Impact of Balanced Caloric Diet and Physical activity on Body Composition and Fat Distribution of Obese Egyptian Adolescent Girls

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Abstract: ***Objective:*** The aim of this study was to evaluate the effects of 6 months of balanced caloric moderately deficit diet program combined with individualized moderate Physical exercise on the body weight, body composition and fat distribution of adolescent girls**.** ***Subjects & methods:*** It was a longitudinal survey comprised 1244 adolescent girls, aged from 14 to 18 years. Their body weight and height were measured, and the BMI was calculated. Of the total sample, only one hundred and eleven girls (8.9%), with mean age was 15.82$\pm$ 0.75 years, were suffering from obesity based on their body mass index; which is greater than the 95th percentile for age and gender based Egyptian Growth Reference Charts. These obese girls were undergoing nutritional intervention (specific dietary program, nutritional education and exercise) for 6 months. At the start of this program, the obese girls were assessed for their anthropometric measures: the body weight, body height (or stature), body mass index (BMI), waist and hip circumferences, waist/hip ratio, skin folds thickness at 5 sites and, according to BIA, their body composition. This assessment was repeated after 6 months. Only thirty eight girls completely finished the program till the end. ***Results:*** The current study showed that after following the dietary program and physical activity, there were highly significant reduction in waist circumference, the skin fold thickness at the 5 sites (triceps, biceps, sub scapular, suprailiac and abdominal), peripheral and central adiposity, and fat mass, and significant reduction in body weight, hip circumference and fat%. The change in BMI was not significant. On the other hand, there was a highly significant increase of the total body water and Basal metabolic rate after following the dietary program and physical activity. ***Conclusion:*** The nutritional intervention program was succeeded in 38 obese adolescent girls. These girls show highly significant reduction in body composition and body fat distribution.This revealed that the combined program of diet restriction and exercise is necessary.

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Introduction

The prevalence of obesity has reached alarming levels. Obesity is affecting virtually both developed and developing countries of all socioeconomic groups including all age groups thereby posing an alarming problem, described by the World Health Organization (WHO) as an "escalating global epidemic"[(1)].

Worldwide, over 22 million children under the age of 5 are severely overweight, as are 155 million children of school age. This implies that one in 10 children worldwide is overweight [(2)]. The dramatic increase in the prevalence of obesity in the past few decades can only be due to significant changes in lifestyle influencing children and adults [(3)]. These obesity-promoting environmental factors are usually referred to under the general term of "obesogenic" or "obesigenic" [(4)]. The current changing nature of this obesogenic environment has been well described in a WHO Technical Report as Changes in the world food economy have contributed to shifting dietary patterns, for example, increased consumption of energy-dense diets high in fat, particularly saturated fat, and low in unrefined carbohydrates. These patterns are combined with a decline in energy expenditure that is associated with a sedentary lifestyle [(5)].

With changing food habits and increasingly sedentary lifestyles, a potential deluge is evident across the globe with obesity rates increasing more than two fold over the past 25 years in the U.S., almost threefold in the past 10 years in England, and almost fourfold over a similar time frame in Egypt [(6)]. Recently, in Egypt research of National Survey for Diet, nutrition and non-communicable diseases "DNPCNCD" by National Nutrition Institute (2008) [(7)] stated that the prevalence of overweight and obesity among adolescents aged 10-18 years was 20.5 %.

Obesity in children and adolescents is associated with several metabolic and hemodynamic abnormalities: dyslipidemia, high blood pressure (BP), impaired glucose tolerance, insulin resistance and assorted cardiovascular risk factors [(8)]. In addition, atherosclerosis reportedly begins in childhood [(9)].

So, the need for evidence-based treatment recommendations is a critical health care issue, because obese children and adolescents are at risk for developing many of the co-morbidities seen in obese adults. Studies demonstrated that fasting serum glucose, insulin, and triglyceride levels and the prevalence of impaired glucose tolerance and systolic hypertension increase significantly as children become obese (BMI of ≥95th percentile) [(10)]. Even children and adolescents who are overweight (BMI of 85th to 94th percentile) are at risk for co-morbidities. Therefore, interventions using dietary modifications, increased physical activity, and behavioral therapy may be beneficial for overweight children and adolescents, with more-aggressive intervention directed toward obese children and adolescents [(11)].

Health care professionals, however, may find it difficult to determine which interventions will be most efficacious for their patients. Clinical trials have failed to determine whether specific dietary modifications alone without behavioral interventions and increased physical activity are effective in reducing childhood overweight and obesity rates. Comprehensive interventions that include behavioral therapy along with changes in nutrition and physical activity are the most closely studied and seem to be the most successful approaches to improve long-term weight and health status [(12)]. However, the clinical trials testing these interventions often are limited in their ability to determine the relative efficacy of individual strategies. Ultimately, children and adolescents (and adults, for that matter) become overweight or obese because of an imbalance between energy intake and expenditure. Dietary patterns, television viewing and other sedentary activities, and an overall lack of physical activity play key roles in creating this imbalance and therefore represent opportunities for intervention.

The aim of this study was to evaluate the effects of 6 -month of balanced caloric moderately deficit diet program combined with individualized moderate physical exercise on the weight, body composition and fat distribution of adolescent girls.

Subjects and methods:

This study was conducted by the National Research Centre, Egypt, to estimate the prevalence of obesity among secondary school adolescent girls. It was a longitudinal survey, comprised 1244 adolescent girls, with age ranged from 14 to 18 years. They were recruited from "Gamal Abd-El-Naser Secondary Public School", in Giza governorate, for a whole studying year from October, 2008 to April 2009. Girls were excluded if they had a prior major illness, including type 1 or 2 diabetes, took medications or had a condition known to influence body composition, insulin action or insulin secretion (e.g. glucocorticoid therapy, hypothyroidism and Cushing's disease).

Permission to perform the study was granted by the Ministry of Education, and the director of the school included in the research. Parents were informed about the purpose of the study and their permission in the form of written consent was obtained. Another assent from the student's involved in the research was obtained. The protocol was approved by the "Ethical Committee" of the "National Research Centre".

Each girl underwent a complete physical examination, including anthropometric measures which are following the recommendations of the International Biological program [(13)]. The body height was measured to the nearest 0.1 cm on a Holtain portable anthropometer, and the body weight was determined to the nearest 0.01 kg on a Seca scale Balance with the subject wearing minimal clothing and no shoes. Body mass index (BMI) was calculated as body weight (in kilograms) divided by body height (in meters) squared.

Of the total sample, only one hundred and eleven girls or 8.9% with mean age 15.82$\pm$ 0.75 years, were suffering from obesity based on their body mass index; which is greater than the 95^{th} percentile for age and gender based on the Egyptian Growth Reference Charts [(14)]. These obese girls were undergoing nutritional intervention (specific dietary program, nutritional education and exercise) for 6 months. At the start of this program, the obese girls were assessed for following anthropometric measures and calculated parameters: the body weight and body height; waist and hip circumferences; five skin fold thickness; BMI; waist/hip ratio; and body composition according to BIA. This assessment was repeated after 6 months.

Anthropometric measures: Body weight was measured as previously mentioned. Waist circumference was measured at the level of the umbilicus with the subject standing and breathing normally, hip circumference at the level of the iliac crest, using non-stretchable plastic tape to the nearest 0.1 cm. Skin fold thickness were taken at five sites: triceps, biceps, sub scapular, suprailiac and abdominal. Each skin fold was measured three times on the left side of the body with Holtain skinfold caliper to the nearest 0.2 mm, and the mean was recorded. The following indices were calculated:

- Body mass index (Kg/m^2)
- Waist/ Hip ratio (cm/ cm).
- Peripheral adiposity: as the sum of triceps and biceps skin fold thickness.
- Central adiposity: as the sum of subscapular, suprailiac and abdominal skin fold thickness.

Body Composition: Whole body resistance and reactance (capacitance) were measured using a Bioelectrical Impedance Analyzer (HOLTAIN LIMITED). As specified by the manufacturer, the unit was calibrated before testing using 400-ohm resistor, and electrodes were placed on right wrist and ankle. By using girl´s sex, age, body weight and body height approximated to the nearest unit, the percentage body fat (Fat %), fat mass (FM), fat free mass (FFM), total body water and basal metabolic rate (kcal) were derived.

Nutritional intervention (specific dietary program, nutritional education and exercise)*:* **A** balanced caloric moderate deficit diet (BCDD), is a reduced-energy **diet (**– 500 kcl/day) was established by a dietician. The diet was selected from the usual 4 food groups in quantities thought to meet basic requirements of all macronutrients and micronutrients in a healthy proportion: (25-30% of total calories from fats, 8-10% from saturated fats, up to 15% of total calories from monounsaturated fatty acids, up to 10% from polyunsaturated fats ,< 300mg/d cholesterol , approximately 15% of total calories from protein, 55% from CHO. , 20—30gm/d fiber ,no more than 1. 5 gm /d Na , water not less than 2.5 liter /d, 1000—15000 mg/d calcium). These diet regimen supplies enough calories to enable the patients to proceed normally in their life & not feel hungry nor lacking energy .Also, it can be adherent to and safe in long and short time, the diet design was individualized, flexible allowing the patients to exchange items, so as not to be boring, and produce 1 Ib or 0.5 kg loss per week .We spread the food through the day to meet the energy needs, avoiding long periods of no food or hunger. The foods were selected according to the girl's dietary habits. PowerPoint presentations and role-play scripts were designed for trainers to be used during the educational program.

Exercise: moderate Physical activity in the form of unsupervised walking for an hour daily or at least 5 times /week, starting by half an hour then gradually increase the duration to an hour after 3 days. This was encouraged and motivated by grouping teams of students.

The anthropometric measurements and body composition were remeasured after 6 months from the start of the dietary program to assess the effect of the nutritional modifications.

Statistical Analysis: Graphic presentation of the % of girls with different effect of the program, according to the reduction of the % body fat was drawn. Evaluation of the statistical distribution of the variables was done using Kolmogorov - Smirnov Goodness of Fit Test. Most the variables have asymmetric distribution ($p<0.05$);except skin fold thickness at the triceps and suprailiac crest, fat free mass and total body water; where they have normal distribution ($p>0.05$). All values are reported as the mean ± SD (the range). The changes in the used parameters before and after the dietary program were calculated. WILCOXSON non parametric t- test was used to examine the differences before and after the dietary program for the variables which had asymmetric distribution, while Paired sample *t test* (d-statistics) was used for the variables which had normal statistic distribution. The level of significance was set at a probability of less than 5% ($p<0.05$). Statistical evaluation of the results was performed with the SPSS 9.05 computer program.

Results:

The nutritional intervention program started with 111 girls; but unfortunately; 38 girls only continued strictly with the program for the 6 months. All of them undergo weight reduction, except 3 girls showed very minimal changes in weight but significant changes in body fat distribution and body composition. Their ages ranged between 15 to 16 years (with mean age 15.45 ± 0.50).

Percentage of the girls with different effect of the program; according to the reduction in % body fat; are presented in figure (1). It was noticed that 38.6%(14 girls) had no effect on the % body fat; in spite of the reduction in their weight;26.3% (10 girls) had reduction less than 5%, 18.4% (7 girls) had reduction between 5 - 10%,and 18.4% (7 girls) had reduction between 10 - 20%.,

Anthropometric measurements at the beginning and the end of the nutritional intervention were summarized in table (1) and figure (2). The main baseline of BMI was 32.39 ± 3.13 Kg/m², which indicates that; on average; these girls were obese at the beginning of the nutritional intervention. After the 6 months nutritional intervention, highly significant reduction in body weight and waist circumference, and significant reduction in hip circumference were recorded after following the dietary program, nutritional education and physical activity. However, the change in BMI was insignificant. Body fat distribution at the beginning and the end of the nutritional intervention program were summarized in table (2) and figure (3).Highly significant reduction in all the skin fold thickness at the 5 sites (triceps, biceps, sub scapular, suprailiac and abdominal), peripheral and central adiposity, waist circumference and waist-hip ratio was recorded.

Body composition at the beginning and the end of the nutritional intervention program were summarized in table (3).It was observed that there were highly significant reduction in fat % and fat mass, while, total body water and basal metabolic rate showed highly significant increase. However, the fat free mass was not significantly increased or even not changed. The nutritional intervention program was succeeded in 38 obese adolescent girls. These girls show highly significant reduction in body composition and body fat distribution.

Table (1): Anthropometric measurements before and after the 6 months nutritional intervention

	Before Mean± SD (Range)	After Mean± SD (Range)	Changes Mean± SD (Range)
Weight (Kg)	**86.01 ± 6.79**	**82.93 ±5.93****	**3.08 ± 2.92**
	(76.00 ~ 94.00)	**(73.80 ~ 92.10)**	**(- 1.60 ~ 8.60)**
BMI(kg/m²)	**32.39 ± 3.13**	**32.36 ± 2.14**	**0.029 ± 1.48**
	(28.50 ~ 37.80)	**(30.30 ~ 36.40)**	**(- 1.90 ~ 1.40)**
Waist C(cm)	**85.55 ±6.70**	**80.79 ± 8.08****	**4.76 ± 2.87**
	(77.00 ~ 97.00)	**(74.00 ~ 95.00)**	**(2.00~ 10.00)**
Hip C (cm)	**105.84 ± 9.39**	**100.45 ±9.01***	**5.39 ± 2.88**
	(93.00 ~ 120.00)	**(89.00 ~ 116.00)**	**(3.00 ~ 11.00)**

N.B.: The significance was tested using WILCOXON non parametric test

* Significant ($p < 0.05$); **Highly significant ($p < 0.01$)

Table (2): Fat distribution before and after the 6 months nutritional intervention

	Before Mean± SD (Range)	After Mean± SD (Range)	Changes Mean± SD (Range)
Skinfold Thickness			
+Triceps	32.68 ± 6.79	26.87 ±6.65**	5.82 ± 1.65
	(22.050 ~ 42.00)	(18.00 ~ 35.00)	(4.00 ~ 8.50)
#Biceps	24.74 ± 5.82	19.62 ± 5.76**	5.12 ± 1.65
	(17.00 ~ 32.00)	(12.00 ~ 27.00)	(1.80 ~ 7.00)
#Subscapular	31.26 ± 5.59	25.68 ± 6.51**	5.58 ± 2.21
	(23.00 ~ 41.00)	(18.00 ~ 37.00)	(3.00 ~ 10.00)
+Suprailiac	26.89 ±7.24	21.95 ± 6.19**	4.95 ± 1.29
	(19.00 ~ 40.00)	(15.00 ~ 33.00)	(2.00 ~ 7.00)
#Abdominal	27.32 ± 7.95	21.99 ± 7.16**	5.33 ± 1.54
	(17.00 ~ 38.00)	(15.00 ~ 32.00)	(1.00 ~ 6.50)
#Peripheral Adiposity	57.42 + 11.72	46.49 ± 11.99**	10.93 ± 2.95
	(44.50 ~ 74.00)	(32.00 ~ 61.00)	(7.00 ~ 15.50)
#Central Adiposity	85.47 ± 18.74	69.62 ± 18.44**	15.86 ± 3.48
	(70.00 ~ 119.00)	(51.00 ~ 102.00)	(6.00 ~ 20.00)
#Waist Circumference(cm)	85.55 ±6.70	80.79 ± 8.08**	4.76 ± 2.87
	(77.00 ~ 97.00)	(74.00 ~ 95.00)	(2.00~ 10.00)
#Waist-Hip Ratio (cm/cm)	0.81 ± 0.05	0.81 ± 0.06**	0.005 ± 0.01
	(0.76 ~ 0.91)	(0.74 ~ 0.91)	(- 0.01 ~ 0.02)

N.B.: # The significance was tested using WILCOXON non parametric test

+ The significance was tested using Paired sample t-test

*** Significant (p < 0.05) **Highly significant (p < 0.01)**

Table (3): Body Composition before and after the 6 months nutritional intervention

	Before Mean+ SD (Range)	After Mean+ SD (Range)	Changes Mean+ SD (Range)
#Fat %	42.93 +2.96 (37.80 ~ 46.10)	41.40 + 3.08** (37.70 ~ 46.30)	1.53 + 2.19 (-1.40 ~ 4.20)
#Fat mass (Kg)	38.04 + 3.68 (31.20 ~ 42.40)	34.33 + 3.65** (30.70 ~ 39.50)	3.71 +2.61 (0.00 ~ 6.90)
+Fat free mass(kg)	48.26 + 3.57 (42.80 ~ 53.70)	48.60 + 4.24 (43.10 ~ 54.80)	- 0.34 + 1.24 (-2.20 ~ 1.60)
#Total body water	28.92 +14.17 (31.30 ~ 39.30)	35.58 + 3.09** (31.60 ~ 40.10)	- 0.47 +0.63 (-1.60 ~ 0.10)
+BMR(KC)	1586.0 + 82.21 (1499.00 ~ 1714.00)	1642.32 + 62.13** (1542.00 ~ 1714.00)	- 56.32 +34.04 (- 104.00 ~ 0.00)

N.B.: # The significance was tested using WILCOXON non parametric test

+ The significance was tested using Paired sample t-test

*** Significant ($p < 0.05$); **Highly significant ($p < 0.01$)**

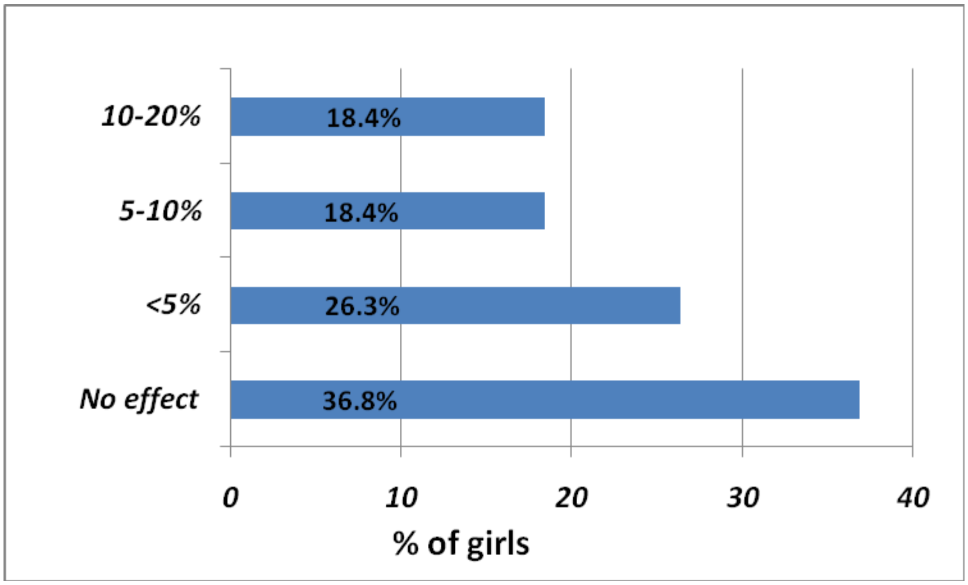


Fig 1: The different effect of the 6 months nutritional intervention program on the reduction in body fat percentage

Fig. 2: Hip and waist circumferences before and after the 6 months nutritional intervention program

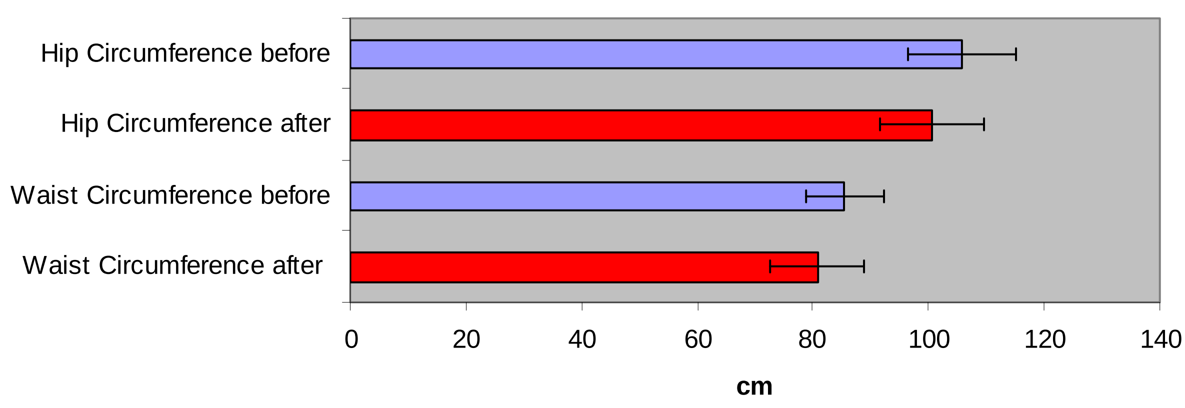
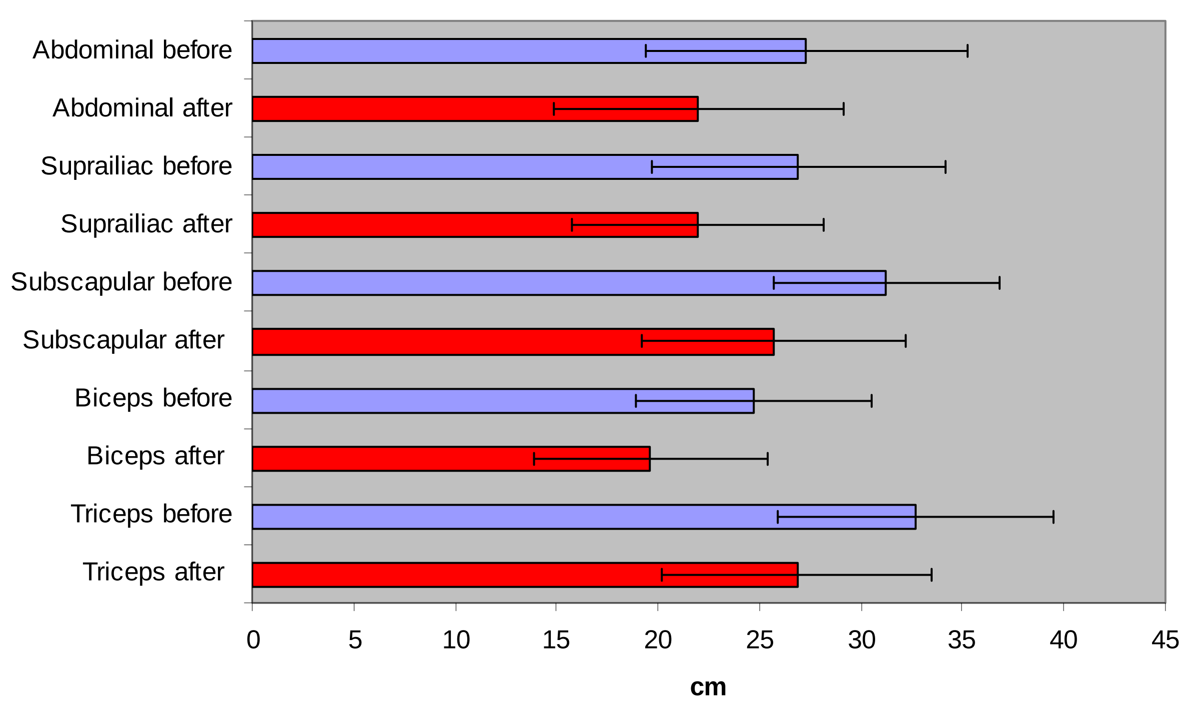


Fig. 3: Fat distribution before and after the 6 months nutritional intervention program



Discussion

Adolescents who are overweight or obese are more likely to remain so in adulthood than pre-adolescents aged 10–14 [15], unless the latter obtain treatment.

Treatment for children and adolescents who are overweight or obese seems easy, that is, just counsel children, adolescents and their families to eat less and to exercise more. In practice, however, treatment of childhood obesity is time-consuming, frustrating, difficult, and expensive. In fact, choosing the most effective methods for treating overweight and obesity in children is complex at best. This is especially true for primary care providers, who have limited resources to offer interventions within their offices or programs. The paucity of providers to whom they can refer patients adds to the problem.

A multi-factorial approach has been in use for the treatment of obesity, including dietary modification, exercise, psychotherapy and medication. There are several reports in the literature about exercise programs for adolescents with obesity [16, 17]. However, the focus of most programs is on long-lasting endurance activities, which in our opinion are boring for the pediatric population. Furthermore, most programs are not easily reproducible due to lack of detail or requirement of special equipment. Therefore, our aim was to encourage adolescents to do a simple, cheap, cost effective activity which is accessible to everyone and motivates adolescents by walking with their colleagues.

Low physical activity levels may be as important as excess energy intake [18]. Although data from previous studies were equivocal, Swinburn et al. (2006) [19] found energy intake was a more important determinant of high body weight than low physical activity. TES, 2008 [20] stated that in the absence of caloric restriction, moderate exercise does not generally cause weight loss. However, in combination with decreased caloric intake, exercise can achieve significant weight loss. This matches our results as with both caloric restriction and regular physical activity over a period of 6 months our patients achieved weight reduction. Wittmeier et al., 2008 [21], also, reported that lower durations of both moderate physical activity (MPA) and vigorous physical activity (VPA) are associated with increased odds of overweight and adiposity. They concluded that forty-five minutes of MPA and fifteen minutes of VPA were associated with reduced body fat and BMI. A total of one hour per day of moderate-intensity activity, such as walking on most days of the week, is probably needed to maintain a healthy body weight [22].

In general, to lose weight, you either have to decrease the amount of calories you are eating and drinking, exercise to burn more calories, or even better, do a combination of both. To lose 1 pound in 1 week, you can decrease your calories by 500 a day or burn 500 extra calories a day. The American Diabetic Association [23] stated that: Use of a reduced-energy diet (not less than 1200 kcl/ day) in the acute treatment phase for adolescent overweight is generally effective for short-term improvement in weight status; and this is agreed with our data which showed significant reduction in weight of the studied group.

The BMI can be easily assessed at low cost, and has a strong association with body fatness and health risks [24]. The subcutaneous skin fold thicknesses have been widely used to estimate body fat. The main advantages are simplicity of use and suitability for epidemiological studies [25]. It is used as a measure of nutritional status in children on assumption that increased subcutaneous fat reflects a greater caloric reserve [26]. It has been shown to correlate with estimates of total body fat and with lean body mass [27].

In this study, BMI and sum of skin fold thickness were used as indicators of overall adiposity. The sum of skin fold is reported as a reliable estimate of obesity and regional fat distribution [28]**.** WC was considered as an appropriate predictor of abdominal fat in children [29] and adolescents [30]. Another indicator of abdominal adiposity is WHR, which was reported as a better indicator of adiposity independent of age and sex [31]. But in this study the changes of WHR were discrete and not significant, so the future investigations are needed about the sensitivity of WHR in detection of obesity, in the population of Egyptian girls.

Highly significant reduction in waist circumference was also, noticed after following the dietary program and physical activity. However, the change in BMI was not significant. Skin fold thickness at 5 sites (triceps, biceps, sub scapular, suprailiac and abdominal) were significantly deceased. Highly significant reduction in fat mass, peripheral and central adiposity; significant reduction in fat %; and highly significant increase in total body water were found. There was a highly significant increase of the basal metabolic rate, but the increase of fat free mass was not significant. The BMI didn't show a reduction, and probably one of the possible reasons for this is a highly significant increase of total body water in our investigated girls.

Decrease in the fat percent with preservation of the FFM and increase of the resting metabolic rate (RMR) of the girls was also observed. The weight reduction and maintenance appears to be antagonized by a reduction in the resting metabolic rate (RMR) which comes in agree with our results. As the largest component of daily energy expenditure, RMR comprises approximately 60–70%, Fat-free mass (FFM) is the main factor that accounts for the magnitude of resting metabolism [(32)]. As a heterogeneous compartment, FFM consists of highly metabolically active muscle and organs and low-metabolic rate tissues such as bone and connective tissue [(33)]. Therefore, any diet or exercise interventions, which are capable of maintaining FFM or at least attenuating its decline following weight loss, could have significant effects on total energy balance. The foremost objective of a weight-loss trial has to be the reduction in fat mass leading to a decrease in risk factors for a metabolic syndrome. Both with regard to a reduction in risk factors and long-term weight maintenance the content of adipose tissue in the weight lost has to be maximized, thus preserving FFM [(34)]. A decline in body weight can be achieved while favorably modifying body composition with the maintenance of FFM is through physical activity [(35)].

Wells and Victoria [(36)], 2005, also, stated that changes in body composition indicators may have important health implications, as it has been demonstrated that the health risks associated with obesity derive primarily from fat rather than body weight. Moreover, it is not only the total amount of fat that is important, but also the distribution of fat in the body [(37)], with central fatness being most related to health risks [(38)]. Teixeira et al. (2001) [(39)] showed that measures of central adiposity such as WC and WHR significantly correlated with serum lipid levels in obese children and adolescents but not in leaner individuals. Kelishadi et al. (2007) [(40)] concluded that BMI, WC and WSR were the most appropriate indices in predicting CVD risk factors. Many studies confirming the predictive value of BMI for CVD risk factors [(41, 42)].

Finally the current research also, revealed that after the 6 months nutritional intervention, reduction in body weight, hip, and waist circumference were significant after following the dietary program. However, the change in BMI was minimal. The reduction in all the measured skin fold thickness at the 5 sites (triceps, biceps, sub scapular, suprailiac and abdominal), reflects a reduction in peripheral and central adiposity. However, the change in waist-hip ratio was minimal.

In summary, it can be concluded from this research that dietary composition can modify the physiological adaptations to energy restriction. A balanced diet with moderate energy restriction together with moderate physical activity and behavioral modification result in body weight loss with preservation of the FFM and a decrease in the fat percentage. This study may contribute in establishing evidence based Egyptian program for obesity and overweight management.

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