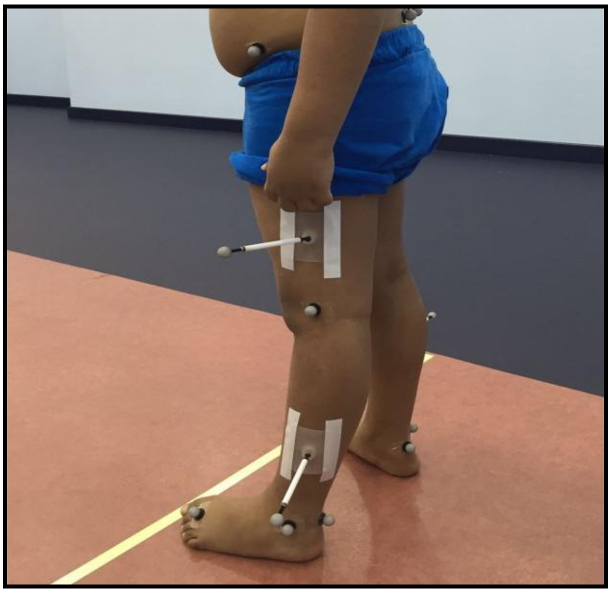

Figure (2): Placement of the reflective marks.

Each child was asked to walk freely two to three times before measurement to be familiar with the lab environment. Each child was asked to standing on the force plate with feet apart and arms extended and abducted 90° to start markers' calibration **Fig.(3)**.

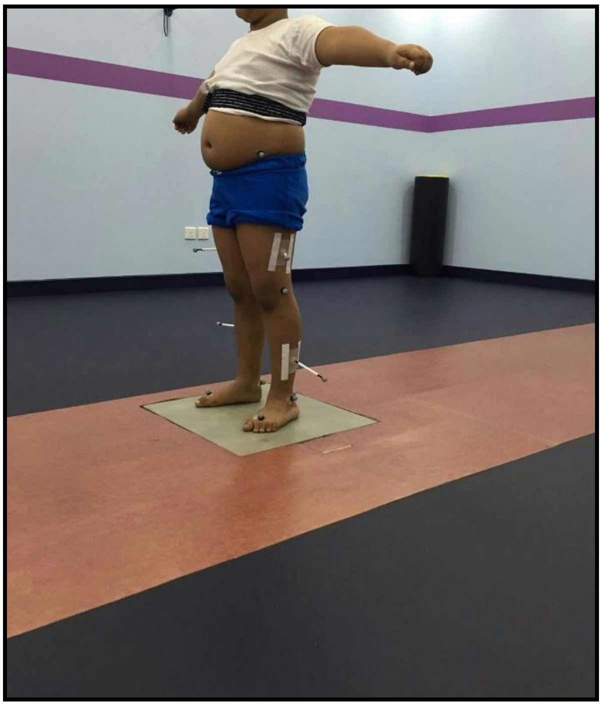

Figure (3): Position of the child on the force plate for calibration

Later, each child started to perform six trials as their comfortable speed, to decide the preferred average speed. For reducing effect of speed variability on biomechanical parameters, all trials must be calculated in the data analysis are compulsory to be within 5% of the detected average speed [25]. Kinematics and ground reaction forces were recorded simultaneously while subjects walked barefoot alongside the 8-m pathway. Solitary, trials wherein the entire foot made contact with the force-plate without targeting were involved in the analysis **Fig. (4)**.

Figure (4): The child walked barefoot along the walkway

Parameters:

Spatial-temporal gait cycle parameters including; cadence, speed, step (length, width, and time), and stride (length and time) were collected.

Data processing:

Gait data were computed using Nexus 2.1 software. Data later exported to Polygon 4.2 software to be further processed **Fig. (5).**

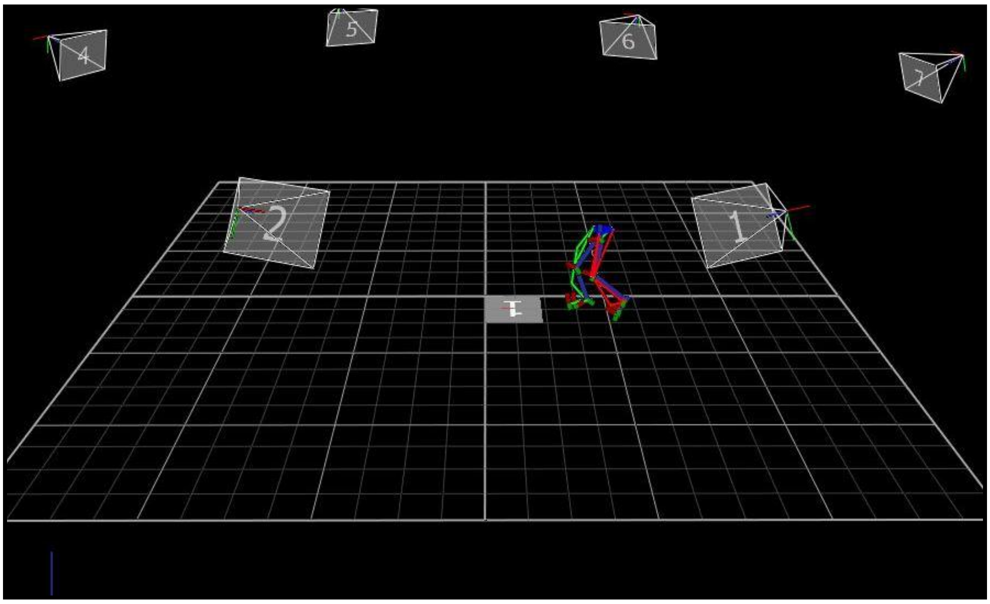

Figure (5): Data processing

Statistical analysis:

Results of the parameters of the six trials were averaged for each subject. Unpaired t-test was used to compare gait parameters between groups.

III. DISCUSSION

The study was conducted to examine the differences in spatiotemporal gait parameters measured by 3-D motion analysis among obese children non-obese children.

In this study, there were no statistically significant differences in the mean values of age and height between obese and non-obese children.

Our results revealed a significant decrease of step length and stride length while the step width was significantly increased. The significant decrease of the step length and the stride length could be explained by This is supportive with findings of **Lai et al.** [26] who compared the gait of lean and obese adults at a self-selected speed and they found that obese adults walked slower, had shorter strides, and spent more time in stance phase.

The increasing of step width could be attributed to poor balance resulting from the abnormal distribution of body fat in the abdominal area. This come in consistent with **(Forhan & Gill)** [27] who reported that the obese persons carry their weight toward the front of their feet, leading to anteroposterior instability during static and dynamic balance.

The current study revealed prolonged stride time and step time while decreased walking speed in obese children this come in agreement with **Spyropoulos et al.,** [20] who suggested that obese individual has to walk slowly, take shorter strides, and remain in double support longer to maintain balance.

Hills and Parker [28] concluded that a reduced physical activity, along with weight, can be significant factors causing instability at slower walking speeds, seen in the obese children's gait being characterized by longer double-support phases.

Moreover**, Teasdale et al.** [29] reported that walking speed in obese children was slower and they may require more balance control than non-obese children so as to accommodate for the increased body mass.

Our results also, come in agreement with **Sarkar** [30] found that the spatiotemporal parameters of gait like cadence, speed, stride, and support base and foot angle were significantly lower in the obese subjects, while the step width was increased for support base which was more. These were consistent with poor musculoskeletal performance, high-energy expenditure and limited physical activity.

The findings of the current study showed a non-significant change in the cadence, this come in consistent with the results of **Nantel et al.** [31]**,** but our results come in contradiction with those stated by **Hills and Parker** [28] who mentioned that a reduced cadence in obese children compared with non-obese children. This difference may be attributed to using larger BMI than our study or small number in our sample.

Francesco [32] concluded that the body geometry is modified as a result of obesity by adding mass to different regions and influencing the biomechanics of activities of daily living.

IV. CONCLUSION

The present study concluded that there was significant changes in the spatiotemporal gait parameters in obese children compared with non-obese children using 3D gait analysis.

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