Original Article

CORRELATION OF SKELETAL MATURATION STAGES OF MP3 WITH ONSET OF MENARCHE AMONGST RURAL AND URBAN SCHOOL GIRLS

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ABSTRACT

Introduction: The purpose of this study was to evaluate and correlate skeletal maturation stages of Middle phalanx of third finger (MP3) with the onset of menarche in rural and urban school girls.

Materials and methods: 100 urban school girls and 100 rural school girls were randomly selected comprising of 50 menarche unattained girls and 50 menarche attained girls respectively for each group. For each subject, radiographs of middle phalanx of middle finger and record about onset of menarche were taken after every three months for a total duration of one and half year comprising a total of 6 visits.

Results: The results showed onset of menarche at HI MP3 stage for 50%, HMP3 stage for 47.5% and GMP3 stage for 2.5% in rural girls (subgroup D2) whereas onset of menarche was at HMP3 stage for 41.6%, HI MP3 stage for 50% and GMP3 stage for 8.33% in urban girls (subgroup B2). No significant difference in the MP3 skeletal stage distribution of two groups was seen after applying Chi-square test ($P>0.05$). The mean menarche attaining age of the rural girls was $12.6\pm.84$ years and urban girls was $11.8\pm.79$ years.

Conclusions: The correlation between MP3 skeletal maturation and onset of menarche, established the onset of menarche at H and HI stage for both rural and urban school girls. The results show earlier mean menarche-attaining age for urban girls than rural girls.

Keywords: Middle phalanx third finger (MP3), Menarche, Peak height velocity, Skeletal maturity indicators, Growth

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INTRODUCTION

Skeletal maturation is the metamorphosis of the cartilaginous and membranous bones of the foetus to the fully ossified bones of the adult [1] or can be defined as the degree of development of ossification in bone [16]. As a person grows from foetal life through child hood, puberty and finishes growth as a young adult, the part of bone, the epiphysis changes in size and shape. There is initial appearance of epiphysis and subsequent ossification of epiphyseal cartilage and finally its fusion which can be appreciated in the radiographs. These sequences of changes in bone is consistent for every individual since everyone has his own biologic clock.

The introduction of radiography by Roentgen was of great utility in various fields. Hand and wrist radiographs for skeletal maturation assessment were first utilized by Greulich and Pyle [17] followed by Grave and Brown [13], Fishman [11] and Hagg and Taranger [15]. Similarly, lateral cephalograms for skeletal maturation assessment were first utilized by Lamparski [26] followed by Hassel and Farman [16] and Baccettie et al. [5]. Skeletal maturation assessment with the middle phalanx of the third finger (MP3) was studied by Hagg and Taranger [15] which was later modified by Rajgopal and Kansal [27]. They described the various stages of development of the middle phalanx of the third finger as FMP3, FGMP3, GMP3, HMP3, HIMP3 and IMP3 (Fig. 1) and concluded that it is a simple, accurate, easy to interpret, practical and economical method with minimal radiation exposure for making a

decision on treatment timing when compared to Cervical Vertebrae Maturation Index staging.

Menarche is a distinct benchmark for sexual maturation. The age at menarche, an easily recallable event, is an important biologic indicator in assessing the physiologic maturity in girls. The relationship between the growth spurt in body height and onset of menarche has been investigated [25,28]. It has been seen that the peak height velocity is attained a year before menarche [8] and so, it occurs after the initiation of the adolescent growth spurt. It is known to be influenced by genetics, ethnic origins, socioeconomic status, general living conditions, and environmental factors [19].

The identification of skeletal maturation levels and its correlation with onset of menarche provides a very useful means of identifying specific periods along the path of adolescent growth that provides a new dimension for evaluating general and individual growth including facial growth with the help of middle phalanx of third finger (MP3) radiographs. This identification of peak growth period helps in treating orthopaedic problems such as mandibular retrognathism effectively by myofunctional appliance therapy. These are designed to alter the position of mandible both sagittally & vertically inducing lengthening of the mandible and stimulating increased growth at the condylar cartilage. Hence the aim of this study is to evaluate and correlate skeletal maturation stages of MP3 (Middle phalanx of third finger) with the onset of menarche in rural and urban school girls.

MATERIALS AND METHODS

This was a prospective longitudinal study consisting of 200 girls randomly divided into 100 urban school girls (Group I) and 100 rural school girls (Group II). 100 urban girls (Group I) further consisted of 50 menarche unattained girls (Sub group B) and 50 menarche attained girls (Sub group A). Out of 50 menarche unattained urban girls (Sub group B) 25 remained unattained (Subgroup B1), 24 had attained menarche (Subgroup B2) and there was 1 drop out. Similarly, 100 rural girls (Group II) further consisted of 50 menarche unattained girls (Sub group D) and 50 menarche attained girls (Sub group C). Out of 50 menarche unattained rural girls (Sub group D) 10 remained unattained (Subgroup D1) and 40 had attained menarche (Subgroup D2). The age group of the sample was taken from 10 years to 14 years. A written consent from the parents of school children was taken for taking third finger X-ray for the study.

For each subject, radiographs of middle phalanx of middle finger and record about onset of menarche were taken after every three months and were taken for total duration of one and half year comprising total of 6 visits. For taking X-ray, armamentarium used for the study was Portable X ray machine (Genoray portable X-ray system Power output: 180W, Tube Voltage: 60KV, Tube Current: 2mA, Focal Spot: 0.8mm, Exposure time set: 0.1-2.0 sec, Power requirement: 22VDC), RVG (Digital Radiovisiography, Kodak RVG 5100 system resolution: 14 lp/mm.) and customized portable X ray box.

For taking X-ray, the RVG sensor was placed over the finger and sensor stabilizing unit in the X ray box. Then the moving glass slide was placed over the sensor and individual was asked to pass her hand inside the portable X-ray box keeping their third finger on glass slide which was placed over the stand. Then this was exposed to X-rays by passing the X-ray tube above it. The MP3 Xrays were evaluated and staged according to the system given by Rajgopal and Kansal [27] (Fig. 1). Our study showed that Spearman's rank correlation of interobserver reliability ranged from 0.997 to 0.999 for the MP3 staging system. The correlation for intraobserver reliability was 1.000 and all correlations were found to be statistically significant.

Descriptive statistics were used to calculate the means and standard deviations of the chronological age of onset of menarche. Unpaired T test for comparison of mean menarche attaining age and for comparison of MP3 stages at onset of menarche between rural and urban girls were carried out.

Fig. 1. Skeletal developmental stages of the middle phalanx of the third finger.

RESULTS

The mean age of the girls in our study was 12.19 ± 1.01 years. The mean age of the rural girls (Group I) was 12.24 ± 1.04 years and urban girls (Group II) was 12.15 ± 1 years (Table 1 & Fig. 2). The mean menarche attaining age of the rural girls was 12.6 ± 0.84 years and urban girls was 11.8 ± 0.79 years (Table 2 & Fig. 3).

The age of attaining menarche was higher in rural girls (subgroup D2) as compared to urban girls (subgroup B2) and the difference was statistically significant ($P < 0.01$) as shown in (Table 2 and Fig. 3).

When comparing the menarche attaining age at various modified skeletal MP3 maturation stages for rural and urban group i.e. subgroup D2 and B2, it showed onset of menarche at HI MP3 stage for 50%, HMP3 stage for 47.5% and GMP3 stage for 2.5% in rural girls (subgroup D2) whereas onset of menarche was at HMP3 stage for 41.6%, HIMP3 stage for 50% and GMP3 stage for 8.33% in urban girls (subgroup B2).

No significant difference in the MP3 skeletal stage distribution of two groups was seen after applying Chi-square test ($P > 0.05$). (Table 3 and Fig. 4).

The urban and rural girls who had already attained menarche (subgroup C and D) showed HI and I MP3 stages and unattained menarche girls (subgroup B1 & D1) showed FG MP3 and G MP3 stage.

DISCUSSION

The knowledge of growth, its effect on development of dentofacial complex in particular and the body in general leads to early prevention and interception of dentofacial deformities. This further depends upon accurate interpretation of the inherent facio-skeletal pattern and overall growth and development.

Since several studies [2, 6, 27, 22, 18] showed high correlation of MP3 developmental stages when compared with CVMI stages or hand-wrist assessment or with dental maturity indicators, so MP3 stages can be used as sole indicator for skeletal maturation assessment of an individual. MP3 radiograph show high degree of clarity, with no superimposition of bones or variations in posture as in evaluation of the cervical vertebrae. They show discrete, easily identifiable stages of development, unlike the more subtle changes in CVMI stages as described by Raj Gopal Kansal [27]. They show good reliability and reproducibility [27]. CVMI methods requires elaborate equipment and the radiation exposure time and dose are also high. Digital radiography was used instead of using conventional film in the present study since Abdel-Kader 1998 [3] concluded that digitized radiographic images of the MP3 have five times less exposure than conventional approach. These digital images also increase the scope for cross-sectional and longitudinal studies.

The age of attainment of menarche is influenced by various factors such as Socio-economic status, diet, nutrition, genetic factors

and physical activity [19]. The mean menarche attaining age for rural girls was 12.60 ± 0.84 years (subgroup D2) and 11.8 ± 0.79 years for urban girls (subgroup B2) showing statistically significant difference. The mean rural menarche attaining age (12.04 ± 0.89 years) was in accordance with study done by Banerjee I et al (2007) [4], Khatoon (2011) [19], Khadgawat et al (2016) [20] and Pandey M and Pradhan A (2017) [23] in which the mean age at menarche was 12.3 years, 12.43 ± 1.49 years, 12.4 years and 12.52 years respectively. Whereas the present results are contrary to the study of Pathak et al [24].

This reduction of menarche attaining age in our study was due to improvement in the field of scientific and technological advancement, economic growth, agriculture, food supply, public health systems and hygiene, which markedly help to improve the general health, nutritional level and over all standard of living of the population when compared to past several decades.

The results show earlier mean menarche attaining age for urban girls (subgroup B2 11.8 ± 0.79 years) than mean menarche attaining age for rural girls of (12.60 ± 0.84 years in subgroup D2) showing statistically significant difference. This is in accordance with the study of Chidiebere et al [9] and Khatoon et al [19]. Since rural girls do more physical activity, have low socioeconomic status and are less nourished hence show less fat accumulation. Thus, there is release of androgen hormones (aldosterone) which delays menarche.

When comparison was done for menarche attaining age at various modified skeletal MP3 maturation stages given by Rajagopal and Kansal [27] for rural and urban group i.e. subgroup D2 and B2. It was seen that menarche was attained in HI MP3 stage for 50%, HMP3 stage for 47.5% and GMP3 stage for 2.5% in rural girls (subgroup D2) whereas menarche was attained in HMP3 stage for 41.6%, HIMP3 stage for 50% and GMP3 stage for 8.33% in urban girls (subgroup B2). The increased per cent of earlier skeletal MP3 stage in urban girl (sub group B2) compared to rural girl (sub group D2) attributed to earlier menarche attaining age in urban girls compared to rural girls. According to Rajagopal and Kansal [27] modified 6 MP3 stage can be compared to 6 CVMI stages. Therefore, our results are in accordance to the study of Moradinejad et al where highest incidence rates of menarche were noted in the fourth and fifth stages of the development of cervical vertebrae.

The results are in contradictory to the study of Vichare et in which Menarche occurred during SMI 7-8 and CVM Stage III-IV which may be due to overall poor reproducibility of the CVM method according to Gabriel et al [14], Baptista et al [7] and Nestman et al [21]. So there is variation in staging done from MP3 stage.

CONCLUSION

Several studies [10,12,29] support the hypothesis that the peak height velocity is attained one year before menarche and then it

Age (in years)	Group		Total (n=124)	P value
	Rural(n=94)	Urban(n=94)		
10-11 years	16 (17.0%)	13(13.8%)	29 (15.5%)	0.615
11-12 years	16 (17.0%)	24 (25.5%)	40 (21.3%)	
12-13 years	38 (40.5%)	31 (32.9%)	69 (36.7%)	
>13 years	24 (25.5%)	26(27.6%)	50 (26.5%)	
Total	94 (100.00%)	94(100.00%)	188 (100.00%)	
Mean $\pm$ Stdev	12.24 $\pm$ 1.04	12.15 $\pm$ 1	12.19 $\pm$ 1.01	0.787
Median (IQR)	12.49 (11.519 - 13.014)	12.38 (11.253 - 13.116)	12.43 (11.352 - 13.036)	

Table 1. Comparison of age distribution between rural (Group I) and urban (Group II) girls

Fig. 2. Comparison of age distribution between rural (Group I) and urban (Group II) girls

Menarche attaining age in years	Rural (n=40)		Urban (n=24)		P value
	Mean $\pm$ Stdev	Median (IQR)	Mean $\pm$ Stdev	Median (IQR)	
	12.60 $\pm$ 0.85	12.50(12.229 - 13.104)	11.91 $\pm$ 0.79	11.87(11.167 - 12.458)	

Table 2. Comparison of menarche attaining age between rural and urban girls (subgroup B2 & subgroup D2)

Fig. 3. Comparison of menarche attaining age between rural and urban girls (subgroup B2 & subgroup D2)

MP3 Stages	Group		Total	P value
	Rural(n=40)	Urban(n=24)		
G MP3	1 (2.5%)	2 (8.33%)	3 (4.69%)	0.514
H MP3	19 (47.5%)	12 (50.00%)	31 (48.44%)	
HI MP3	20 (50.00%)	10 (41.67%)	30 (46.87%)	
Total	40 (100.00%)	24 (100.00%)	64 (100.00%)	

Table 3. Comparison of MP3 Stages at onset of menarche between rural and urban girls (subgroup D2 & B2)

Fig. 4. Comparison of MP3 Stages at onset of menarche between rural and urban girls (subgroup D2 & B2)

slows down thereafter and stops within 1 year after menarche because of the closing of epiphyses of long bones. In our study the correlation between MP3 skeletal maturation and onset of menarche showed onset of menarche at H and HI stage, So this helps in timing the functional appliance which are most effect when given at mandible's maximum growth potential and after onset of menarche. After HI MP3 stage, the treatment planning moves towards orthognathic surgeries. Hence correlation of skeletal MP3 stages with onset of menarche helps in identifying growth status of a person by diagnosing MP3 radiographs which further helps in deciding various treatment modalities.

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