Comparison Balance and Footprint Parameters in Normal and Overweight Children

Amir Hossein Barati, Ahmad Bagheri[1], Reza Azimi[2], Mohsen Ali Darchini[2], Hossein Nabavi Nik[2]

Departments of Physical Education, Shahid Rajaee Teacher Training University, Tehran, Iran, [2]Department of Physical Education and Sport Science, Kharzami University, Sport Complex of Shahid Keshvari, Tehran, Iran, [1]Department of Rehabilitation Committee Sports Medicine Association, Esfahan, Iran

Correspondence to:
Dr. Amir Hossein Barati
Departments of Physical Education, Shahid Rajaee Teacher Training University, Tehran, Iran.
E-mail: Ahbarati20@gmail.com

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Original Article

ABSTRACT

Background: The present study was done in order to compare balance and footprint parameters in two groups of normal and overweight children.

Methods: This semi-experimental study included randomly selected 22 male children (11 normal and 11 overweight boys). To measure the footprint parameters, an ink paper system was used, i.e., after putting their feet in the ink, the subjects were asked to stand comfortably on paper and their footprints were recorded. Then, with the use of ImageJ software, the areas of anterior, middle, and posterior parts, the total area, and the arch index parameter were calculated. For measuring balance in three posterolateral, posteromedial, and anterior directions as well as the total balance, Y-balance test was done. Finally, to analyze the data, mean and standard deviation were calculated and ANOVA test was used to compare the parameters.

Results: Data analysis showed a significant difference between normal and overweight subjects in the anterior and posterior areas, whereas, in balance test, only the anterior areas showed significant difference ($P < 0.05$).

Conclusions: It seems that area parameters in these two groups do not have significant difference; hence, it cannot be used as the criteria for analyzing the effects of being overweight on these parameters. In addition, it is probable that, in a dynamic situation, recorded footprints are more valid parameters for analyzing foot structure.

Keywords: Arch index, balance, footprint, overweight

INTRODUCTION

In many developed and developing countries, there are many concerns about being overweight and obesity; these concerns have become a universal and comprehensive problem progressing at different ages.[1-4] According to statistics by World Health Organization (WHO), about 10% of 5-17-year-old school children are overweight and 3% of them are obese. In US, this number is roughly 33% (10% obese) and, in Europe, it is 20% (4% obese).[5] Nowadays, obesity in childhood is considered as one of the most important health problems in Europe, especially in Italy, Greece,

and Spain.[6] According to research on obesity by Lobstin and Ferlot,[5] southern European countries have the most number of overweight children. In a study done at Aragon (Spain), the body mass index (BMI) results indicated that over 1.3% of 6-7-year-old children were overweight, while it was comparatively less in 13-14 year-old children.[7] Moreover, in Asian and Middle-East countries, the matter of overweight and obese children turned out to be a universal problem so that, in the past decade, a significant and major increase in the number of overweight children has been reported.[8-13]

Also, in Iran, as a developing country facing increasing phenomenon of industrialization and urban living, the amount of prevailing overweight children has been more than the expected percentage in recent years and, as people are aging, this percentage is increasing.[14] As such, prevailing rate of 17% epidemic of overweight and obesity at the beginning of primary school has made Iran correspondent with the big cities in Europe.[15] Among the reasons of rapid overweight growth is the nutrient transition that Iran experienced from 1990s onward and then it confronted an increased amount of received energy and decreased physical activity, leading to overweight during recent years.[14] In a study by Tilaki *et al*., in 2011, the amount of overweight and obesity epidemic among 7-12-year-old children was reported, respectively, as 12.3% and 5.8%[16] and, in another survey done at female primary school in Tehran, this amounts were reported, respectively, as 13.2% and 7.7%.[17]

In addition to the annually increasing costs imposed on World Health Organizations by overweight and obesity,[4] their relationship with mortality is fairly proved and is an issue that has been evaluated and revisited many times,[18] which in long term can affect children's health,[19-21] and it is more probable that the adolescents afflicted by weight issues and obesity may be obese adults in future; however, most of these children may experience negative consequences of obesity and being overweight in next decades.[24,25] Nevertheless, obesity affects musculoskeletal system including lower limbs' misalignment, fracture risk, and mobility weakness, leading to appearance of some health problems for infants and adolescents.[24] In comparison to other children of same age, obese children are less willing to do activities.[26-28] Also, the results of a previous reports shows that obese children have problems in gait, running, and flexibility,[3] leading to appearance of some changes in their foot structure. Overweight children may suffer a flat foot probably due to increase of fat layer amount in their mid-foot. Moreover, by aging, stretching power of plantar increases and flat foot problem is diminished automatically. On the other hand, if being overweight lasts for a medium or long term, the weight gaining process overcomes the stretching power of plantar and foot flatness forms at mid-foot.[29,30] Executed studies show physical changes in children due to obesity as it could reduce their balancing ability.[31] Berrigan *et al*., in 2006 demonstrated that body fat mass increase in adults causes decrease of their postural stability.[32] Bernard *et al*., in 2003 utilized Romberg's test in order to control posture in 13-17-year-old adolescents and concluded that control posture of these children is weaker than in other same age adolescents.[32]

According to the related literature, being overweight has mal-effects on children's physical features, so it seems that also balance, as one of the most important factors of physical fitness, is affected by these features. However, since musculoskeletal system is a consolidated and interrelated collection, disorder in one of its parts affects the other parts too. Hence, the researchers in this study attempted to determine if being overweight affects balance and footprint parameters.

METHODS

The present study is a semi-experimental research. We selected 22 participants randomly and divided them equally in two groups of normal and overweight. Participants were categorized according to Cole *et al*., (2000) table of BMI, which is based on age and sex.[34] Statistical details of participants are given in Table 1.

At the beginning, we asked parents of the participants to fill in the personal consent questionnaire. They also filled in self-report questionnaires of health that showed no disorder in visual and vestibular balance systems, proprioceptive sensory system, and every kind of injury, especially in the lower limb. In order to record the footprint of participants, we used roll papers of 200 × 70 cm and gouache color, which were not harmful to their health. After explaining

Table 1: Physical details of participants in normal and overweight groups

Participant	Number	Age (years)	Height (cm)	Weight (kg)	BMI (kg/m^2)
Normal	11	11.60 (0.52)	140.4 (3.53)	31.9 (5.72)	16.12 (2.38)
Over weight	11	11.82 (0.40)	150.27 (5.04)	54.73 (4.88)	24.19 (0.80)

BMI=Body mass index

the protocol, in order to record static footprint, we asked participants to stand on a stamp painted with gouache and while they were gazing at the horizon, they should step comfortably by their right foot on the paper and then with their left foot. Participants exercised this process several times before the final record of their footprint was done. Then, we selected the best footprint after 3 repetitions and scanned it using Canon 550 scanner with DPI of 200. We saved the final file as a jpg file. Then, we used ImageJ software (for 32 bit windows) to calculate the anterior area, mid area, posterior area, total area, arch index (AI). To find these information, we analyzed the right foot of participants as the dominant foot. To calculate the variables of area, we considered footprint without toes [Figure 1].

Instructions for determining the variables using software are given in analogous studies.[35] The footprint was divided in to three sections: Anterior, mid, and posterior areas. We determined the area of these three sections. The total area was determined through sum of the area of anterior, mid, and posterior sections. The AI was determined through dividing the mid area by total area.[35]

To test the balance of participants, we used Y test. Previous studies have reported a good reliability of this test (ICC = 0.85-0.91).[36] When we explained the protocol to all participants, we asked them to try the test in three trials. During the test, all participants stayed on the center of the grid with a single leg while they were wearing sport shoes. We asked them to maintain this position and make their contralateral lower limb to touch as far as possible along three lines of posteriolateral, posteriomedial, and anterior. The maximum distance possible in each trial was recorded. After completion of all three trials in three lines, we determined the average value of each line. To determine the total score of each participant, we divided the average value by the length of participants' legs, which were from the anterior superior iliac spine to medial malleolus.

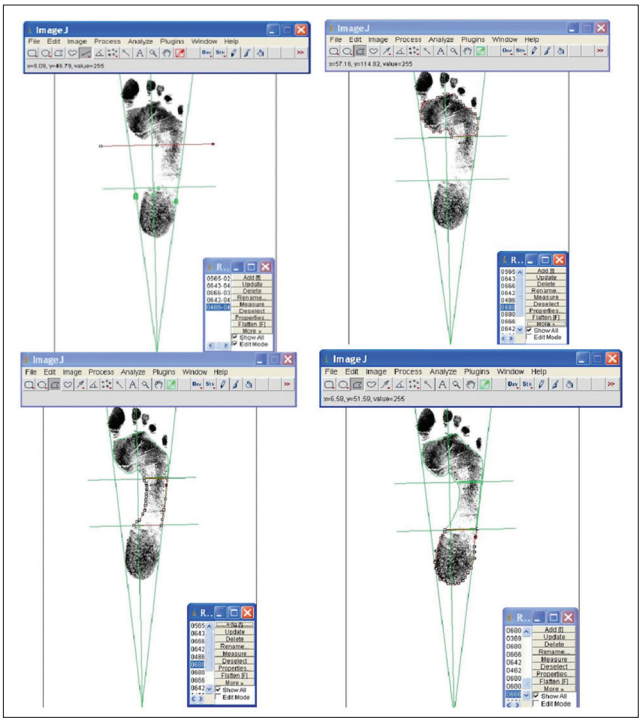

Figure 1: Different sections of footprint for determining area variables

Then, we multiplied the product by 100 in order to convert it into a percent of leg length. Next, the data were put into SPSS (version 16). We used descriptive statistics, mean, and standard deviation to analyze the data. We used Kolmogorov–Smirnov test to make sure about the normal distribution of scores, and one-way analysis of variance ($P \leq 0.05$) was used to compare the characteristics of footprint and balance of participants with overweight and normal children.

RESULTS

The mean and standard deviation of the data of footprint and balance of participants were determined, and the results from descriptive analysis showed that the area of anterior, medial and posterior sections in overweight children was higher than in normal children (M = 4519.20,

M = 2691.18, M = 3055.7, respectively). Thus, the total area in this group was also higher than in the normal group (M = 10266.09). The AI was the same in both groups (normal group: M =0.2590; overweight group: M =0.2573). However, participants in the normal group had a better status in balance indices of Y test in posteriolateral, posteriomedial, and anterior lines (M = 110.23, M = 106.7, M = 99.86) and, therefore, their total balance indices were higher too (M = 105.6). We used one-way analysis of variance to compare footprint characteristics and balance of normal participants and overweight participants. The data of this test are given in Table 2.

Results from one-way analysis of variance between normal and overweight groups show that there is a significant difference among anterior, posterior, and total areas between overweight and normal participants ($P < 0.05$). However, there was no difference in terms of mid area between the two groups ($P > 0.05$). In addition, there was significant difference between the total areas of these two groups ($P < 0.05$). Also, there was no significant difference in AI between them ($P > 0.05$). We found a significant difference between the two groups when comparing parameters of Y test in anterior line ($P < 0.05$). We also found no significant association between weight and balance of the participants [Table 3].

Table 2: One-way analysis of variance to compare variables in normal and overweight groups (significant difference $P \leq 0.05$)

Variable	df	F	*P* value
Footprint indices			
Anterior area	11	6.29	0.021
Mid area	11	4.17	0.055
Posterior area	11	16.50	0.001
Total area	11	9.97	0.005
AI index	11	0.015	0.903
Balance indices			
Posterior-lateral	11	3.97	0.061
Posterior-medial	11	0.55	0.467
Anterior	11	8.74	0.008
Total	11	4.32	0.051

*Significant difference ($P \leq 0.05$)

Table 3: Difference between balance and body weight

Parameter	Balance
Weight	0.4*

*Significant difference ($P \leq 0.05$)

DISCUSSION

The aim of this study was to investigate the effect of being overweight on the balance and footprint parameters of children. Based on the findings of this study, there is a significant difference between parameters of footprint, anterior, posterior, and total area of the subjects, while there was no significant difference in the mid area. The results of current study corresponds with those of Nieto *et al*., who carried out their study with participation of two groups of male and female students aged 11.6 ± 0.5 years with normal and overweight characters;[37] the findings of this study, taking into consideration the mid area of the subjects' feet, showed that there was no significant difference between subjects who were in normal and overweight condition, which again approves the findings of Nieto *et al*.,[37] Also, there is significant statistical difference in the parameter of total foot area of both groups of subjects; this finding corresponds to that in, Riddiford- Harland *et al*. and Nieto *et al*.[29-37]

In this study, the method of footprint was used to record the trace of foot on the paper but, in previous studies, Riddiford- Harland *et al*. and Nieto *et al*., the methods that were applied to record the trace of foot were pedograph and photopodogram, respectively.[29,37] Results indicated that these methods are more reliable than the method used in the current study.

After calculating different segments of the foot with method of footprint, another factor, AI, was calculated by dividing mid area of the foot on total area of the foot, which showed no significant difference between the two groups of (overweight and normal) subjects; this does not agree with results reported by the abovementioned researchers. Furthermore, another study by Mickal *et al*., stated that subjects who are overweight have more noticeable AI than those with normal weight,[38] this difference in result may be because the factor of total area between these two groups showed no significance difference based on the literature of the current study. On the other hand, concerning the mid area of the foot, there was similarity between this study and other ones mentioned previously.

Based on the results of balance testing that was carried out in this study, there was no significant difference between both groups of subjects, which is in contrast with the findings of Goulding *et al.*, which included teenage boys aged 10-21 years and which reported significant difference between body weight, BMI, and percent of total fat mass with balance examination.[39] Teenagers who suffer from obesity have less balance than others with a normal weight. According to these findings, Bernard *et al.*, reported the same result on examining obese subjects aged 13-17 years,[33] stating that the existing differences between these two result could have been due to the differences between the age of subjects. The method of evaluation of balance, which was used by Goulding *et al.*, was single-leg stance test on the Pedograph[39] that is a static test and can be considered as a laboratory method of balance testing. Biodex was used by Bernard *et al.*, to assess and calculate the balance factors, the main reason of difference between the findings of this study with the current one could be due to the difference in the methods applied in these researches as the current study is based on field test method that evaluates dynamic balance of subjects. Therefore, study of dynamic balance on the special devices such as Pedograph may lead to different results, this attitude is relevant to specialist claim that recording of foot area in dynamic status represents more precisely the features of foot structure.

CONCLUSION

In order to evaluate and define the pathology of foot structure, most of specialist use AI. According to the findings of this study, in static condition, being overweight has no significant effect on AI. Further studies need to be done to survey the effect of being overweight on dynamic balance.

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