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Bone Age Estimates the Onset of the Adolescent Growth Spurt Among Male Basketball Players

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Abstract: The adolescent growth spurt is an essential phase in human growth and development. Although inaccurate, parents, teachers, and coaches commonly use chronological age to estimate the onset of the adolescent growth spurt. Compared to chronological age, the bone age method is an easy, less-invasive alternative to estimate the onset of the adolescent growth spurt. Using the bone age method, this study aimed to investigate the onset of the adolescent growth spurt among male basketball players. The subjects were 23 healthy male volunteers from under-14 (U-14) and under-16 (U-16) basketball teams. The measurements of bone age were made with anteroposterior (AP view) wrist X-rays. The U-14 subjects' bone age was seven months older than their chronological age. The subjects who were experiencing an ongoing adolescent growth spurt were 7 cm taller than the late-onset subjects were. Bone age is more effective in assessing an ongoing adolescent growth spurt than chronological age is. An early-onset adolescent growth spurt resulted in taller height than a late-onset adolescent growth spurt did.

1 INTRODUCTION

A growth spurt is a distinct phase of physical growth corresponding with dramatic increases in height. After birth, there are two phases of growth spurts: the juvenile or mid-growth spurt and the adolescent growth spurt. While the juvenile growth spurt occurs at a relatively similar age for all individuals, the adolescent growth spurt varies in timing and is difficult to estimate (Cameron 2012).

The upper part of the human body grows rapidly during the first five years of age, whereas the lower part of the body grows swiftly after entering the maturation phase towards adulthood. The maturation phase is characterized by the alteration of diet patterns, physical activity patterns, and hormonal patterns. Teenagers experiencing an ongoing adolescent growth spurt consume more food and feel hungry more easily. In addition, these teenagers are very active but less easily fatigued. All these alterations are the effects of a growth hormone (GH) surge on the epiphyseal plates, beta pancreas, and muscles (Tanner 1981; Cameron 2012).

The GH surge results from a positive feedback mechanism from the testicular male hormone. The mature testes produce the male reproductive hormone: testosterone. Testosterone then stimulates the hypothalamus and anterior pituitary gland to produce a high concentration of GH (Foss et al. 1998).

GH and testosterone surges stimulate the early phase of the adolescent growth spurt. Both GH and testosterone surges are difficult to identify using routine laboratory examination. Serial blood collection with an invasive method is needed (Perinetti & Contardo 2016). Studies have explored some less-invasive alternative methods to determine growth spurts among teenagers (Pena & Mayorga 2016; Lai et al. 2008; Soegiharto et al. 2008; Lopes et al. 2016). One of them is bone age estimation, which uses X-rays to analyze the ossification of the bones of the hand. This study aimed to analyze some characteristics of the adolescent growth spurt among male basketball players using X-rays of hand ossification.

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2 METHODS

2.1 Subjects

The subjects were 23 healthy male teenagers who were aged 13–16 years old and who were members of the basketball club CLS Knights Surabaya. The subjects were divided based on chronological age for the basketball competitions: the under-14 (U-14) team, which consisted of 13 participants, and the under-16 (U-16) team, which consisted of ten participants. All subjects, coaches, and parents were informed of the purposes and measurements of the experiments. All subjects voluntarily joined the experiment with the permission of their parents.

2.2 Examination

The subjects' bone ages were examined using anteroposterior (AP view) left wrist X-rays to evaluate the ossification of the bones of the hand. Body height (cm) was measured using an anthropometer. The bone age data was then compared with the chronological age data from the subjects' ID cards and school reports. We categorized the subjects based on bone age versus chronological age on a crosstab. There were two categories in each team: ongoing growth spurt subjects (chronological age < bone age) and late-onset growth spurt subjects (chronological age > bone age) (Cobley et al. 2009). We then compared the subjects' heights among the categories.

3 RESULTS

We found a significant difference between chronological age and bone age only for the U-14 basketball team. Bone age was estimated to be seven months older than chronological age (Table 1).

Table 1: Comparison of chronological age and bone age for the U-14 and U-16 basketball teams.

	Method	N	Mean of age (years)	Std. deviation	p
U-14 team	Chronological age	13	13.62	.51	0.022*
	Bone age	10	14.20	.63	
U-16 team	Chronological age	10	15.10	.58	0.394
	Bone age	10	14.50	1.30	

* Significant at p<0.05

Bone age showed hand ossification as the mark of an ongoing adolescent growth spurt. Bone age identification was used to distinguish the ongoing adolescent growth spurt category and the late-onset adolescent growth spurt category. Subjects who had chronological ages younger than their bone ages were categorized into the ongoing adolescent growth spurt group. Subjects who had chronological ages older than their bone ages were categorized into the late-onset adolescent growth spurt group (Table 2).

Table 2: Crosstab of adolescent growth spurt phases of the U-14 and U-16 basketball teams.

		Adolescent growth spurt		Total
		Ongoing	Late onset	
Basketball team	U-14	9	4	13
	U-16	4	6	10
Total		13	10	23

There were nine subjects in the U-14 basketball team who were categorized into the ongoing adolescent growth spurt group. The subjects in the ongoing growth spurt group had grown faster than the late-onset subjects had. The results of the height measurements confirmed that they were ±7 cm taller (Table 3).

Table 3: Comparison of height between ongoing adolescent growth spurt subjects and late-onset adolescent growth spurt subjects in the U-14 basketball team.

Adolescent growth spurt	N	Mean of height (cm)	Std. deviation	p
Ongoing subjects	9	174.00	5.97	0.03
Late-onset subjects	4	167.67	5.81	

4 DISCUSSION

Bone age can be estimated using X-ray examination of hand ossification (Lai et al. 2008). The human hand consists of 27 "puzzle" bones. It supports muscle contraction for hand movement. These bones are separated from each other by cartilage tissue on the tips. During the maturation phase, the cartilage will be replaced by hard, mineralized bone in a process known as ossification. The ossification of cartilage is stimulated by GH (Soegiharto et al. 2008).

GH stimulation is increased during the adolescent growth spurt. The pituitary gland secretes GH into the bloodstream and stimulates its receptors at periphery. This GH surge is induced by GH-releasing factor, which is released from the

hypothalamus. During the ongoing adolescent growth spurt in males, testosterone stimulates the hypothalamus constitutively to release GH-releasing factor (Foss et al. 1998).

Testosterone is the most important male reproductive hormone. This anabolic steroid hormone is produced and released from mature testicular organs. Sexual maturation is the key factor to initiate the adolescent growth spurt. Early sexual maturation initiates early onset of the adolescent growth spurt. Likewise, late sexual maturation initiates late onset of the adolescent growth spurt (Foss et al. 1998; Cameron 2012).

Early onset of the growth spurt stimulates high-speed growth at the beginning of the adolescent phase. It was beneficial for the U-14 basketball team to reach their optimal height. Additionally, it favors other physical performance aspects, for example speed, strength, and endurance (Balyi & Way 2005), which are particularly crucial in order to play basketball games competitively (Canada Basketball Association 2008). Unfortunately, this study did not evaluate the physical performance of the U-14 basketball team. Further research is needed to confirm our findings using a physical performance assessment.

Early onset of the adolescent growth spurt gave a longer period for the U-14 subjects to grow and develop than the late-onset subjects. Nevertheless, the late-onset subjects had an equal chance to reach the ideal height at the end of the growth spurt phase. The late-onset subjects accelerated in growth and development due to their shorter periods to grow (Balyi & Way 2005).

The body needs an adequate amount of nutrition, physical stimulation, and rest during the adolescent growth spurt period. Teenagers tend to get hungry more easily and tend to engage in outdoor activities with their friends. Thus, their body metabolism will be increased to cater to the needs of the rapid physical growth and to provide energy to support activities (Canada Basketball Association 2008).

Parents, teachers, and coaches should observe and anticipate this period wisely. Teenagers in the growth spurt period should be given good nutrition in the proper amounts. Each meal should be balanced, consisting not only of proteins, carbohydrates, and fats but also of vitamins and minerals. Vitamin D and calcium are involved in the ossification of bones and hence are essential micronutrients needed to support growth spurts (Tanner 1981).

5 CONCLUSIONS

Bone age is more effective than chronological age in estimating the onset of the adolescent growth spurt. Early onset of the adolescent growth spurt resulted in taller height than late onset of the adolescent growth spurt did.

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