Evaluation of Menstrual Status, Bone Mineral Density and Body Composition in Egyptian Ballet Dancers

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ABSTRACT

Background: *A cross-sectional study was performed to evaluate the effect of physical training on menstrual status and bone health in adolescent ballet dancers.* ***Methods:*** *Twenty-four ballet dancers and 14 healthy controls matched with age and weight were studied. Menstrual status and training-related characteristics were assessed by a self- administered questionnaire. BMD and body composition were measured by dual X-ray absorpiometry.* ***Results:*** *Forty-five ballet dancers suffered from oligomenorrhea. They had non-significant lower BMD at weight bearing sites, trunk and abdomen (P>0.05) and significant lower total BMD, legs BMD (P<0.01), BMI (P<0.05), lower fat mass at total body, abdomen and legs (P<0.001), trunk and arms (P<0.01) when compared with their controls. Eumenorrheic dancers showed slightly higher BMD at femoral neck, ward's triangle and greater trochanter, higher total and regional lean mass (P>0.05), as well as slightly lower BMD at total body and legs (P>0.05). Participation years to sport before menarche showed strong correlations with age at menarche (R=0.9, P>0.0001), menstrual length (R=0.49, P<0.01) and No of menstrual cycles (R=-0.51, P<0.01). Strong positive correlations found between total lean mass and femoral neck BMD (R=0.46, P=0.02), ward's triangle BMD (0.41, P=0.04), greater trochanter BMD (0.042, P<0.03) and trunk BMD (P=0.04).* ***Conclusions:*** *Ballet dancers with regular menstrual cycle experience higher BMD at weight bearing sites and higher total and regional lean mass due to training. Young ballet dancers with menstrual irregularities had generalized low BMD, with maintaining total and regional lean mass when compared with their controls. The periodical evaluation of ballet dancers is very important and educational programs should be designed to increase awareness about menstrual problems and their effect on bone health.*

Keywords: *Ballet dancers, BMD, Body composition, Oligomenorrhea.*

INTRODUCTION

Ballet dancing is an art form in which aesthetic criteria encourage low BMI. Young dancers often limit their energy intake to maintain a thin body especially if they are going for professional career[1]. It had been reported that many teenage dancers demonstrated high-energy expenditure, extreme leanness, and delayed puberty[6].

Menstrual disorders have been recognized in female athletes[12]. There are two identifiable classes of menstrual disorders considered in athletes, which are amenorrhea and oligomenorrhea. Amenorrhea is defined as the absence of menstrual cycle for at least three months or three or fewer cycles per year while, oligomenorrhea is defined as menstrual cycles that are at intervals ranging from 35 to 90 days or as four to nine cycles per year[3,4]. It was thought that the "stress" of exercise may have a role in these disorders[13].

It had been reported that 3.4% to 66% of athletes have menstrual dysfunction[9]. Many factors increase the prevalence of menstrual disorders in athletes including aesthetic, endurance and weight class-sports, younger age, increase years of training and lower body weight[15].

Exercise-associated menstrual dysfunction has a profound negative impact on the skeleton. It leads to a failure of reaching peak bone mass and bone loss, which may predispose hypoestrogenic athletes to osteopenia, osteoporosis and increased risk of bone fractures[17].

Many studies had examined BMD in adult ballet dancers [11,21,22] but there are few data regarding bone health status in adolescent ballet dancers with or without menstrual dysfunction in comparison with control subjects. Thus, the aim of this study is to evaluate effect of menstrual status and physical training on BMD and body composition at multiple sites in adolescent ballet dancers with or without menstrual dysfunction. It also, determined the contribution of lean mass and fat mass to BMD at multiple measured sites.

METHODS

Subjects:

Twenty-four ballet dancers were selected from Higher Institute of Ballet, Egypt. They were 14-18 years of age. They engaged in sport training before the onset of menarche. They did not use oral contraceptive pills within 6 months before starting the study. Also, ballet dancers who were out of training at least 3 months before starting the study were excluded from this study.

Fourteen healthy females matched for age and weight as well as, experiencing regular menstrual cycle participated in this study. They did not engage in any regular physical training or organized sport. Females receiving hormonal therapy or other medications that affect bone metabolism or conditions that cause hypogonadism or females with diabetes, cardiopulmonary diseases or leg deformities were excluded from this study.

Details of the study protocol and testing procedures were explained for each female and informed consents were assigned from the parents of the participants before starting of this study. Weight-Height scale was calibrated. Then, weight and height for each female were measured two times and the averages were taken. Body mass index (BMI) was calculated according to the formula: BMI= weight (kg)/height (m^2).

Questionnaire:

A self-administered questionnaire was used to assess menstrual history for each female)[14]. Each female were asked to record her age at menarche, menstrual cycle length and number of menstrual cycles in the last year. Ballet dancers were classified as eumenorrheic if they had 10 or more menstrual cycles in the last year and oligomenorrheic if they had 4-9 menstrual cycles in the last year or amenorrheic if they had fewer than 4 menstrual cycles in the last year [4-5]. Also, history of training characteristic of ballet dancers was taken. Each ballet dancer was asked about her age of participation to ballet training and the number of hours training per day from which the number of hours training per week (h/wk) can be calculated. Total training duration (yrs) can be calculated from (current age minus participation age to training). In addition, training duration (yrs) before menarche was calculated (age at menarche minus participation age to training).

Bone mineral density and body composition measurement: BMD (g/cm^2) at total body, hip (femoral neck, ward's triangle and greater trochanter), trunk, abdomen, legs and arms, as well as body composition including total fat percentage, total fat mass (g), total lean mass (g) and regional fat and lean mass (trunk, abdomen, legs, and arms) were measured using Dual Energy X-ray Absorptiometry (Norland Xr 46, version 3.9.6/2.3.1, America). All females were asked to avoid heavy physical activity 24 hours before screening to avoid the effect of hydration status on body composition measurement. This study was approved by the ethics committee of Cairo University.

Statistical Analysis

Data was analyzed and represented as means and standard deviations. Analysis of variance (ANOVA) was used to determine differences between groups followed by the Tukey-Kramer test to correct for multiple comparisons. Pearson correlation coefficient was used to correlate between variables. It was considered significant at P-values< 0.05.

RESULTS

Baseline Characteristics: Forty five percent of ballet dancers met the criteria for oligomenorrhea and 55 % experiencing normal menstrual cycles. Age, weight and height showed no significant differences between oligomenorrheic ballet dancers when compared with either eumenorrheic dancers or control females (P>0.05). Also, BMI showed no significant difference between eumenorrheic dancers and control females while BMI was significantly lower in oligomenorrheic dancers than control females (P<0.05). Oligomenorrheic dancers had significantly menarche age of 1.2 and 1.5 yrs later than eumenorrheic dancers (P<0.01) and control females (P<0.001), respectively. Also, they had greater menstrual cycle length and lower number of menstrual cycles in the last year than eumenorrheic dancers (P<0.001), and control females (P<0.001). According to training related characteristics, results showed no significant differences between oligomenorrheic and eumenorrheic dancers in the age of starting the training, training h/wk and total years of training (P>0.05), (table 1).

Table (1): Characteristics of oligomenorrheic dancers, eumenorrheic dancers and control subjects.

	Oligomenorrheic ballet dancers (n=13)		Eumenorrheic ballet dancers (n=11)		Eumenorrheic Control females (n=14)		P-value
	Mean	SD	Mean	SD	Mean	SD	
Age (yrs)	15.90	1.30	15.77	1.23	15.43	1.83	0.086
Height (cm)	161.41	3.77	158.85	5.97	157.78	4.47	0.19
Weight (kg)	49.90	4.16	51.15	6.93	53.43	3.80	0.23
BMI (kg/m^2)	19.15[a]	1.42	20.30	2.37	21.36	1.22	0.01
History of menstrual cycle							
Age at menarche	13.54[c,d]	1.21	12.30	0.75	12	0.68	0.0003
No. of menstrual cycle	7.09[c,e]	1.30	12.08	0.49	12.14	0.94	<0.0001
Menstrual cycle frequency	52.18[c,e]	9.18	29.92	1.19	29.64	2.09	<0.0001
Training related characteristics							
Training intensity (h/wk)	18.18	2.52	17.5	2.50			0.51
Total training duration (yrs)	8.18	1.94	8.23	1.74			0.95
Training duration Before menarche (yrs)	6.09	1.37	4.61	1.19			0.01

a: P<0.01, b: P<0.00, c: P<0.001, oligomenorrheic dancers and eumenorrheic dancers compared with controls, d: P<0.01, e: P<0.00,1oligomenorrheic dancers compared with eumenorrheic dancers.

Bone mineral density: Eumenorrheic dancers showed significant lower total BMD (6.5%, P<0.05), non-significant lower BMD at trunk (4.8%), legs (5.3%) and arms (5.1%) and non-significant higher BMD at femoral neck (6.9%), ward's triangle (4%) and greater trochanter (1.4%) than control females.

Oligomenorrheic dancers had significantly lower BMD at total body (9.8%), legs (9.5%) and arms (16.4%) than control females (P<0.01). They also, showed lower BMD at femoral neck (3.4%), ward's triangle (1.3%), greater trochanter (0.72%) and trunk (7.1%) than controls but these differences were non-statistically significant (P>0.05).

Also, results showed that oligomenorrheic dancers showed non-significant lower BMD at femoral neck (9.8%), ward's triangle (6.4%), greater trochanter (1.4%), total body (2.3%), trunk (1.3%), legs (3.4%) and arms (10.9%) than eumenorrheic dancers, (table 2).

Table (2): Means and SD of bone mineral density for oligomenorrheic dancers, eumenorrheic dancers and control females.

	Oligomenorrheic ballet dancers (n=13)		Eumenorrheic ballet dancers (n=11)		Eumenorrheic Control females (n=14)		P-value
	Mean	SD	Mean	SD	Mean	SD	
Femoral neck BMD (g/cm^2)	0.83	0.07	0.92	0.12	0.87	0.07	0.07
Femoral neck z-score	-0.27	0.25	0.12	0.56	-0.20	0.31	0.04
Ward's triangle (g/cm^2)	0.73	0.09	0.78	0.13	0.75	0.08	0.50
Greater trochanter (g/cm^2)	0.68	0.07	0.70	0.09	0.69	0.06	0.86
Total BMD (g/cm^2)	0.83[b]	0.06	0.85[a]	0.06	0.92	0.06	0.002
Trunk BMD (g/cm^2)	0.78	0.07	0.79	0.06	0.84	0.05	0.054
Abdomen BMD (g/cm^2)	0.94	0.09	0.98	0.08	1.04	0.07	0.16
Legs BMD (g/cm^2)	0.86[b]	0.06	0.89	0.08	0.95	0.05	0.007
Arms BMD (g/cm^2)	0.49[b]	0.07	0.55	0.08	0.59	0.07	0.008

a: P<0.01, b: P<0.00, c: P<0.001 oligomenorrheic and eumenorrheic dancers compared with controls.

Body composition: Eumenorrheic dancers showed lower total fat percentage (7.8%, P<0.01), lower soft tissue percentage (8.3%, P<0.001) and also lower fat mass at trunk (25.1%, P<0.05), abdomen (27.7%, P<0.01), legs (31.6%, P<0.001) and arms

(16.7%, P>0.05) than controls. They showed higher lean mass at total body (4.4%), trunk (8.1%) and abdomen (7%) but these differences weren't statistically significant (P>0.05).

Oligomenorrheic dancers showed significant lower values at total fat percentage (10%, P<0.001), soft tissue percentage (10.5%, P<0.001) and fat mass at trunk (38%, P<0.01), abdomen (38.9%, P<0.001), legs (32.4%, P<0.001) and arms (27.3%, P<0.01), while they showed non-significant higher lean mass at total body (2.6%), trunk (4.1%) and abdomen (0.43%) than controls. When they compared with eumenorrheic dancers, they showed also, lower values at total fat percentage (2.2%), soft tissue percentage (2.2%), and lower fat mass at trunk (17.2%), abdomen (15.5%), legs (1.1%) and arms (12.6%), as well as lower lean mass at total body (1.7%), trunk (3.7%) and abdomen (6.1%) but all these differences weren't statistically significant, (table 3).

Table (3): Body composition means and SD values for oligomenorrheic dancers, eumenorrheic dancers and control females.

	Oligomenorrheic ballet dancers (n=13)		Eumenorrheic ballet dancers (n=11)		Eumenorrheic Control females (n=14)		P-value
	Mean	SD	Mean	SD	Mean	SD	
Total fat mass (g)	11785[c]	3249	13542[b]	4205	19381	4196	<0.0001
Total fat %	23.45[c]	5.18	25.61[b]	5.52	33.50	4.83	<0.0001
Soft tissue fat %	24.36[c]	5.33	26.54[c]	5.64	34.86	4.87	<0.0001
Total lean mass (g)	36069	2428	36707	3650	35172	2466	0.39
Trunk fat mass (g)	5692[b]	1769	6879[a]	2254	9187	2366	0.001
Trunk lean mass (g)	16406	1633	17036	2165	15760	1028	0.15
Abdomen fat mss (g)	2419[c]	716	2863[b]	910	3958	936	0.0002
Abdomen lean mass (g)	7455	779	7941	931	7423	796	0.22
Legs fat mass (g)	5206[c]	949	5266[c]	1232	7697	166	0.0001
Legs lean mass (g)	12887	1091	12925	1817	12917	1562	0.99
Arms fat mass (g)	1308[b]	407	1497	300	1799	327	0.003
Arms lean mass (g)	3091	367	3001	294	3032	272	0.77

a: P<0.01, b: P<0.00, c: P<0.001 oligomenorrheic and eumenorrheic dancers compared with controls.

Correlation analyses: Pearson correlation analyses between menstrual history and training-related characteristics of ballet dancers showed that training years before menarche had strong positive correlations with age at menarche (r=0.9, P<0.0001) and menstrual length (r=0.49, P<0.01), as well as strong negative correlation with No. of menstrual cycles in the last year (r=0.51, P<0.01). In addition, training intensity (h/wk) showed positive linear correlation with menstrual length (r=0.27, P=0.2) and negative linear correlation with No. of menstrual cycle (r=0.23, P=0.27).

Correlations between regional BMD and regional fat and lean mass showed that trunk BMD had significant positive correlations with trunk fat mass (r=0.45, P=0.02) and lean mass (r=0.46, P=0.02), figure 1. Abdomen BMD had significant correlation with abdomen fat mass (r=0.49, P=0.01) and abdomen lean mass (r=0.40, P=0.04), figure 2. For the extremities, legs BMD showed weak correlation with legs fat mass (r=0.23, P=0.27) and lean mass (r=0.1, P=0.64), while arms showed strong correlation with arms fat mass (r=0.62, P=0.001) and weak correlation with its lean mass (r=0.23, P=0.27).

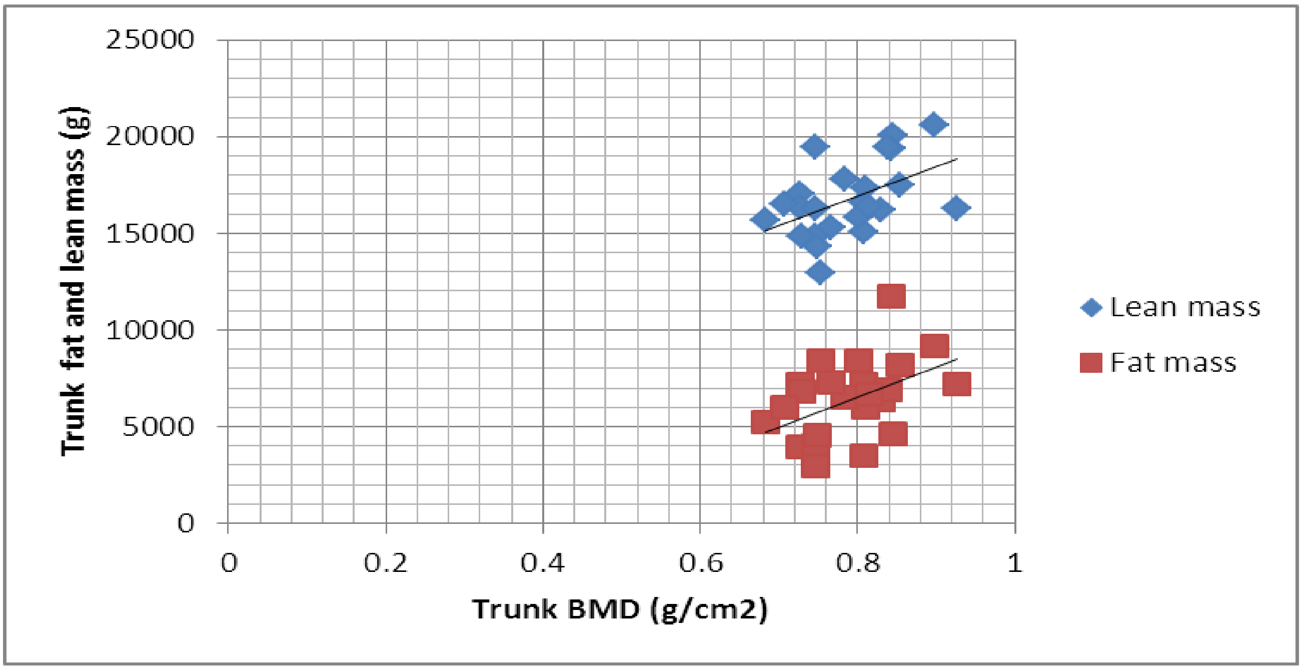

Fig. (1): Correlation between trunk BMD and trunk fat and lean mass in ballet dancers.

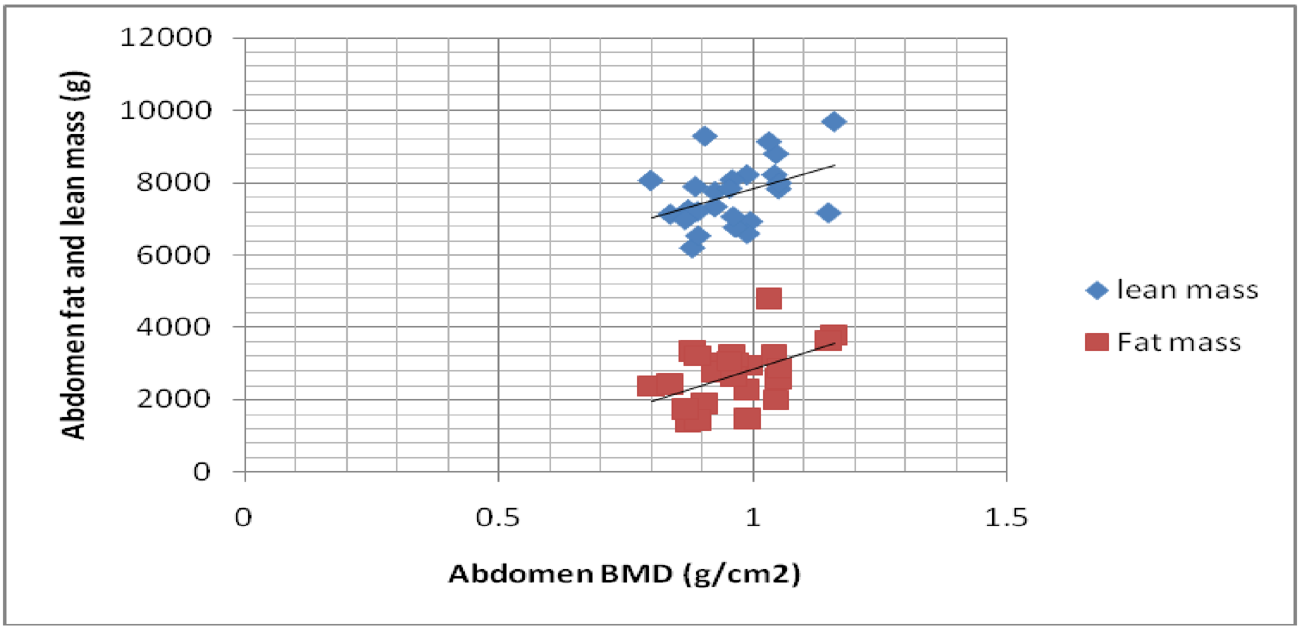

Fig. (2): Correlation between abdomen BMD and abdomen fat and lean mass in ballet dancers.

As illustrated in table 4, correlation analyses between menstrual history and BMD showed that only femoral neck BMD had a linear negative correlation with menstrual length and positive correlation with No of menstrual cycles. In addition, strong associations were found between almost measured sites of BMD and BMI, training duration and total lean mass. However, total fat mass showed only strong positive correlation with legs BMD.

Table (4): Correlations between site-specific BMD and related factors in ballet dancers.

	Femoral neck BMD		Ward's triangle BMD		Greater trochanter BMD		Trunk BMD		Abdomen BMD		Legs BMD		Total BMD	
	r	P	r	P	r	P	r	P	r	P	r	P	r	P
Age at menarche	-0.01	0.96	0.11	0.6	0.05	0.80	0.33	0.11	0.23	0.27	0.11	0.59	0.32	0.12
Menstrual length	-0.28	0.18	-0.11	0.58	-0.01	0.94	0.05	0.79	-0.03	0.87	-0.09	0.65	-0.02	0.89
No. of menstrual cycle	0.33	0.11	0.14	0.49	0.05	0.82	0.01	0.98	0.08	0.68	0.14	0.51	0.07	0.72
Training yrs before menarche	0.03	0.88	0.19	0.37	0.12	0.56	0.43[1]	0.03	0.35	0.09	0.16	0.45	0.35	0.09
Training duration (yrs)	0.39	0.054	0.41[a]	0.04	0.17	0.41	0.69[c]	0.0002	0.690	.0002	0.45[a]	0.02	0.6[c]	0.001
BMI	0.26	0.2[a]	0.15	0.47	-0.05	0.80	0.42[a]	0.03	0.42[a]	0.04	0.54[b]	0.005	0.43[a]	0.03
Total fat mass	0.15	0.48	0.11	0.61	-0.14	0.52	0.38	0.06	0.37	0.07	0.45[a]	0.02	0.33	0.1
Total lean mass	0.46[a]	0.02	0.41[a]	0.04	0.42[a]	0.03	0.41[a]	0.04	0.53[b]	0.008	0.28	0.18	0.28	0.17

Note. a: P<0.05, b: P<0.01, c: P<0.001.

DISCUSSION

This cross-sectional study discussed the influence of physical training and menstrual status on bone health in adolescent ballet dancers. Training for ballet begins at younger age. Emphasis on appearance and thinness is considered in ballet sport so diet restriction to maintain low body weight is common among ballet dancers[8].

Body mass index for eumenorrheic dancers was near the lower normal limit according to BMI classification of world health organization. In addition, dancers with oligomenorrhea had significantly lower BMI when compared with their controls however, still near the lower normal limit.

Results showed that oligomenorrheic dancers had significantly later menarche age than eumenorrheic dancers and control subjects. Also, eumenorrheic dancers had later menarche age than eumenorrheic controls by 3 months only. In this study, the menarche age of eumenorrheic dancers was lower than reported by other studies on ballet dancers [21-23]. This was explained by that the ballet dancers in other studies may contain percentage of oligo/amenorrheic subjects.

Menarche age of oligomenorrheic dancers was later than eumenorrheic dancers despite there was slight differences in BMI, percentage of fat mass or total fat mass and training related characteristics.

The menstrual length and number of menstrual cycles in the last year showed strong correlations with training years before menarche and also, linear correlation with training intensity (h/wk) suggesting that participation to intensive training at young age increases the risk of irregular menstrual cycles. This was supported by many studies which reported menstrual dysfunctions in ballet dancers[7,11,20,23].

Low BMI, delayed menarche age and intensive exercise in combination affect critical periods in which peak bone mass accumulation occurs[16]. So, insufficient peak bone mass obtained during puberty can cause low BMD in ballet dancers.

In the present study, eumenorrheic dancers had mean values of BMD at femoral neck and ward's triangle above the mean values of their controls while BMD at the other sites were below. However, they have significantly lower total BMD than controls. Ballet dancers had lower BMI than their controls and high BMD was not expected.

This was in agreement with a study by Karlsson and his collegues[10] who reported the same findings in professional ballet dancers except for higher BMD in the lower extremities. In addition, studies on female runners reported the same findings[19]. It was in with contrast with a study which reported that ballet dancers had higher BMD at total body, legs and spine but, in the previous study the authors did not compare BMD with age and weight matched group but with age and weight matched reference population[22].

Oligomenorrheic dancers had significantly lower BMD at total body, trunk, legs and arms compared with eumenorrheic controls. However, BMD at femoral neck, ward's triangle and greater trochanter were not significantly reduced. Also, they showed lower BMI, lower total fat percentage, and lower total fat mass than their controls.

This was confirmed by significant positive correlations found between BMI and measured sites BMD. Also, the non-significant reduction in site-specific weight bearing area may be attributed to that the beneficial effect of ballet dancing training may neutralize the deleterious effect of hypogonadal state on bone metabolism[11,16]. It was not expected that legs BMD showed significant reduction but in this study, it had been shown that lower legs fat mass was strongly associated with lower legs BMD.

Oligomenorrheic dancers had non-significant lower BMD at all sites when compared with eumenorrhoeic dancers. These findings were in agreement with the view that athletes with menstrual dysfunction are at increased risk of generalized low BMD at all sites (non-weight bearing sites are more affected than weight bearing sites). However, the reduction of BMD may depend on the history of menstrual dysfunction and the amount of cortical and trabecular bones.

Oligomenorrheic and eumenorrheic dancers had significantly lower values at total fat mass, total fat percentage and lean mass. This was in agreement with studies on ballet dancers[10,24]. Also, they showed lower values at regional fat mass (trunk, abdomen, lower legs and arms) and soft tissue fat percentage.

Bronson and Manning[5] reported that fat stores are important component of energy balance and ovulation is regulated somewhat to whole body energy balance. Oligomenorrheic dancers had low BMI and lower fat mass, which are indicators of low energy balance in combination with regular intensive exercise, may lead to energy imbalance that results in menstrual dysfunction in this group.

Lean mass consists mainly of muscle tissue. It is associated with BMD in athletes as it exerts passive mechanical loading and active biomechanical stress on bone[2]. In the present study, there were higher total and regional lean mass; however they weren't significant, in eumenorrheic dancers compared with their controls reflecting the effect of weight bearing exercise.

Bone mineral density at different measured sites was related to BMI. Sowers and his colleagues reported that BMI is not a determinant of BMD and muscle mass has an independent effect[18]. Indeed, there were significant positive correlations found between total lean mass and almost measured sites of BMD while total fat mass was not related to total, trunk and abdomen BMD. However, legs and arms fat mass were considered as significant predictors for their regional BMD.

Conclusions

Our data suggest that participating in intense physical training before puberty and low BMI could be associated with delayed menarche, irregular menstrual cycles and insufficient peak bone mass obtained during puberty that cause low BMD in adolescent ballet dancers.

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الملخص العربي

تقييم وظائف الحيض وكثافة العظام وتكوين الجسم في لاعبات البالية المصريات

هدف الدراسة : تهدف هذه الدراسة إلى تقييم تأثير التدريب البدني علي وظائف الحيض وصحة العظام في لاعبات البالية المراهقات . وقد تم إجراء الدراسة علي أربعة وعشرين لاعبة بالية وكذلك أربعة عشر فتاة لا تمارسن الرياضة ولهن نفس السن والوزن . القياسات : تم تقييم وظائف الحيض والخصائص التدريبية للفتيات بواسطة استبيان وتم تقييم كثافة العظام وتكوين الجسم بواسطة جهاز الدكسا . النتائج : أظهرت النتائج أن 45 % من لاعبات البالية تعانين من اضطرابات الحيض . فقد أظهرن هؤلاء الفتيات نقص ليس له دلالة إحصائية في كثافة العظام في مناطق تحمل وزن الجسم وكثافة عظام الظهر والبطن ونقص ذو دلالة إحصائية في كثافة العظام الكلية وكثافة عظام الأرجل ومؤشر كتلة الجسم ونسبة الدهون الكلية ونسبة دهون البطن والأرجل والبطن والأيدي عند مقارنتهن بالفتيات في المجموعة الضابطة بينما اللاعبات اللاتي لديهن انتظام في الدورة الشهرية أظهرن زيادة في كثافة العظام في منطقة الفخذ ومثلث وارد والمدور ا الأكبر للفخذ وأيضا زيادة ليست لها دلالة إحصائية في نسبة العجاف الكلية والجزئية عند مقارنتهن بالفتيات في المجموعة الضابطة. سن الالتحاق بالرياضة أظهر علاقة ايجابية ذات دلالة إحصائية عالية مع سن الحيض ومدة الحيض وعلاقة سلبية ذات دلالة إحصائية مع عدد الدورات الشهرية. وأيضا كان هناك علاقة ايجابية ذات دلالة إحصائية بين نسبة العجاف الكلية وكثافة عظام الفخذ ومثلث وارد والمدور الأكبر للفخذ وكثافة عظام الظهر .
الخلاصة : يمكن أن نستنتج أن الفتيات اللاتي لديهن انتظام في الحيض لديهن كثافة عظام عالية في مناطق تحمل الوزن وزيادة في نسبة العجاف الكلية والجزئية مقارنة بالفتيات اللاتي لاتمارسن الرياضة. بينما اللاعبات اللاتي لديهن اضطرابات في الحيض كان عندهن نقص معمم في كثافة عظام الجسم مقارنة بالفتيات في المجموعة الضابطة وأيضا كان هناك حفاظا إلى حد ما علي نسبة العجاف الكلية والجزئية نتيجة لممارسة الرياضة. من هنا يجب التوصية بضرورة الفحص الدوري لفتيات البالية الصغيرات وعمل برامج توعية حول مشاكل الحيض وكيفية تأثيرهن عل صحة العظام .
الكلمات الدالة : لاعبات البالية ، كثافة العظام ، تكوين الجسم ، اضطرابات الحيض .