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Impact of Nutritional Status on the Pubertal Transition in a Sample of Egyptian School Girls

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Abstract: Pubertal growth is influenced by many factors including the environmental and nutritional status. To assess the impact of nutritional status on pubertal stages, ovarian and uterine volumes among school girls. Cross sectional study was carried out on one thousand healthy school girls, aged 8-18 years old. They were selected randomly from girl schools in 6 October district at Giza governorate. They were categorized according to their ages into three groups 8-12 years, 13-15 years and 16-18 years ±6 months, then according to their body mass index percentile (National Egyptian Growth Curves for Children and Adolescents) to normal weight (=15-<85.), overweight (=85-<95) and Obese: (=95). All girls were subjected for anthropometric assessment body weight (Kg), height (cm), body mass index], nutritional markers (WAZ (Weight/age Z score), HAZ (Height/age Z score) and BMI-Z (Body mass index Z score), pubertal assessment (Tanner stage) and pelvic transabdominal sonography. Highly significant differences in age, ovarian and uterine volumes and nutritional markers (WAZ, HAZ and BMI-Z score) were detected among the different grades of puberty in the two age groups (8-12 years, 13-15 years), except HAZ in the second age group where the differences were insignificant. Girls aged 15-18 years reached to final volume for the uterus and ovary with insignificant differences. Pubertal stage, ovarian and uterine volumes were highly significantly correlated with the nutritional markers. Nutritional status has a crucial role in determining pubertal stage, ovarian and uterine volumes among Egyptian girls during the pubertal process.

Key words: Pubertal Stage % Nutritional Markers % Girls % Ovarian and Uterine volumes

INTRODUCTION

Growth during childhood and adolescence is influenced by many factors including genetic, endocrinal and environmental factors [1]. Several studies also support a major role of nutritional status in influencing childhood growth, as clearly evidenced by the association between short stature and malnutrition, as well as between over nutrition and tall stature [2, 3].

Puberty is a period of physical and psychological maturation with long-term effects on health. Over the last decades a secular trend towards earlier puberty has occurred in association with improvements in nutrition and the increasing number of obese patients [4]. Puberty is initiated by gonadotropin-releasing hormone from the hypothalamus followed by a complex sequence of endocrine changes (Estradiol production in girls) and is regulated by genetic, nutritional and environmental factors [5]. Its onset is determined by the appearance of breast buds in girls because breast tissue is the primary target for estradiol. Menarche usually occurs in middle or late puberty [6].

Pelvic ultrasound is considered a non-invasive, rapid and reliable tool for imaging the internal genitalia of girls. Several studies have assessed the growth of the uterus and ovaries during childhood and adolescence.

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However, they have shown wide variation in their results [7, 8]. Pelvic transabdominal sonography is an important tool of evaluating the developmental status and treatment effect in normal and precocious puberty girls [9].

Aim of the Study: This study aimed to investigate the impact of nutritional status on pubertal stage, ovarian and uterine volumes among Egyptian girls.

MATERIALS AND METHODS

Cross sectional study was done on one thousand healthy girls. They were recruited randomly from Experimental language schools (El Tahrir, El Talaa and El Nasr schools) at 6 October district in El Giza governorate, Egypt. Their ages were ranging from 8-18 years old. All were from high-mid socioeconomic class. The study was accepted from "Ethical Committee" of National Research Centre. Informed consents were taken from Ministry Of Education, School managers and parents.

The girls were categorized according to the following variables,

- According to their ages; into three age groups: (8-12 years±6 months), (13-15 years ±6 months) and (16-18 years ± 6 months).
- According to body mass index; using age specific body mass index percentile of National Egyptian Growth Curves for Children and Adolescents [10], to: normal weight (BMI =15-<85), overweight (BMI =85-<95) and obese (BMI =95).
- As regard to pubertal stage, they were classified according to Tanner classification: from 1 to 5 Tanner stages [11].

All girls were subjected to complete clinical examination, anthropometric assessment in form of body weight (Kg), body height (Cm) following the recommendations of international Biological Program [12]. Then, body mass index (BMI) [Wt (kg)/Ht (m^2)] was calculated. By using the "National Egyptian Growth Curves for Children and Adolescents [10], nutritional markers in the form of WAZ (Weight/age-Z score), HAZ (Height/age-Z score) and BMI-Z (Body mass index-Z score) were calculated. Pelvic transabdominal sonography was simultaneously done for all girls and interpreted by the same physician. Ultrasounds were performed on the first day of the menstrual cycle; assessing the number, size and distribution of the developing follicles, amount of stroma and uterine and ovarian volumes giving out the uterine-ovarian ratio. All these parameters were correlated to Tanner pubertal stages.

Statistical Analysis: Collected data were compiled, coded, verified and analyzed using the computer program SPSS (Statistical package for social science) version 16. Data was examined by using "One-Sample Kolmogorov-Smirnov Test" for normal distribution, which revealed that it was normally distributed. Continuous data were expressed as means ± standard deviation and compared through different groups using ANOVA. Partial correlation analysis was conducted to evaluate the association between continuous exposure and continuous covariates after adjustment for ages. $P < 0.05$ was accepted as statistically significant, while $P < 0.01$ was accepted as highly statistically significant.

RESULTS

Data from this study postulated that ovarian volume increased progressively (1-2 cm^3) during the ages 8 to 11 years, followed by transient stationary course from age 11 to 13 years and then increased again by 2 cm^3 at age 14 year to be followed by second stationary course up to 18 year. Uterine volume showed also progressive increase, which became nearly constant between 16 to 18 years. Uterine volume was nearly triple the ovarian volume during the age 8-18 years (Fig 1).

Frequency distribution of the sample by the pubertal stages and age (Fig. 2) revealed that 7.2% are in the prepubertal stage which was represented by T1. While 92.8% of the girls; are in the pubertal stages which were represented by T2, T3, T4 and T5 (9.4, 13.9, 18.7 and 50.8 % respectively). All students aged from 16 years (21.8%) achieved complete puberty. The Egyptian girls started puberty by age of 9 years and achieved complete puberty by age of 15 years. The mean age of onset of puberty in the current study was 11.65 ± 1.84 years. The mean age of complete puberty was 15.02 ± 1.68 years. The mean age of menarche was 14.79 ± 1.75 years.

Frequency distribution of the sample according to BMI showed that 7% was obese and 15.7% was overweight.

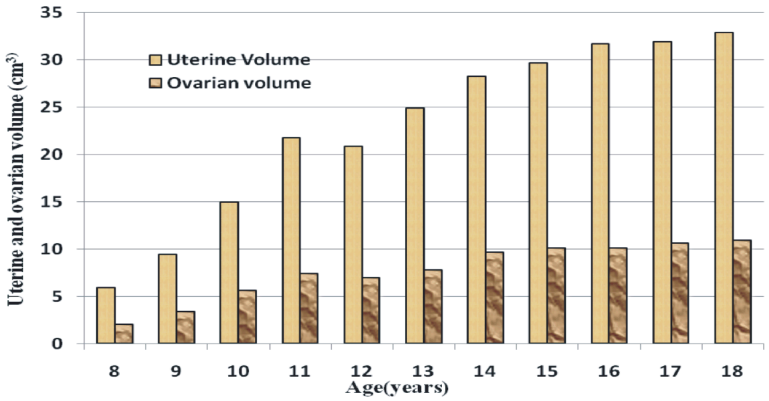

Fig. 1: Comparison between mean uterine and ovarian volumes in cm^3 at ages 8 to 18 years old

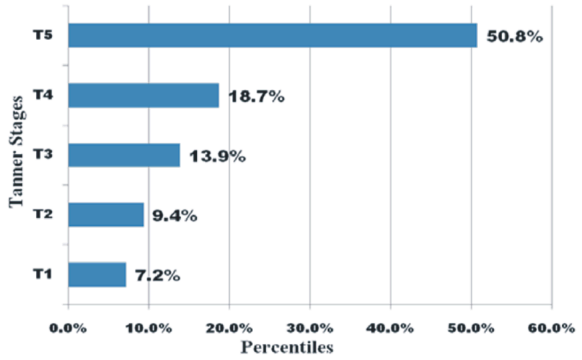

Fig. 2: Frequency distribution of the sample by the pubertal stages and age

As regard to nutritional markers which selected in this work, these markers had highly significant differences between the three BMI groups in the first age group ($p < 0.05$). HAZ showed significant difference due to different linear growth in age between 8-12 years old. WAZ and BMI-Z score had highly significant differences between the three BMI groups in the second and third age groups ($p < 0.001$), while HAZ had insignificant difference. Ovarian and uterine volumes had highly significant differences between normal, overweight and obese girls in first and second age group ($p < 0.05$), while in the third age group the differences were insignificant (as the uterus and ovary completed their growth). All significances come in advance of the obese girls (Table 1).

The Nutritional status and ovarian and uterine volumes in relation to different pubertal stage in girls' age 8-12 and 13-15 years old among the candidates were presented in Tables 2. Highly significant differences in age, ovarian and uterine volumes and nutritional markers (WAZ, HAZ and BMI-Z score) were detected among the different grades of puberty in the two age groups (8-12 years, 13-15 years) ($p < 0.05$), except HAZ in the second age group where the differences were insignificant. All girls in the third age group (16-18 years) achieved puberty, so comparisons could not be done.

Partial Correlation coefficient to exclude the effect of age; was presented in Table 3. Pubertal stage and uterine volume showed positive significant correlations with the nutritional markers: WAZ, HAZ and BMI-Z ($p < 0.05$). However, ovarian volume showed positive significant correlation with HAZ and negative significant correlation with WAZ and BMI-Z ($p < 0.05$).

DISCUSSION

In the current study, highly significant differences in ovarian and uterine volumes and nutritional markers (WAZ, HAZ and BMI-Z score) were detected among the different grades of puberty in the two age groups (8-12 years, 13-15 years) ($p < 0.05$), except HAZ in the second age group where the differences were insignificant. All significances come in advance of the obese girls i.e. with increase of BMI. Furthermore, pubertal stages and ovarian and uterine volumes revealed highly positive significant correlations with the nutritional markers. Also, nutritional markers (WAZ and BMI-Z score), showed a highly significant differences between the three BMI groups in all age groups. HAZ showed a significant difference in the first age group only due to different linear growth in ages between 8-12 years old. So, pubertal growth and ovarian and uterine volumes were significantly depend on nutritional status in the present study.

Table 1: Nutritional status and ovarian and uterine volumes in relation to different body weight categories in the studied school girls

	Normal	Overweight	Obese		
	Mean ± SD	Mean ± SD	Mean ± SD	F	P
Group I (N=300)(Age8-12)	(N=239)	(N=49)	(N=12)		
Age (years)	10±1.3	10.1±1.4	9.6±1.4	0.599	0.550
BMI (Kg/m²)	26.9±2.7	31.7±0.4	34.7±1.4	128.025	0.001
Ovarian volume(cm³)	4.6±2.8	7.8±2.9	7.9±3.5	26.961	0.001
Uterine volume(cm³)	13.1±10.3	21.9±8.4	27.8±10.3	16.402	0.001
HAZ	-0.2±1.0	0.7±0.8	0.6±1.1	23.436	0.001
WAZ	-0.3±0.8	1.2±0.3	1.7±0.6	120.244	0.001
BMI Z score	-0.4±0.8	1.3±0.1	2±0.3	158.07	0.001
Group II (N=450)(Age13-15)	(N=354)	(N=42)	(N=54)		
Age (years)	13.8±0.9	13.3±0.7	14±0.8	0.001	0.999
BMI (Kg/ m2)	25.8±2.1	32.6±0.6	33.6±1	415.796	0.001
Ovarian volume(cm)3	8.3±2.4	9.2±1.2	10.1±1.7	16.321	0.001
Uterine volume(cm)3	24.8±6.1	28.9±2.8	30.3±3.5	29.665	0.001
HAZ	0.13±1.0	0.3±1.0	-0.1±1.0	1.91	0.149
WAZ	-0.4±0.7	1.3±0.7	1.4±0.6	234.926	0.001
BMI Z score	0.4±0.6	1.4±0.1	1.8±0.2	559.287	0.001
Group III (N=250)(Age16-18)	(N=180)	(N=66)	(N=4)		
Age (years)	16.5±0.8	16.5±0.8	16.5±0.6	0.001	0.999
BMI (Kg/m2)	24.8±2.3	32.9±0.4	33.7±0.1	415.796	0.001
Ovarian volume (cm³)	10.3±0.9	10.5±0.7	10.6±0.2	1.179	0.309
Uterine volume (cm³)	31.7±2.1	32.3±1.4	32.8±1.4	2.223	0.11
HAZ	5.4±0.0	0.1±1.0	1.8±0.1	0.995	0.371
WAZ	-0.5±0.6	1.3±.5	1.3±0.1	239.689	0.001
BMI Z score	-0.5±0.6	1.4±0.1	1.6±0.0	417.72	0.001

P < 0.05 is significant

Table 2: Nutritional status and ovarian and uterine volumes in relation to different pubertal stage in the studied school girls (Age 8-15 years)

	T1Mean±SD	T2Mean±SD	T3Mean±SD	T4Mean±SD	T5Mean±SD	F	P
Group I(Age8-12)	N=65	N=65	N=52	N=64	N=54		
Age (years)	8.7±0.6	8.8±0.7	10±0.6	11.0±0.6	11.7±0.5	283.196	0.001
Ovarian volume (cm)3	1.7±.9.0	2.6±.9.0	6.1±2.0	7.3±1.8	8.9±1.5	271.402	0.001
Uterine volume (cm)3	4.9±3.7	7.3±3.7	14.6±7.1	21.6±9.1	27.3±6.0	138.927	0.001
HAZ	-0.4±0.9	0.1±1.2	0.1±1.1	0.1±0.8	0.1±1.0	2.297	0.001
WAZ	-0.3±1.1	0.0±1.0	0.1±1.0	0.1±1.0	0.3±0.8	3.01	0.001
BMI Z score	-0.3±-0.3	0±0.9	0.1±1.0	0±1.0	0.3±0.9	3.316	0.019
Group II(Age13-15)	N=7	N=29	N=87	N=123	N=204		
Age (years)	12.5±0.0	12.6±0.2	13±0.3	13.5±0.6	14.4±0.6	172.33	0.001
Ovarian volume (cm)3	2.3±0.2	5.3±3.1	10.5±5.5	10.2±7.3	10.3±6.2	24.992	0.001
Uterine volume(cm)3	8.5±.6	13.5±5.8	19.3±9.2	19.7±10.4	23.8±11.1	14.642	0.001
HAZ	-0.7±0.3	0.0±1.1	0.0±1.0	0.0±0.9	0.0±1.1	0.908	0.459
WAZ	-1.3±0.1	0.0±0.8	0.0±0.9	0.0±1.0	0.1±1.1	3.313	0.011
BMI Z score	-1.2±0.2	0.0±0.8	0.0±0.9	0.0±1.1	0.1±1.0	2.544	0.039

P < 0.05 is significant T = Tanner stage

Table 3: Partial Correlation coefficient between pubertal stage, ovarian and uterine volumesat one side and the nutritional markers

	Pubertal stage		Ovarian volume		Uterine volume	
Item	r	p	r	p	r	p
HAZ	0.1	0.002	0.091	0.004	0.178	0.001
WAZ	0.138	0.001	-0.216	0.001	0.573	0.001
BMIZSCOR	0.14	0.001	-0.284	0.001	0.633	0.001
Ovarian volume(Cm³)	0.2921	0.001			0.5155	0.001
Uterine volume(Cm³)	o.3882	0.001	0.5155	0.001		
Pubertal stage			0.2921	0.001	0.3882	0.001

r = partial correlation coefficient

P < 0.05 is significant

The mean age of onset of puberty, of menarche and of complete puberty in the current study were, 11.65±1.84, 14.79±1.75 and 15.02 ±1.68 years respectively. These results are in concordance with the previous studies of Ghaly *et al.* [10] and Hosny *et al.* [13], in Egypt. In contrast, Saffari *et al.* [14] found that the mean age of pubertal onset in girls living in Qazvin in Iran is 9.71 years, while menarche occurs at mean age of 12.52 years. This difference can be attributed to racial, genetic and environmental factors between the two communities.

Mounir *et al.* [15] in Alexandria showed that the nutritional status of the girls had a significant association with the onset of menstruation and the age of menarche which is in concordance with the results of the present study. Boyne *et al.* [16] examined the effects of birth size, growth rates throughout childhood, on the onset of puberty in Afro-Caribbean children in Jamaica. They concluded faster growth throughout childhood, especially with fat mass accretion, which associated with more advanced puberty apart from menarche. With the onset of puberty, lean mass accretion significantly increases. Although, their study was a longitudinal one in contrast to our cross sectional study, their results showed a significant correlation between pubertal stages and nutritional status proposing that childhood growth is dependent on nutritional status. Kaplowitz [17] in USA, Ahmed *et al.* [18] in UK studied the relationship between body mass index (BMI) and timing of pubertal onset in girls. They found an association between body fat and earlier timing of puberty and that the data supported but did not establish causality. Rosenfield *et al.* [19], Burt and McCartney [6] in USA detected an association between BMI and early puberty. They explained this association by the altered levels of the insulin, leptin and estrogen hormones (Due to excess body fat) which are responsible for the acceleration of puberty. Ong *et al.* [20] in UK noted the linkage of a gene that was associated with pubertal timing (A polymorphism of LIN28B) with increased BMI at ages 15-43; this suggests a genetic association between earlier puberty and obesity. In contrast to these studies, Himes *et al.* [21] in Minneapolis, USA, demonstrated that the average effects of menarcheal status on BMI assessments of overweight and obesity are small and usually should not be clinically important.

Razzaghy *et al.* [22] attempted to provide normal references of sonographic uterine and ovarian volumes in premenarcheal healthy girls aged 6-13 years in different stages of puberty in Iran. They concluded that there is a progressive increase in size of internal female genitalia in relation to age, height, weight and puberty. Uterine volume presented the best correlation with age and stage of puberty. Badouraki *et al.* [23] in Greece, studied the development of the uterus and ovary in ninety-nine girls, their age range 1 to 12 years old, by ultrasound. They concluded that there was gradual increase in the uterine and ovarian volume and this increase had relationship to age, length, weight and Tanner stage of puberty. Seth *et al.* [24] in India tried to derive norms for the size of uterus and ovarian volumes in girls in various Tanners stages of puberty. A statistically significant increase in uterine and ovarian volumes was observed with progressive pubertal stages. The previous studies with the current study detected an association between uterine and ovarian volumes with pubertal stages among the studied girls. Ersen *et al.* [25] investigated uterine and ovarian ultrasonagraphy in healthy girls and establish reliable cut-off limits in the Turkish population. Age-related increases of pelvic organs were noted after 10-10.9 years. Significant correlation was detected between age and ovarian and uterine volumes in pubertal girls, but age only correlated with ovarian volume in prepubertal girls. A cut-off value of 2.57 cm^3 for uterine volume and 1.58 cm^3 for ovarian volume were the best discrimination values for entering puberty. De Vries *et al.* [26] studied the role of pelvic ultrasound in assessment of uterine and ovarian volumes and their relation to pubertal state. They concluded that increased uterine and ovarian measurements may be an early and sensitive sign of precocious puberty. Pelvic ultrasound, a noninvasive, inexpensive and reliable tool, may give the clinician a complementary indication to the gonadotrophin-releasing hormone GnRH test in distinguishing isolated premature thelarche (growth of breast buds without any other manifestations of puberty) from early-stage precocious puberty in girls with early breast budding. Khadilkar *et al.* [27] studied the pattern of female reproductive organ growth in Indian girls from birth to 18 years of age. They found significantly higher ovarian and uterine volumes ($P<0.001$) and this correlated with age, height and weight.

The present study was performed regional, cross sectional only in girls which can be seen as limitations of the study. However, strong points characterize the study including large sample size that increases the precision of findings.

CONCLUSION

Nutritional status, reflected by nutritional markers, has a role in determining the pubertal stage, uterine and ovarian volumes in girls during the pubertal process.

Declaration of Conflicting Interests: The authors have no conflicts of interest to disclose.

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