THE EXISTENCE OF A PEAK IN ADOLESCENT'S HEIGHT INCREMENTS

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ABSTRACT

The adolescent growth spurt has been regarded as a uniquely human growth pattern. This research was to test the existence of growth spurt in urban and rural school-children from Cape Coloured (South Africa). Yearly height increments were calculated from the students that were constituted of at least four increments. A formula of the error of measurements was developed, to decide whether the curve was a significant peak or a non-significant peak. The results showed that among high socioeconomic status (HSES) Cape Coloured schoolchildren, some children had significant peaks in height increments, while others had non-significant peaks. Both urban and rural groups had individuals who experienced non-significant (low) peaks and significant (high) peaks. Only half of the HSES females experienced significant peaks. There were no significant differences between the averages of the peaks of those urban and rural Cape Coloured schoolchildren, despite the significant differences in their height averages.

Keywords: *body height, adolescent, increments, peak, longitudinal study*

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INTRODUCTION

The adolescent growth spurt has been regarded as a uniquely human growth pattern (Bogin 1988; Bogin & Smith 2000; Laird 1967). Based on this assumption scientists developed the growth-fitting curve (e.g., Gasser et al. 1990; Largo et al. 1978; Preece-Baines 1978), growth references and height velocity standards (e.g., Cole 1988; Cole 1990; Gasser et al. 1990; Karlberg 1987; Preece-Baines 1978; Tanner and Whitehouse 1976; Tanner et al. 1966), believing that the growth spurt was present in every normal-healthy human population. A child who has a low velocity throughout puberty would be considered pathological (Eveleth & Tanner, 1990:10). The aim of this research was to test the existence of growth spurt in urban and rural school-children from Cape Coloured (South Africa). Yearly height increments were calculated from the students that were constituted of at least four increments.

MATERIAL AND METHODS

The characteristics of the Cape Coloured have been described in previous articles of Henneberg & Louw (1998), and Henneberg et al. (1998, 2001). The schoolchildren were measured more than once, and the yearly height increments were calculated. Thus, children who were measured six times would have a set of five increments. In females, the peak of the height increments (the largest growth spurt) was determined using the greatest increment, after taking into account the age of menarche of the girl. In males, the peak of the height increments was based on the highest point of the curve, after adjusting the approximate age of puberty. In males the increasing growth rate usually begins at about two years older than in females (Bogin & Smith, 2000; Johnston 1998), and females are always ahead in reaching maturity (Tanner 1978).

The age of the greatest height increment was set as zero on the x-axis; the previous increment is –1, and the increment after the highest point is +1. This removed the effect of age of puberty. A formula of the error of measurements was developed, to decide whether the curve was a significant peak or a non-significant peak.

E_X = error of measurement

$$E_{(X_t - X_{t-1})} = \sqrt{2.E_x{}^2}$$

E height velocity $= \sqrt{2.E^2{}_{height}}$

From Table 1 in Henneberg & Louw (1998):

$$CV_{error} = \frac{E_x}{X_{10}}$$

$$CV\ E_{height} = 0.6\%$$

The average of 10 year old children, that falls roughly in the middle of other averages, was used for the following equation (Henneberg & Louw, 1998). Therefore:

$$CV_{height} = \frac{E_{height}}{X_{10}}.100$$

$$E_{height} = \frac{CV_{height}.X_{10}}{100}$$

Because E height velocity $= \sqrt{2.(E^2_{height})}$

Then, E height velocity $= \sqrt{2(\frac{CV_{height}.X_{10}}{100})^2}$

Confidence interval of velocity = (1.645 * E $_{velocity}$) ± velocity

RESULTS AND DISCUSSION

Although it had long been believed that the growth spurt always occurred in 'normal growing children' who had good living conditions and health services, the evidence does not seem to support this. Among high socioeconomic status (HSES) Cape Coloured schoolchildren, some had a significant peak in height increments, while others had non-significant peaks. As shown in Table 1, only 23% of males (n=70) and 54% of females (n=26) experienced a significant growth spurt.

Table 1. The number of significant and non-significant spurt in Cape Coloured schoolchildren

	Urban Cape		Rural Cape	
	Male	Female	Male	Female
Significant spurt	16	14	24	36
Uncertain	52		53	
No significant spurt	2	12	14	22
Total	70	26	91	58

Table 2. The averages of height increments (mm/year) of urban Cape Coloured males' longitudinal data

Year(s) from the peak	Average	Maximum	Minimum	St Dev	n
–3	54.35	62.18	46.51	11.08	2
–2	54.00	71.10	35.55	9.42	13
–1	44.82	73.43	9.12	17.35	18
0	82.96	117.02	48.23	21.87	18
1	50.76	73.96	31.23	14.24	16
2	33.50	53.00	23.00	12.13	5
3	59.78				1

Note: Zero (0) is the year when the peak of height velocities occurred

Standard scientific approach tends to sum up data into variance, median, mean, etc., while any population may have a range of individuals' variations (Johnston 1998). Figures 1 to 4 show the variation in growth spurts in Cape Coloured schoolchildren. The range of peaks for urban males is shown in Figure 1. The peak ranges from 63.92 mm/year to 117.61 mm/year (Table 2). The range of peaks for rural Cape Coloured males is shown in Figure 2. Figure 1 and figure 2 show that the ranges of the peaks for urban and rural Cape Coloured males greatly overlap. The PHV in rural males ranged from 49.12 mm to 130.87 mm. The highest PHV matched the highest in the range in the Third Harvard Growth Study (Johnston 1998). Tanner (1978), referring to European males, said that the height of most males increases around 70 to 120 mm at the PHV. Figure 3 and figure 4 depict the ranges of peaks for urban and rural Cape Coloured females. When the averages of peaks of urban and rural Cape Coloured are put together in one diagram, the two peaks are close to each other (Figure 5 and Figure 6). The averages of the increments for urban and rural males, when aligned at the peaks, are illustrated in Tables 2 and 3 respectively. Differences between the averages, compared using a *t*-test, were not significant (*t*= -0.35, *p*=0.73).

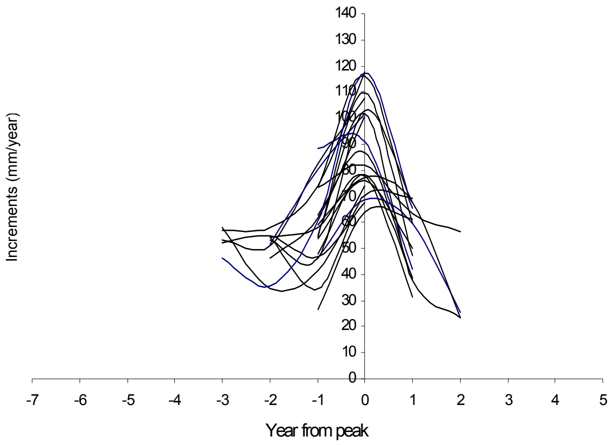

Figure 1. Height increments of urban Cape Coloured males derived from longitudinal data. Zero (0) is the year when the peak of height velocities occurred. The variety of colours represents variety of individuals.

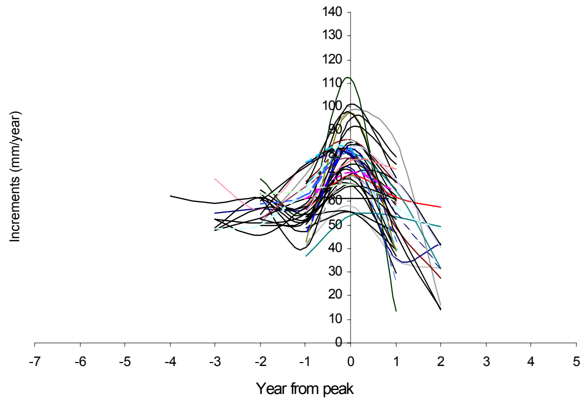

Figure 3. Height increments of urban Cape Coloured females derived from longitudinal data. Zero (0) is the year when the peak of height velocities occurred. The variety of colours represents variety of individuals.

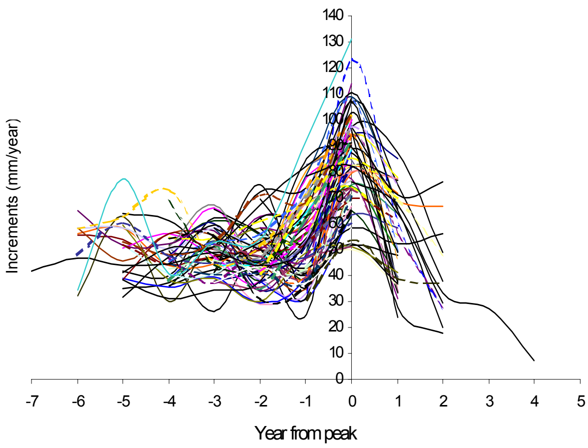

Figure 2. Height increments of rural Cape Coloured males derived from longitudinal data. Zero (0) is the year when the peak of height velocities occurred. The variety of colours represents variety of individuals.

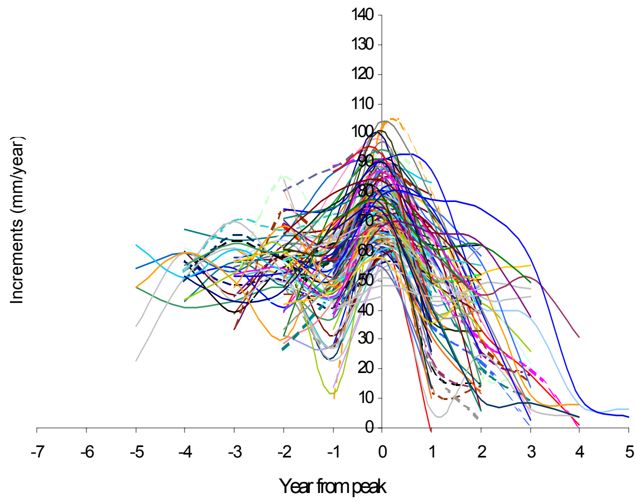

Figure 4. Height increments of rural Cape Coloured females derived from longitudinal data. Zero (0) is the year when the peak of height velocities occurred. The variety of colours represents variety of individuals.

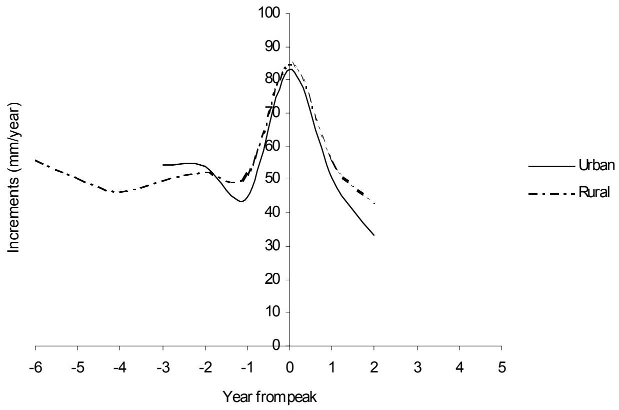

Figure 5. The averages of height increments of urban and rural Cape Coloured males. Zero (0) is the year when the peak of height velocities occurred

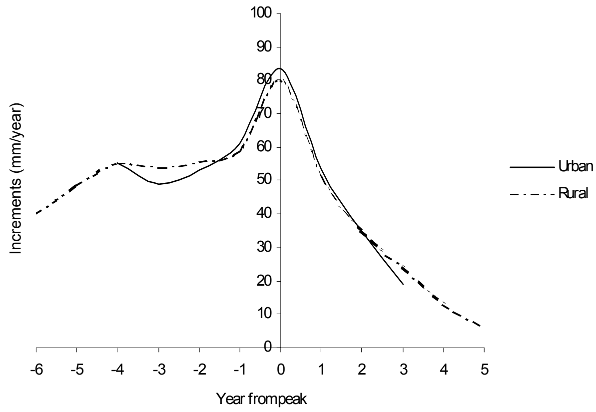

Figure 6. The averages of height increments of urban and rural Cape Coloured females. Zero (0) is the year when the peak of height velocities occurred

Table 3. The averages of height increments (mm/year) of rural Cape Coloured males' longitudinal data

Year(s) from the peak	Average	Maximum	Minimum	St Dev	n
-6	56.24				1
-5	50.64	59.30	40.93	7.89	6
-4	46.37	62.99	35.40	8.00	13
-3	49.60	74.02	25.95	10.51	23
-2	52.39	75.08	30.00	10.61	32
-1	51.66	82.64	-4.00	17.58	37
0	84.92	123.26	49.12	18.99	38
1	55.22	87.09	22.49	17.67	36
2	43.16	76.37	19.89	19.80	9

Note: Zero (0) is the year when the peak of height velocities occurred

The averages of the peaks for urban and rural Cape Coloured females were also compared (Tables 4 and 5), and there was no significant difference (t= 0.84, p=0.41). Although the height averages for rural Cape Coloured schoolchildren were well below those of their urban counterparts (Hennebreg & Louw 1998), the height increments themselves were practically the same in both males and females.

Table 4. The averages of height increments (mm/year) of urban Cape Coloured females' longitudinal data

Year(s) from the peak	Average	Maximum	Minimum	St Dev	n
-4	55.11	62.39	50.95	6.33	3
-3	48.83	76.95	0.00	19.55	11
-2	53.35	69.61	0.00	14.04	24
-1	61.14	91.61	33.73	11.47	25
0	83.60	111.89	61.16	13.07	26
1	53.43	88.42	13.29	19.96	20
2	35.10	64.10	13.89	18.35	8
3	18.85	24.50	13.20	7.99	2

Note: Zero (0) is the year when the peak of height velocities occurred

For urban Cape Coloured females the range of the peak height increments was 61.16 mm to 111.89 mm (Table 4), and for rural Cape Coloured females it was 54.26 mm to 126.54 mm (Table 5). According to Tanner (1978) most European girls gained around 60 to 110 mm/year during their PHV. The greatest peak height increment among Cape Coloured females (111.89 mm – 126.54 mm) matched the greatest peak height increment in the Third Harvard Growth Study (Johnston 1998).

Table 5. The averages of height increments (mm/year) of rural Cape Coloured females' longitudinal data

Year(s) from the peak	Average	Maximum	Minimum	St Dev	n
-6	39.88				1
-5	48.72	53.99	42.78	4.60	4
-4	55.44	104.03	26.35	18.12	12
-3	54.01	78.93	34.18	9.96	22
-2	55.88	80.69	26.65	13.06	45
-1	59.07	88.51	28.11	12.72	55
0	80.23	126.54	54.26	14.38	58
1	51.24	87.60	-1.89	19.07	52
2	34.91	68.19	2.84	19.30	35
3	24.15	68.44	2.84	18.98	17
4	12.91	30.75	0.94	12.57	6
5	6.13				1

Note: Zero (0) is the year when the peak of height velocities occurred

Rural Cape Coloured schoolchildren clearly had a very different SES background and were less fortunate in their environment than their urban counterparts. However, their growth rate increments matched those of the urban schoolchildren. It is suggested that growth rate variations of children under certain nutritional circumstances are also genetically influenced (Ulijaszek 1998). Figures 7 and 8 show the averages of urban and rural Cape Coloured males and females who did not have a significant peak and those who did. This reveals the biggest difference between the two groups. The largest increment among the urban Cape Coloured males who had a significant peak was similar to the greatest growth peak found in studies of Western children; e.g., the Third Harvard Growth Study in Boston (Johnston 1998), and Montbeillard's son (Tanner 1978).

The average of the greatest increment among Cape Coloured males who had a significant peak (Figure 7) was significantly different from the average for those who did not experience a significant peak (t=4.41, p=0.00). Similarly, the significant peak for Cape Coloured females (Figure 8) also differed significantly from the non-significant peak (t=5.93, p=0.00). Therefore it can be concluded that the biggest difference in the patterns of increments among Cape Coloured schoolchildren was between children who had a peak and those who did not, and not between urban and rural samples. The next thing to investigate is whether children who do not have a peak are as "normal" as children who have a peak. Henneberg et al. (1998) found that small children from affluent groups were as "normal" as others who were taller. It is suspected, therefore, that children who have a non-significant peak in height increments are as normal as others who have a peak. When a population has more children who have a significant peak in growth increments, the average of the peak will be high. Most modern growth references, such as those from United States and Britain, have a high peak of increments. When a population has more children who do not experience a significant peak, the average peak will be lower than the growth reference.

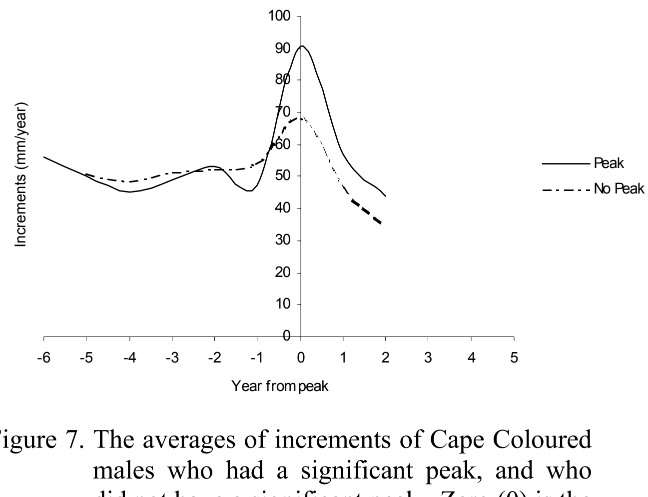

Figure 7. The averages of increments of Cape Coloured males who had a significant peak, and who did not have a significant peak. Zero (0) is the year when the peak of height velocities occurred

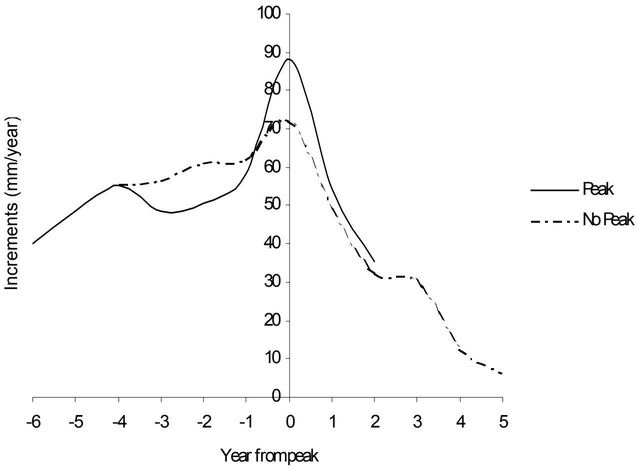

Figure 8. The averages of increments of Cape Coloured females who had a significant peak, and who did not have a significant peak. Zero (0) is the year when the peak of height velocities occurred

CONCLUSION

There are several important points to be made from the results above. First, the peak of height increments was irregularly found in the groups of Cape Coloured schoolchildren. Only half of the high socioeconomic status females experienced significant peaks. Second, the peaks ranged from the lowest-non significant to the highest (significant) peak. Both urban and rural groups had individuals who experienced non-significant low peaks and significant high peaks. Finally, the averages of the peaks showed that there were no significant differences between urban and rural Cape Coloured schoolchildren. A similar finding was noted among rural children in Hyderabad (Satyanarayana et al. 1989) who were undernourished from neonate to 5 years, but during puberty they attained a total height gain similar to that of children who had an adequate diet. The increments of height around puberty for urban and rural schoolchildren were similar despite the significant differences in the height averages. The results presented in this chapter agree with previous studies which concluded that the tempo and rate of growth are strongly genetically controlled (Wilson 1976).

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