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The Effects of Diet and Physical Activity on Resting Metabolic Rate (RMR) Measured by Indirect Calorimetry, and Body Composition Assessment by Dual-Energy X-Ray Absorptiometry (DXA)

Diyet ve Fiziksel Aktivitenin İndirekt Kalorimetrik Yöntemle Ölçülen Dinlenme Metabolizma Hızı (DMH) ve Dual-Enerji X-ray Absorpsiyometresi (DXA) ile Ölçülen Vücut Bileşimine Etkisi

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Summary

Objective: This study was planned to investigate the effects of diet and physical activity on resting metabolic rate (RMR) measured by indirect calorimetry, and body composition assessed by dual energy-X-ray absorptiometry (DXA).

Materials and Methods: This is a longitudinal, clinical intervention study of weight loss diet daily with/without exercise for 12 weeks. Overweight women with a body mass index (BMI): 25.0-29.9 kg/m^2 and obese women with a BMI>30.0 kg/m^2 (n:37), aged 20-45 years were included in the study. The subjects were divided into two groups: DA - the group received diet alone (n:20), DPA - the group received diet and exercise therapy (n:17). Various anthropometric measurements were performed; body composition of the subjects were measured by DXA and bioelectrical impedance analyzer (BIA) and resting energy expenditure (REE) was assessed by Cosmed K4 B2 at the beginning and end of the study.

Results: Basal metabolic rate (BMR) and RMR during the weight loss program in DA group were significantly lower than at baseline ($p<0.001$). While BMR measurements decreased, RMR levels increased significantly in DPA group at the end of the study ($p<0.001$). There were significant differences between the groups in terms of body weight (kg) ($p=0.001$), body fat mass (kg) ($p=0.001$) and body fat percentage (%) ($p<0.05$) that was measured by DXA.

Özet

Amaç: Bu araştırma, diyet ve fiziksel aktivitenin indirekt kalorimetrik yöntem ile ölçülen dinlenme metabolizma hızı (DMH) ve Dual-enerji X-ray absorpsiyometre (DXA) ile ölçülen vücut bileşimine etkilerini saptamak üzere planlanmıştır.

Gereç ve Yöntem: Çalışma, 12 hafta süresince günlük uygulanan zayıflama diyeti ve/veya egzersizin etkisinin incelendiği uzunlamasına planlanan klinik bir araştırmadır. Yaşları 20-45 yıl arasında değişen, beden kütle indeksi (BKİ): 25,0-29,9 kg/m^2 olan fazla kilolu ve BKİ > 30,0 kg/m^2 olan şişman kadınlar (n:37) çalışmaya alınmıştır. Bireyler iki gruba ayrılarak ilk gruba tek başına diyet (n:20), ikinci gruba ise diyete ek olarak egzersiz tedavisi uygulanmıştır (n:17). Çalışmanın başında ve sonunda, DXA ve biyoelektrik impedans analizörü (BİA) kullanılarak bireylerin antropometrik ölçümleri ile vücut bileşimleri ve Cosmed K4 B2 cihazı ile dinlenme durumunda enerji harcaması (DEE) ölçümleri alınmıştır.

Bulgular: Diyet (DA) grubundaki bireylerin bazal metabolizma hızı (BMH) ve DMH ölçümleri zayıflama süresince başlangıç değerlerine göre düşük bulunmuştur ($p<0,001$). Diyet+aktivite (DPA) grubundaki bireylerin başlangıca göre BMH ölçümlerinde azalma gözlenirken, DMH düzeylerinde istatistiksel olarak anlamlı artışın olduğu saptanmıştır ($p<0,001$). Bireylerin DXA ile saptanan vücut ağırlığı ($p=0,001$), vücut yağ kütlesi (kg) ($p=0,001$

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Conclusion: Diet and exercise together could accelerate body fat loss, preserve fat-free mass and prevent/increase in RMR more effectively than with diet restriction alone. It is suggested that, in order to ensure healthy weight loss, increasing physical activity in addition to diet should be recommended. *Turk J Phys Med Rehab 2012;58:1-8.*
Key Words: Resting metabolic rate (RMR), dual energy-X-ray absorptiometry (DXA), energy expenditure, diet, physical activity

ve vücut yağ oranı (%) (p<0,05) ölçüm değerlerindeki farklılık grup içi ve gruplar arasında istatistiksel olarak önemli bulunmuştur.
Sonuç: Zayıflama diyeti ve egzersizin birlikte, vücut yağ kaybının hızlandırılması ve yağsız doku kütlesinin korunumunun sağlanması; ek olarak DMR düzeyinin yükseltilmesi/korunumunda, tek başına diyet uygulamalarına göre, daha etkili olduğu düşünülmektedir. Bu nedenle, sağlıklı zayıflamanın sağlanması amacıyla diyete ek olarak fiziksel aktivitenin arttırılması önerilmelidir. *Türk Fiz Tıp Rehab Derg 2012;58:1-8.*
Anahtar Kelimeler: Dinlenme metabolizma hızı (DMH), dual-enerji X-ray absorpsiyometresi (DXA), enerji harcaması, diyet, fiziksel aktivite

Introduction

Obesity is one of the most important health problems among the advanced and developing countries in recent years (1). Although the prevalence of obesity in industrialized countries is higher, it is more frequently seen in middle- and high-income developing countries. According to the World Health Organization (WHO), over 400 million of individuals in the world are obese and also around 1.6 billion are overweight. This rate is expected to reach 700 million and 2.3 billion in 2015, respectively (2). With respect to "Turkish Obesity and Hypertension Survey" (n=23.888) performed in Turkey, the overweight and obesity rate was found to be 41%, and 25.2%, respectively (3). According to the Prospective Urban Rural Epidemiology (PURE) Study results, prevalence of overweight and obesity has increased from 34% to 52% in Turkey (4).

An imbalance of energy intake and energy expenditure leads to obesity which is associated with increased morbidity and mortality. In contrast, persistent weight loss significantly reduces overall mortality. Physical activity improves weight loss and is also a good predictor of long-term weight loss maintenance. Total energy expenditure (TEE) consists of resting energy expenditure (REE), the thermic effect of food (TEF) and activity thermogenesis (AT) (5). Indirect calorimetry is commonly accepted as the criterion standard for measuring REE. Energy expenditure varies between normal and obese individuals. Furthermore, Basal Metabolic Rate (BMR) is defined as energy expenditure for membrane turnover and thermogenesis of the organism measured after 12-14 hour-period of starvation and through 30 minutes' of absolute rest of an individual (6). Resting Metabolic Rate (RMR) is approximately 3-6% higher than BMR, but in practice both of them can be used interchangeably (6).

Body composition (BC) measurements are integral to nutritional assessment of the individuals. Dual-energy X-ray absorptiometry (DXA) has been extended to allow the study of the total skeleton and its regional parts, as well as soft-tissue composition measurement (7). DXA is now one of the most frequently used techniques for BC measurement as a result of the increasing worldwide availability of these scanners. The technique is attractive because it is noninvasive, is easily applied for both healthy individuals and patients and the radiation dose is extremely small (8,9).

In the present study, we investigated the effects of diet and physical activity on RMR measured by indirect calorimetry, and BC assessment by DXA.

Materials and Methods

Subjects

The study was conducted on 37 women [diet alone (DA) group (n:20), diet+physical activity (DPA) group (n:17)] aged 20-45 years, for 12 weeks. The size of the sample was calculated as a total of 40 individuals with repeated measures analysis of variance in the "Statsdirect Program". The study has started with 55 volunteers for the reason that it was a prospective study and also for the risk of individuals leaving from the investigation. During the three-month follow-up period, a portion of individuals have been left outside the scope of the study with various reasons and the research was completed with 37 subjects.

The participants were voluntarily divided into two groups according to their dietary habits, socio-cultural and working status and the lifestyle habits. The first group had diet alone (DA), the second group had both diet+physical activity (DPA). The second group attended an exercise program (brisk walking) by 30-45 minutes, 3-5 days a week. The subjects were informed and followed about the importance of regular activities to provide accuracy and continuity of the research.

The general characteristics of the subjects were as follows:

• Overweight and obese women, aged 20-45 years, with body mass index (BMI) 27-40 kg/m^2

• Individuals without any chronic illness or a history of obesity (according results of consultation provided by a internal medicine specialist, the subjects were identified regardless of their diets by measuring the levels of fasting blood glucose, triiodothyronine (T3), thyroxine (T4), thyroid stimulating hormone (TSH).

The participants were voluntarily divided into two groups: the first group received diet therapy alone (DA), and the second group - both diet and physical activity (DPA). According to the needs of each individual, diet program was maintained to provide a weight loss 0.5-1 kg/week.

The individuals signed a voluntary participation form and filled the questionnaires adhered to the Declaration of Helsinki (World Medical Association). Ethical approval was obtained from the Gulhane Military Medical Academy (GATA) ethics committee (Approval number: 1491-228-06).

Anthropometric Measurements

Determination of body composition by Bioelectrical Impedance Analysis (BIA): Body weight, body fat and fat free-mass of the subjects were measured using the Tanita TBF 300 throughout 12 weeks. The subjects were asked to wear light clothing during the measurements. For the BIA measurement, they have been asked not to do heavy physical activity 24-48 hours before the test, and not to have consumed much liquid (water, tea, coffee) and to fast for at least 4 hours before the test.

Determination of Body Composition with Dual Energy X-Ray Absorptiometry (DXA): Body fat, lean body mass and bone mineral density of the subjects were measured by DXA in the Department of Radiology at Etimesgut Military Hospital.

Measurement of Resting Metabolic Rate (RMR) with Ergospirometry: RMR of the subjects were measured by "Cosmed K_4 B_2" ergospirometry. For each individual, measurement of RMR was repeated four times for 12 weeks. Cosmed K_4 B_2 determines RMR by using measured values of oxygen consumption (VO_2) and carbon dioxide production (VCO_2). RMR was calculated with the equation by software of the device with "Wier Equation" [RMR (kcal/day): (3.9 x VO_2+1.1 xVCO_2) x 1.44]. The obtained RMR values were used in the calculation of daily energy requirements of the individuals.

The subjects placed the heart rate monitor around their chest and were asked to wear face mask whilst lying in a comfortable supine position with the battery pack and portable unit placed beside them. The face mask contains a turbine which allows the air flow to be measured. The portable unit contains both the oxygen and carbon dioxide sensors, sampling pump, ultra high frequency (UHF) transmitter, barometric sensors and electronics. It is where the analysis of the expired air sample is carried out. These data are then sent to the receiver unit (connected to a computer) via telemetry. Oxygen consumption and carbon dioxide production were measured in terms of rate per breath whilst resting for a total of 30 minutes. The last 20 minute of steady state was kept for measurement.

Calibration of the Cosmed K_4 B_2 was carried out prior to the measurement of each subject. The instrument calibrations required for accurate and reliable measurement were made by researchers at the recommended frequency before each measurement.

The calculation of physical activity and energy expenditure of the individuals: The detailed dietary and physical activity records for 3 consecutive days were taken every month to calculate the physical activity and energy expenditure of individuals. The activities during the day were recorded at five-minute intervals. The activity coefficient of the standard physical activity (Physical Activity Ratio-PAR) for each activity was calculated to evaluate activity period (minutes). The average 3-day records were taken for each month. The physical activity levels (PAL) were evaluated as [PAL=TEE/RMR] and activity energy expenditure (AEE) as [AEE=TEE- (RMR+ 0.1 x TEE)]. The value which was calculated as "0.1 x TEE" represents diet-induced thermogenesis (10). The PAL values were classified as <1.40 sedentary, 1.40-1.60 slight, 1.70-1.99 moderate, 2.00-2.40 heavy, >2.40 was considered too heavy activity, according to the United Nations Food and Agriculture Organization, World Health Organization, United Nations University Expert Committee (FAO / WHO / MEAL) report (11).

Dietary Therapy and Physical Activity Program: The daily energy and nutrient intakes were obtained according to food consumption records of each individual before starting diet program. TEE was calculated using RMR measured by ergospirometry.

Dietary energy of the individuals was regulated to provide 0.5-1 kg weight loss per week by reducing 10-30% of daily energy requirements. The dietary energy was planned to provide 50-60% carbohydrate, 15-20% protein, and 25-30% fat in a way peculiar to each subject.

Statistical Analysis

The data analysis was carried out using SPSS version 13.0 for Windows (SPSS Inc., Chicago, IL, USA). Distribution of the data was determined by using the Kolmogorov-Smirnov test. Results were expressed as means (x), and standard error (Sx) for parametric data. Median and interquartile ranges were given for non-parametric data. Chi-square test (for categorical variables), repeated measures analysis of variance (for normally distributed paired data), one-way ANOVA (for normally distributed data), and the Kruskal-Wallis-test (for not normally distributed data) were used. A modified Bonferroni-correction was used to adjust p-values for multiple comparisons in all individuals and significance test of the difference between the two spouses was used for binary comparisons. The significance level was set at 5%, 1% and a two-way analysis was used for all other tests.

Results

This study was conducted on 37 women aged 20-45 years. The mean age was 30.3±1.67 years (BMI: 30.4±0.50 kg/m^2) in DA, and 32.4±1.58 years (BMI: 31.8±0.75 kg/m^2) in DPA.

Table 1 shows BIA and DXA measurements of body composition of the participants during the study period. There was significant changes in body composition except fat-free mass measured by DXA ($p<0.05$) in both DA and DPA.

Table 2 shows the physical activity levels of the subjects. As seen in the table, the percentage of sedentary individuals in DA group has increased during the study period.

The bioelectrical impedance and metabolic rates of the individuals measured by ergospirometry are shown in Table 3. BMR measurements and RMR levels of the subjects were significantly lower than at baseline during the weight loss program in DA group ($p<0.001$). While BMR measurements decreased, RMR levels increased significantly at the end of the study in DPA group ($p<0.001$). There was no significant difference between BMR measured by BIA and RMR measured by Cosmed K_4 B_2 (p=0.412 and p=0.505, respectively). The initial mean BMR and RMR were found to be 1527.1±20.82 kcal/day (range: 1373-1709) in DA, 1594.2±23.19 kcal/day (range: 1468-1848) in DPA and 1225±54.31 kcal/day (range: 773-1727) in DA and 1243±54.89 kcal/day (range: 950-1718) in DPA, respectively. At the end of the study, BMR of each participants has decreased in both groups ($p<0.05$), but RMRs in DPA group have increased while there was a decrease in DA group ($p<0.05$). Dietary energy intakes were calculated as 1375.0±42.84 kcal/day in DA and 1382.3±44.75 kcal/day in DPA.

The weight loss in DPA (according to the differences in percentages of initial body weight) was determined higher than in DA group during the study period and the difference was found to be statistically significant (Table 4).

Discussion

Obesity is a growing health problem worldwide as the prevalence is increasing in Turkey. In the present study, the body composition of the participants measured by BIA and DXA. If weight loss can be achieved between 0.5-1 kg per week, the decrease in RMR and body protein loss should be at least. The mean weight loss rate was 5.7% in DA group, and 7.8% in DPA group in our study ($p<0.05$). With this rate of weight loss in a year, 10-15% of healthy and sustainable loss can be achieved. Fat mass (FM) was highly correlated with that determined by hydrodensitometry, with subcutaneous fat measured as a sum of 10 skinfolds and also with visceral fat determined as an area on the computed tomography (CT) scan. An overestimation of total FM by bipedal bioimpedance has not been revealed in severely obese individuals (12,13). Boneva-Asiova et al. (14) has found a good correlation between weight and body composition parameters derived from BIA and DXA. The comparison of weights by DXA vs. the digital scale component of the Tanita device is independent of any actual impedance measure. However, body composition indices by DXA were not significantly different and were highly correlated with BIA estimates. All correlations were above 0.8 and most were above 0.9. In both sexes, BIA tended to underestimate fat mass (FM) and overestimate fat-free mass (FFM) in lean and moderately obese individuals. In severe obesity, an inverse trend was observed. Statistical significance of the difference was however not reached. These findings are in line with our results. Much of the current data supporting the accuracy of DXA for soft tissue measurements are based on the ability of DXA to predict total weight of subjects of various ages from the sum of bone, fat, and lean (15).

Some studies showed good agreement between BIA and DXA (15-18) as in this present study whereas others indicated that the BIA method lacks precision and accuracy (19,20). Questions such as whether BIA tends to over- or under-estimate BF% when compared with DXA and the extent of this bias remain unanswered because most of the studies were performed with small sample sizes and in patients with different diseases (18). Lazzer et al. (21) studied to determine the accuracy of two foot-to-foot (FF) BIA to assess body composition compared with DXA and hand-to-foot (HF) BIA. It was concluded that the major limiting factor of FF-BIA was the inter-individual variability in FM estimates. FF-BIA and DXA are not interchangeable methods and FF-BIA could be acceptable to assess body composition in large groups of overweight or obese

Table 1. Body composition assessment by BIA and DXA measurements of the individuals.

	DA (n:20)				DPA (n:17)			
	$\bar{X}\pm S\bar{X}$	median	min-max	P	$\bar{X}\pm S\bar{X}$	median	min-max	P
BİA								
Body weight (kg)								
Initial	75.3±1.77	75.7	60.5-91.5	<0.001*	82.5±2.02	82.4	69.7-101.4	<0.001*
End	70.7±1.90	70.0	55.8-89.0		73.9±2.08	73.4	59.8-98.5	
DXA								
Body weight (kg)								
Initial	76.3±1.92	77.3	61.3-94.3	<0.001*	83.0±1.12	82.7	71.1-104.0	<0.001*
End	72.1±1.03	71.8	57.5-91.4		75.0±2.66	75.2	62.1-100.2	
BIA								
Fat mass (kg)								
Initial	28.3±1.10	27.6	18.5-37.4	<0.001*	33.4±1.40	34.2	25.0-46.0	<0.001*
End	24.5±1.25	23.4	15.5-35.9		26.9±1.48	25.6	16.9-42.6	
Fat percentage (%)								
Initial	37.3±0.72	36.7	30.6-43.3	0.022*	40.3±0,84	40.7	34.3-44.5	0.028*
End	33.0±0.92	32.9	23.9-37.9		35.3±1.03	35.1	28.3-43.2	
DXA								
Fat mass (kg)								
Initial	29.0±1.28	29.9	21.6-38.0	<0.001*	33.2±1.92	33.5	24.8-43.7	<0.001*
End	26.9±1.38	26.9	20.1-35.2		28.6±1.40	29.0	20.1-37.9	
Fat percentage (%)								
Initial	38.2±0.83	38.0	32.0-44.3	0.009*	40.4±0.97	40.5	32.8-49.0	0.007*
End	36.7±0.77	36.7	29.9-42.7		37.0±0.90	37.5	29.9-43.4	
BIA								
Fat free mass (kg)								
Initial	47.0±0.83	46.8	40.7-55.6	0.08	49.0±0.85	49.6	43.2-57.5	0.006*
End	46.2±0.80	46.6	40.3-54.9		47.0±0.80	46.8	42.7-55.9	
DXA								
Fat free mass (kg)								
Initial	45.8±1.40	45.5	38.9-55.5	0.225	48.5±1.68	47.2	41.2-61.7	0.365
End	43.6±1.78	43.5	35.6-53.6		46.3±1.24	44.7	39.3-60.0	

*p< 0,05, : Mean values, S : Standard error values adolescents, but cannot be recommended for body composition assessment in obese subjects because of the large errors in individual estimates. Minderico et al. (22) has studied on forty-eight obese women in an out-patient weight-loss program. DXA significantly overestimated the change in FM and FM percentage across weight loss from the reference model in any body composition variables.

The good absolute and relative agreement between changes in body composition assessed by DXA and BIA during weight loss indicates that the BIA methods examined provide useful, valid methods to assess changes in body composition in young obese women during weight loss. BIA may offer a viable alternative to DXA for research laboratories and clinical practices implementing clinical weight loss investigations and interventions (23,24).

Measurement of RMR is a necessary component in the evaluation of the diet therapy in obesity. RMR measurements involve the estimation of the oxygen consumption of the individual, which was then converted into units of heat or energy output. In general, most investigators involved in RMR measurements use a range of techniques available to estimate oxygen consumption, which provide more or less the same results. There were no significant differences between estimates of oxygen consumption obtained by two or more techniques in the same individual at the same time. The Harris-Benedict, Mifflin-St Jeor, Owen, and World Health Organization/Food and Agriculture Organization/United Nations University (WHO/FAO/UNU) equations are used commonly in clinical practices (25). However, predictive equations might generate errors large enough to impact outcome. The Mifflin-St Jeor equation is more likely than the other equations tested to estimate RMR, but noteworthy errors and limitations exist when it has been applied to individuals and possibly when it has been generalized to certain age and ethnic groups (25,26).

We anticipated that total daily EE would be decreased after weight loss because of reduced body mass. In part, this expectation was based on findings of Weigle and Brunzell (27) which showed that the energy intake required for weight stability in 10 obese subjects fell after weight loss. Although these authors did not measure AEE, their data suggest that the decrease in total daily energy requirements was largely due to the reduced energy cost of moving the reduced body weight (28). Contrary to our expectations, in the present study, the women in DPA group spontaneously increased their physical activity sufficiently to maintain their baseline AEEs. Because of this, there may be no need to decrease dietary energy intakes much to maintain reducing body weight of the women.

Exercise may influence REE in such a way: First of all, a prolonged increase occurs in post-exercise metabolic rate from an acute exercise challenge. Secondly, there may be a chronic increase in RMR associated with exercise training. Eventually a possible increase can be seen in EE during non-exercising period (29). In addition to these, exercise helps maintain fat-free mass, which in turn helps to maintain higher RMR. Because of RMR represents 60-75% of total daily EE for many adults, it is also known to play an important role in maintaining in healthy body weight (30).

According to the National Health and Nutrition Examination Survey-I (NHANES-I) Epidemiologic Follow-up Study (1971-1975 to 1982-1984), low recreational physical activity reported at the follow-up survey was strongly related to major weight gain (>13 kg) that had occurred during the preceding ten years. However, no relationship was found between baseline physical activity level and subsequent weight gain among either men or women. These findings suggest that low physical activity may be both a cause and a consequence of weight gain (31). Zhang et al. (32) showed a strong and highly significant correlation between decline in SMR and BMI. It has been reported that physical activity may affect SMR and RMR; also in our study, we found the same effect only in RMR measurements. The RMRs of the women, who did regular physical activity during 12 weeks was significantly increased although they lost weight. This result can be considered as the result of increased PAL and AEE in DPA group. We also found that measurement of BMR is not a good indicator to determine the energy requirement, because it was a value that determined just only by calculations with formulas not with the measurements. RMR is requested not to slow down during weight loss. Diet and exercise together could accelerate body fat loss, preserve fat-free mass and prevent/increase RMR more effectively than with diet restriction alone. It is suggested that in order to ensure healthy weight loss, increasing physical activity in addition to diet should be recommended.

Conclusion

Several notable findings resulted from this study. Firstly, parallel measurement of BF% by BIA and DXA showed that BIA analysis must be carefully interpreted when performed on overweight or obese persons. BIA tends to underestimate body

Table 2. The physical activity level classification of the individuals.

PAL value	DA (n:20)								DPA (n:17)							
	Initial		1. month		2. month		3. month		Initial		1. month		2. month		3. month	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
<1.40 Sedantary	4	20.0	2	10.0	5	25.0	10	50.0	6	35.3	-	-	1	5.9	1	5.9
1.40-1.69 Light activity	16	80.0	18	90.0	15	75.0	10	50.0	11	64.7	12	70.6	14	82.4	13	76.5
1.70-1.99 Mild activity	-	-	-	-	-	-	-	-	-	-	5	29.4	2	44.8	3	17.6
2.0-2.4 Heavy activity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PAL: Physical activity level

fat in women separately. This bias, however, depends on the degree of adiposity. In overweight or obese subjects, BIA tends to underestimate BF% because BIA is used to measure body composition in a variety of clinical settings, such as in patients with wasting or chronic obesity. This bias must be taken into consideration when interpreting BIA data. Secondly, the decreases in sleeping and resting EE in weight-reduced (but weight-stable) women were proportional to changes in body composition. Increasing physical activity and lowering dietary energy intake both may helpful for healthy weight loss.

Table 3. Daily metabolic rate and total energy expenditure of the individuals.

	DA (n:20)			DPA (n:17)			
	$\bar{X}\pm S\bar{X}$	median	min-max	$\bar{X}\pm S\bar{X}$	median	min-max	P
BMR (with BIA) (kcal/day)							
Initial	1527.1±20.82^{a}	1535.0	1373.0-1709.0	1594.2±23.19a	1585.0	1468.0-1848.0	<0.001*
1. month	1501.1±21.34^{b}	1504.5	1346.0-1698.0	1552.2±24.00b	1538.0	1426.0-1813.0	
2. month	1486.9±21.31^{c}	1496.5	1336.0-1688.0	1533.4±24.38c	1529.0	1411.0-1814.0	
3. month	1483.0±22.61^{c}	1471.5	1328.0-1681.0	1512.6±25.37d	1505.0	1371.0-1798.0	
RMR (with ergospirometry) (kcal/day)							
Initial	1225.0±54.31^{a}	1219.5	773.0-1727.0	1243.0±54.89a	1263.0	950.0-1718.0	<0.001*
1.month	1205.2±66.82^{ab}	1101.0	806.0-1763.0	1520.5±66.00b	1498.0	1010.0-2074.0	
2. month	1144.0±65.40^{ab}	1110.0	716.0-1736.0	1438.0±56.35b	1468.0	1154.0-1864.0	
3. month	1122.7±57.40^{b}	1089.5	700.0-1704.0	1455.2±58.28b	1454.0	1120.0-1842.0	
AEE (kcal/day)							
Initial	2056.8±25.77^{ad}	2060.0	1800.0-2275.0	2023.2±37.32a	2061.0	1732.0-2368.0	<0.001*
1.month	2116.9±24.87^{bc}	2118.0	1898.0-2306.0	2332.0±39.81b	2380.0	2021.0-2587.0	
2. month	2097.0±27.20^{bc}	2107.5	1850.0-2268.0	2276.1±35.66cd	2279.0	1945.0-2511.0	
3. month	2014.4±27.08^{d}	2008.5	1812.0-2298.0	2288.4±44.92bd	2277.0	1941.0-2653.0	
TEE (with BIA) (kcal/day)							
Initial	2180.6±38.64^{abc}	2140.1	1832.5-2500.6	2241.3±57.45a	2166.9	1973.7-2736.3	<0.001*
1.month	2206.0±38.00^{b}	2192.0	1774.1-2521.7	2514.5±61.01b	2479.6	2088.3-3165.2	
2. month	2165.0±38.51^{c}	2107.7	1739.5-2469.8	2423.3±54.64c	2388.5	1973.3-3043.4	
3. month	2071.3±38.16^{d}	2080.6	1717.1-2341.9	2402.6± 58.82c	2341.6	1947.7-2900.5	
REE (with ergospirometry) (kcal/day)							
Initial	1751.7±83.91^{abc}	1746.5	1165.6-2526.9	1752.4±91.14a	1729.0	1245.1-2481.6	<0.001*
1.month	1772.4±101.30^{b}	1665.0	1188.9-2522.1	2474.7±131.00b	2459.9	1639.3-3620.9	
2. month	1667.3±98.51^{c}	1675.3	1093.4-2540.1	2282.9±109.38c	2280.0	1558.7-3138.8	
3. month	1564.9±77.07^{d}	1486.3	1043.2-2321.0	2328.0±124.19bc	2377.7	1509.7-3377.0	
PAL							
Initial	1.42±0.01^{a}	1.43	1.25-1.58	1.40±0.02a	1.43	1.20-1.64	<0.001*
1.month	1.47±0.01^{bc}	1.47	1.32-1.60	1.61±0.02b	1.65	1.40-1.80	
2. month	1.45±0.01^{bc}	1.46	1.28-1.58	1.58±0.02c	1.58	1.35-1.74	
3. month	1.39±0.01^{a}	1.39	1.26-1.60	1.59±0.03bc	1.58	1.35-1.84	
Dietary energy (kcal/day)	1375.0±42.84	1400.0	1100.0-1800.0	1382.3±44.75	1300.0	1200.0-1800.0	<0.001*
The decreased energy ratio to ensure weight loss (%)	20.8±1.10	22.5	10.0-25.0	20.9±1.49	25.0	10.0-30.0	<0.001*

(BMR: Basal metabolic rate, RMR: Resting metabolic rate, AEE: Activity energy expenditure, TEE: Total energy expenditure, REE: Resting energy expenditure, PAL: Physical activity level)
*p<0.05
Means with different symbols (a, b, c ,d) shows significances: Different characters show statistically significances (e.g. a, b / a, c / a, d / b, c / b, d / c,d). Similar characters show no statistically significances (e.g. a, a / b, b / c,c / d ,d).

Table 4.The average percentage differences of some variables (mean+standard error) (+S) compared to baseline during the study period.

Percentage of diffrence (%)	DA (n:20)						DPA (n:17)						
	1.month	2. month	3. month				1. month	2. month	3. month				
	$\bar{X}\pm S\bar{X}$	$\bar{X}\pm S\bar{X}$	$\bar{X}\pm S\bar{X}$	t (1.-2. month)	t (2.-3. month)	t (1.-3. month)	$\bar{X}\pm S\bar{X}$	$\bar{X}\pm S\bar{X}$	$\bar{X}\pm S\bar{X}$	t (1.-2. month)	t (2.-3. month)	t (1.-3. month)	P (between groups)
Boy weight (BIA)	0.036±0.003	0.055±0.003	0.061±0.005	-8.51*	-1.53	-6.65*	0.052±0.003	0.077±0.004	0.104±0.007	-8.64*	-6.94*	-9.26*	<0.001*
Boy weight (DXA)	-	-	0.060±0.005	-	-	-	-	-	0.097±0.008	-	-	-	<0.001*
BMI	0.037±0.003	0.056±0.004	0.062±0.005	-7.05*	-1.33	-6.79*	0.053±0.003	0.077±0.005	0.104±0.007	-7.84*	-7.68*	-9.45*	<0.001*
Body fat (BIA)	0.092±0.010	0.129±0.012	0.137±0.015	-5.92*	-1.05	-4.64*	0.082±0.017	0.151±0.011	0.200±0.015	-6.58*	-4.69*	-8.08*	<0.001*
Body fat (DXA)	-	-	0.081±0.015	-	-	-	-	-	0.175±0.017	-	-	-	<0.001*
Fat free mass (BIA)	0.003±0.004	0.011±0.006	0.016±0.004	-1.65	-1.30	-3.69*	0.023±0.006	0.026±0.007	0.039±0.007	-0.72	-2.73	-5.57*	0.452
Fat free mass (DXA)	-	-	0.037±0.006	-	-	-	-	-	0.042±0.007	-	-	-	0.113
Body water (BIA)	0.003±0.004	0.011±0.006	0.016±0.004	-1.55	-1.27	3.84*	0.023±0.006	0.026±0.009	0.039±0.009	-0.79	-2.67*	-5.42	0.493
BMR (BIA)	0.017±0.001	0.026±0.001	0.029±0.002	-8.32*	-1.43	-6.52*	0.026±0.001	0.038±0.002	0.052±0.003	-8.17*	-6.69*	-8.60*	<0.001*
RMR (Ergospirometry)	0.014±0.034	0.063±0.036	0.074±0.037	-1.68	-0.46	-1.47	0.244±0.057	0.179±0.053	0.206±0.073	-1.66	-0.53	-0.57	0.821

*p<0.05. The percentage difference for all months were as follows: The calculated difference % of the month = [(Initial value - Calculated value) / Initial value) x100].

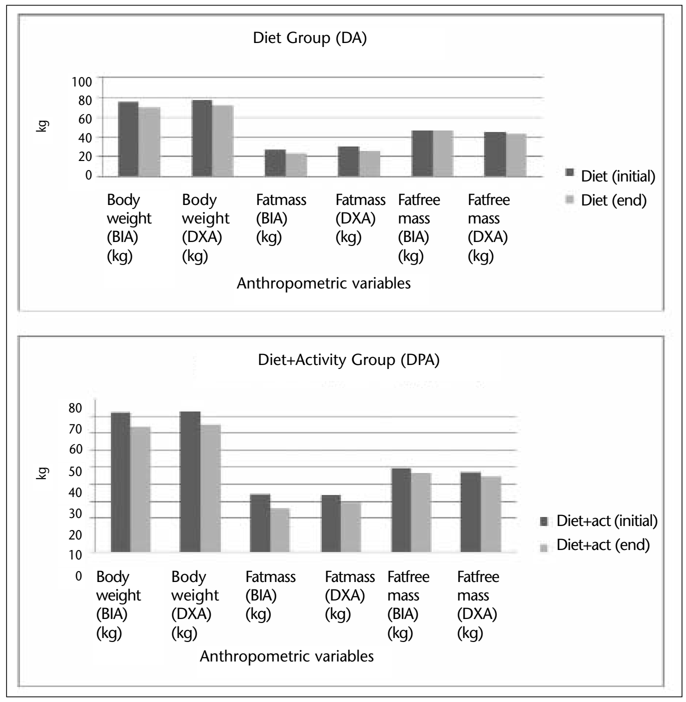

Figure 1. The changes in anthropometric measuremens of the individuals during the study period.

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Conflict of Interest:

Authors reported no conflicts of interest.

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