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Duration of Growth Spurt based on Cervical Vertebrae Maturation In Indonesia Population

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Abstract

Context: Human development consists of periods of accelerated growth where there is an acceleration of growth followed by a period of slower growth. The timing of pubertal growth spurt and maximal growth rate during this developmental phase is different in boys and girls. The increase in growth rate in girls usually occurs at the onset of puberty while boys experience a relatively slow increase in growth rate at puberty.Aims:to compare the differences in the duration of growth spurtbetween girl andboy in Indonesian populations in terms of the Cervical Vertebrae Maturation (CVM) seen in the lateral cephalogram. This information is important to determine the right time and orthodontic treatment plan in order to get maximum treatment results.

Methods and Material: The research variables were divided into 3 types, namely dependent variables (chronological age), independent variables (Cervical Vertebrae Maturation stage, gender). Every sample that met the criteria was performed skeletal maturity analysis using Cervical Vertebrae Maturation (CVM) on each cephalometric photo Skeletal analysis with Cervical Vertebrae Maturation (CVM) by looking at bone maturation

Results: There were differences in the mean / mean age of skeletal maturity in terms of changes in CS 3 to CS 4 between male and female samples ($p < 0.05$). The male sample required a duration of age to reach maturity, namely 15.879 months. Meanwhile, the female sample only required the duration of age to reach maturity, namely 5,184 months

Conclusions:Girls in this study population had a faster growth spurt duration than boys. This is marked by a change in the age of skeletal maturity between the two, which is approximately 10 months apart.

Keywords: *Growth spurt; Cervical Vertebrae Maturation; Boys; Girls; Indonesian*

Introduction

The growth and development period is the period in which various changes occur, including in the oral cavity. Evidence of growth and development is the process of replacing deciduous teeth with permanent teeth. Peak growth (growth spurt) is the fastest growth time which is then followed by slower growth. The peak of the growth spurt depends on gender and varies with each chronological age[1]

Chronological age is the clearest and easiest method of calculating developmental age which can be seen through the child's birth date, but is not an accurate

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indicator of developmental levels. This is because growth and development is different in each individual. Growth and development is influenced by several factors such as genetic, race, nutrition, hormonal, environment and weather conditions. Therefore, to measure age development in children can use dental age and skeletal age [3]

Skeletal age is determined by looking at skeletal maturity which refers to the level of development of ossification in the bone. Socio-economic factors that influence children's growth include: education, employment, technology, culture and family income. These factors will interact with each other so that it can affect nutrient input and infection in children. Availability of nutrients at a low cellular level which will ultimately result in disturbed growth [3]

Based on the background above, the researchers wanted to compare the differences in the duration of growth spurt, dental age and skeletal age between the Malaysian and Indonesian populations in terms of the Cervical Vertebrae Maturation (CVM) seen in the lateral cephalogramThis type of knowledge is useful when patients are referred to orthodontic treatment, particularly because certain stages of pubertal growth spurt may benefit the treatment of some types of malocclusion associated with skeletal disorders.This information is important to determine the right time and orthodontic treatment plan in order to get maximum treatment results.

Subjects and Methods

This research was conducted at the Dental hospital of Airlangga University and was conducted in June 2020. The research variables were divided into 3 types, namely dependent variables (chronological age and sex), independent variable (duration of growth spurt, and skeletal age) and controlled variable (phases of Cervical Vertebrae Maturation (CVM) as well as Indonesian and population). CVM is analyzed to see skeletal age and duration of growth spurt. Statistical analysis using the Multivariate-OnewayAnnova Test, and t-test with SPSS 24.0 previously tested for normality and homogeneity first.

Every sample that met the criteria was performed skeletal maturity analysis using Cervical Vertebrae Maturation (CVM) on each cephalometric photo Skeletal analysis with Cervical Vertebrae Maturation (CVM) by looking at bone maturation and defined into six categories ranging from CS1 to CS6. Cervical Vertebrae Maturation (CVM) analysis in the CS3 and CS4 phases for chronological age was also performed. Every data that has been analyzed is recorded and grouped according to chronological age and calculates the average based on gender and race. It was also conducted to calculate the interval between groups CS3 and CS4 in each sex.

Inclusion criteria

· Good quality of cephalograms.

· No earlier orthodontic treatment.

· No extracted teeth or congenitally missing.

· No systematic or acquired diseases that could have affected over-all development.

· This study used the Cervical Vertebral Maturation (CVM) technique for the detection of the peak in mandibular growth, based on the analysis of the second through fourth cervical vertebrae from a single cephalogram [1].

· Skeletal stages CS3 / CS4 based on the CVM method. CS3 represents the initial stage of the acceleration of the pubertal growth peak, and CS4 presents the final stage of the acceleration of the pubertal growth peak in adolescents[1]

Results

In this study, it is found that duration of growth spurt in boys has a longer period when compared to girls. Based on the results of research on 93 samples of children's cephalometric photos obtained from the medical records of Dental Hospital FKG Airlangga University, in the 2010-2020 period, sex differences had a significant effect on the age of skeletal maturity experienced by children. The stages of the elaboration are arranged consecutively by presenting the data in the form of: age distribution and CVM sample stage at the time the data is collected and observed; Analysis of the

effect of sex differences and CVM stage on chronological age; and Analysis The difference in the mean increase in growth spurt duration seen between the male and female samples (in months) was assessed from the change in CS 3 to CS 4 levels. In the following data, the age frequency distribution table and the CS stage sample are presented taken and observed:

Table 1.1 Cross-tabulation between sexes and skeletal maturation levels observed at the time of data collection

			Sex		Total
			Boys	Girls	
CVM Stage	CS 3	N	22	23	45
		Percentage	48,9%	51,1%	100,0%
	CS 4	N	23	25	48
		Percentage	47,9%	52,1%	100,0%
Total		N	45	48	93
		Percentage	48,4%	51,6%	100,0%

The cross tabulation table illustrates the proportion of the age of the children at the time of the study sample. A total of 45 boys with an age range from 8 years 3 months to 16 years 2 months when the data was recorded was divided into 2 levels, namely 48.9% were at the CS 3 level, and 47.9% had reached the level. CS 4. In the sample of girls ranging in age from 8 years 2 months to 16 years 2 months, 51.1% were recorded at the CS 3 level, while 52.1% of girls were recorded at the CS 4 level.

Next, an analysis of the effect of sex differences and CVM stage on chronological age was carried out. This influence analysis test was conducted to see how the pattern of influence of differences in all independent variables, namely Gender, CVM Stage and Sex Interaction with CVM Stage "together on the dependent variable in the form of Chronological Age in Months. This test will show how the difference between sex and CVM stage is able to determine the difference in skeletal maturation age experienced by children. This difference analysis was tested using the Two Way ANOVA test. The two-way ANOVA test was used on the basis of this study which aims to compare the average difference between the groups divided into two independent variables with categorical data scales, namely gender and CMV stage variables, and one dependent variable with quantitative data scales, namely the skeletal maturation age variable.

Before the two-way ANOVA test (Two Way ANOVA) was carried out, the normality and homogeneity tests were carried out as a prerequisite for assumptions, the following is the result table:

Table 2. Table for normality test between variables

Variable	Age	Sex	CVM Stage
Kolmogorov-Smirnov Z	1,393	2,563	3,359
Asymp. Sig. (2-tailed)	,433	,863	,675

The significance value (p) in the Kolmogorov-Smirnov test in the two groups of variables was 0.433 for the age variable, 0.863 for the Gender variable, and 0.675 for the CVM stage variable (p> 0.05), so based on the normality test for the Kolmogorov-Smirnov the data was normally distributed. Furthermore, in the homogeneity test, the results are shown in the table:

Table 3. Homogeneity test table between variables

	Levene Statistic	df1	df2	Sig.
Age	4,928	1	91	,209
Sex	3,424	1	91	,071
CVM Stage	,031	1	91	,861

Homogeneity significance figures for the variable Age 0.209; variable Gender 0.071; and the CVM Stage variable 0.861. This condition shows that the variable to be tested and assessed for the difference is homogeneous (p≥0.05). Based on the results of the normality and homogeneity tests that have been fulfilled, the two-way ANOVA further test can be carried out.

Table 4. Two-way Anova comparison test between variables

Two Way AnovaTest Dependent Variable: Chronological Age					
Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Corrected Model	4203,538(a)	3	1401,179	2,638	,044
Intercept	1641568,569	1	1641568,569	3090,970	,000
Sex	272,095	1	272,095	,512	,006
CVM Stage	3085,293	1	3085,293	5,809	,018
Sex * CVM Stage	934,775	1	934,775	1,760	,008
Error	4540,814	89	133,085		
Total	1698942,000	93			
Corrected Total	51470,129	92			
a R Squared = ,882 (Adjusted R Squared = ,851)					

Effectof all independentvariables (Gender, CVM StageandInteractionof Sex with CS Gradeor "Sex * CVM Stage") togetheronthedependentvariable (Age in Months). If Significance (Sig.) <0.05 (Alfa) = Significant. The examplesabove are 0.006 respectively; 0.018; 0.008 meansthatthe model isdeclared valid. Effectof sex differencesonchronologicalage (in months) in the model. If Significance (Sig.) <0.05 (Alfa) = Significant. The exampleabove 0.005 meansthatthe sex difference has a gnificant effect on the chronologicalage difference achieved.

The effectofdifferences in CVM Stageonmaturity in the model canbeseen in the CVM Stagerow. If the significance (Sig.) <0.05 (Alfa), then there is a significant difference. Data above 0.018 means that the difference in CVM Stage has a significant effect on the chronological age achieved. Furthermore, toseethe difference in the effect of in teractions between the sexes who have the irrespective CVM stages, in determining their chronological age, it can be seen on the Gender * CVM Stageline. In thisrow, a significancevalue (sig.) <0.05 (Alfa) isobtained, whichmeansthatthereis a significantdifference. This data meansthatthereis a significantdifference in chronologicalage, whichisinfluencedbydifferences in sex withdifferent CVM stages. The value of determination (influence) between allin dependent and dependent variables in thetableaboveisat 0.882. The correlationcoefficient (R) isclosetonumber 1, meaningthatthereis a strongcorrelationbetweenthe sex difference variable and the CVM stage in determining thechronologicalage difference achieved. Furthermore, to see to what extent the difference in the pattern of growth spurt duration in boys compared to girls, it will be concluded based on the following table:

Differences between sex and CVM grade in determining chronological age					
Sex	**CVM Stage**	**Mean**	**SD**	**Different duration of growth spurt**	
				Δ Mean	**p**
Boys	CS 3	125,773	19,250	15.879	,008
	CS 4	143,652	29,776		
Girls	CS 3	128,696	19,389	5,184	
	CS 4	133,880	22,088		

The difference in themean / meanincrease in chronologicalagebetweenthe male andfemalesamples (in months) atthe CS 3 level to CS 4. The male samplerequires a durationofage, namely 143.652 - 127.773 = 15.879 months. Meanwhile, forthefemalesample, onlythedurationofagewas 133,880 - 128,696 = 5,184 months.

Discussion

The peak growth (growth spurt) is the time of the fastest growth followed by slower growth[7]. All children will go through a growth spurt in early adolescence which is clearly visible with changes in height and weight[8]. The occurrence of growth spurt depends on sex and varies with each chronological age. This variation determines the speed and duration of the growth process. Growth spurt in women occurs at the age of 10 to 12 years, while in men aged 12 to 14 years. Pubertal growth spurt in women on average occurs at the age of 12 years, while in men at the age of 14 years[7]. Knowledge of when this growth spurt occurs can determine a person's morphological and dimensional end, namely by utilizing their growth potential and maturity[2]. This information is important to determine the right time and orthodontic treatment plan for children in order to get maximum treatment results.

Referring to the results of previous studies, it is illustrated that in general, the duration of growth spurt in men tends to take longer than women. In this study, this trend also has the same pattern, namely the duration of growth spurt in boys has a longer period when compared to girls. Based on the results of research on 93 samples of children's cephalometric photos obtained from the medical records of RSGM FKG Airlangga University, in the 2010-2020 period, sex differences had a significant effect on the age of skeletal maturity

experienced by children. In determining this evidence, steps were taken in the form of testing the effect of differences in all independent variables (Gender, CVM Stage and Sex Interaction with CVM Stage ") jointly on the dependent variable (Chronological Age in Months). Skeletal maturity was assessed based on the analysis of the Cervical Vertebrae Maturation by Bacceti by tracing the anatomy of the corpus 2, 3 and corpus 4 vertebrae on the patient's lateral cephalometric radiograph that had been collected. The cross tabulation table illustrates the proportion of the age of the children at the time of the study sample. A total of 45 boys with an age range ranging from 8 years 3 months to 16 years 2 months when the data was recorded was divided into 2 levels, namely 48.9% were at the CS 3 level, and 47.9% had reached the level of CS 4. In the sample of girls ranging in age from 8 years 2 months to 16 years 2 months, 51.1% were recorded at the CS 3 level, while 52.1% of girls were recorded at the CS 4 level.

In table 2, it can be seen that the effect of all independent variables (Gender, CVM Stage and Sex Interaction with CS Grade or "Gender * CVM Stage") together on the dependent variable (Age in Months). If Significance (Sig.) <0.05 (Alfa) = Significant. The examples above are 0.006 respectively; 0.018; 0.008 means that the model is declared valid. Effect of sex differences on chronological age (in months) in the model. If Significance (Sig.) <0.05 (Alfa) = Significant. The example above 0.005 means that the sex difference has a significant effect on the chronological age difference achieved. The effect of differences in CVM Stage on maturity in the model can be seen in the CVM Stage row. If the significance (Sig.) <0.05 (Alfa), then there is a significant difference. Data above 0.018 means that the difference in CVM Stage has a significant effect on the chronological age achieved. Furthermore, if you are going to see whether there is a difference in the influence of the interaction between the sexes who have their respective CVM stages, in determining the chronological age, then it can be seen in the Gender line * CVM Stage. In this row, a significance value (sig.) <0.05 (Alfa) is obtained, which means that there is a significant difference. This data means that there is a significant difference in chronological age, which is influenced by differences in sex with different CVM stages. The value of determination (influence) between all independent and dependent variables in the table above is at 0.882. The correlation coefficient (R) is close to number 1, meaning that there is a strong correlation between the sex difference variable and the CVM stage in determining the chronological age difference achieved.

Furthermore, in table 3 to see the extent of differences in the pattern of growth spurt duration in boys when compared to girls, it will be concluded that the difference in the increase in the mean / mean chronological age between the male and female samples (in months) at the CS 3 level towards CS 4. The male sample requires an age duration of 143.652 - 127.773 = 15.879 months. Meanwhile, for the female sample, only the duration of age was 133,880 - 128,696 = 5,184 months.

Puberty is a dynamic period of development marked by rapid changes in body size, shape, and composition, all of which are sexually dimorphic. One of the hallmarks of puberty is the adolescent growth spurt. Body compositional changes, including the regional distribution of body fat, are especially large during the pubertal transition and markedly sexually dimorphic. The hormonal regulation of the growth spurt and the alterations in body composition depend on the release of the gonadotropins, leptin, the sex-steroids, and growth hormone[11]

The growth pattern of each individual is different, one of the factors that play an important role in influencing the growth pattern is sex factor. Sex will affect growth tempo, growth time, skeletal maturity and dental maturity. The difference in puberty timing between male and female affects skeletal maturity. Female growth peak is earlier than that of male. The pattern of female skeletal growth is rapid and brief, while the pattern of male skeletal growth is slow and long[12]

During pubertal development, interactions between GH and the sex steroid hormones are striking and pervasive. Studies of adolescent boys showed that the rising concentrations of testosterone during puberty play a pivotal role in augmenting spontaneous secretion of GH and production of insulin-like

growth factor I (IGF-I). The ability of testosterone to stimulate pituitary GH secretion, however, appears to be transient and expressed only peripubertally; GH and IGF-I concentrations decrease significantly during late puberty and into adulthood, despite continued high concentrations of gonadal steroid hormones[12]. In contrast with testosterone, estrogen modulates GH secretory activity in a disparate manner; low doses of estrogen stimulate IGF-I production through enhanced GH secretion, but higher doses inhibit IGF-I production at the hepatic level[13]

Conclusions

Puberty is a dynamic period of development markedby rapid changes in body size, shape, and composition,all of which are sexually dimorphic. The growth and development characteristics of Indonesian children who were the subjects of this study also showed the same pattern. This pattern is that in boys, it has a longer duration of growth spurt compared to the group of girls. The difference in duration is quite high, so it is necessary to pay attention to chronological age when performing or deciding on procedures related to orthodontic treatment.

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