PUBERTAL DEVELOPMENT IN URBAN XHOSA SCHOOLGIRLS

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Submitted in part fulfilment of the requirements for the Master of Medicine degree (Part III) in Obstetrics and Gynaecology at the University of Cape Town

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DECLARATION

I, Damian Douglas Christopher Largier, hereby declare that the work on which this thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other University.

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Date

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CHAPTER 1
INTRODUCTION

Growth and development during the pre-teen and teenage years comprises two closely related phenomena: puberty, or the process of physical growth and development and adolescence, or the process of cognitive and psychosocial development (Stevens-Simon 1993). Knowledge of the usual sequence and timing of these events is essential to distinguish normal developmental processes from pathological conditions.

Over the last century children have tended to pass through puberty at an increasingly earlier age. General health and socio-economic/nutritional status are regarded as the principal factors in the timing of growth and sexual maturity (Brook, 1982). The average age at menarche in Europe in 1840 was 16.5 years and has reduced at a rate of 3-4 months per decade to its present level of 12.8 years (Rees 1993). This trend has halted in recent times and a report from Warwick University, UK has reported a slight increase in the age of menarche over the last 16 years (Dann 1993). The mean age of menarche among girls in the United States of America has remained unchanged since around 1940 (Hamill 1979) with a mean of 12.8 years and a range of 10 to 16 years (Wheeler 1991). In recent European studies the age at menarche of young girls is reported to be 12.5 years in Germany (Beller et al 1991) and 13.4 years in Switzerland (Sizonenko 1987).

Heredity is also a powerful determinant of the age of menarche as demonstrated in mother-daughter pairs (Tanner,1962), but in large study groups this factor would be eliminated. Strenuous physical activity may delay the onset of puberty as will extreme obesity or weight loss. Moderate obesity is thought to be associated with an earlier menarche (Styne 1993).

The influence of socio-economic factors and nutritional deprivation is demonstrated in extreme circumstances in studies involving Spanish Loyalist girls interned in France (Zimmer et al 1944) and Dutch children interned in the

East Indies (Netherlands Red Cross Feeding Team 1948) both of whom found a delay in the onset of menarche of approximately two years compared with similar children in the home countries.

While studies in girls of the age at menarche are frequent due to the ease with which this information can be obtained and recorded, reliance on personal recall by girls for the age at which their menarche occurred is notoriously inaccurate. Numerous studies have been performed to record the age at menarche in South Africa (Table 1).

Table 1. Age at Menarche Recorded in Studies of South African Populations

Age at Menarche	Year	Race Group	Author/s
13.56	1953	South African Indian	Kark
14.75	1956	Bantu	Oettle et al
14.60	1960	White	Benjamin
15.00	1961	Bantu (Rural)	Burrell et al
13.20	1970	Coloured	Margolis
14.75	1971	Bantu	Frere
13.90	1989	Black and White (Jhb)	Chaning-Pearce and Solomon
14.63	1990	Black (rural)	Cameron et al
13.20	1990	Black (urban - 'well off')	Cameron et al

The trend to an earlier menarche in more recent studies is evident in the South African studies in the above table. An interesting observation made by Cameron et al (1991) is that the age of menarche fell by an average of 0.73 years and 0.34 years per decade in South African urban and rural groups respectively between the years of 1940 and 1989. It is important when comparing studies to take note of the population group studied and whether the sample is of urban or rural origin. Earlier studies reported populations as being either 'Bantu' or 'Black' and have not specified which race groups within the Black community were represented, or in what proportion they were sampled. The figures from Benjamin's study may be misleading as they are taken from a group of menopausal women who were asked to remember their date of menarche and the age thus reflects the status of White women forty years prior to the study date. The studies of Oettle, Frere and Benjamin are all hospital based and thus are not truly representative of the general population. The remainder of the authors mentioned above performed community-based work either using schools or home visits. Burrell's study, performed in 1961, was particularly interesting in that he obtained a 92% return of a questionnaire to 50 000 Transkei schoolgirls. This is the largest study of its type in Southern Africa.

The mean age at menarche for women from other African countries are listed in Table 2. Studies done in the 1980s recorded an age of menarche two to three years younger than those performed 20 years earlier. The only exception is the study by Burgess and Burgess (1964) in Uganda who studied upper class schoolgirls ten miles north of the capital city, Kampala. The authors admit that many of the girls' fathers were in professional occupations and 'food was always plentiful' and they were therefore studying a particularly prosperous subgroup of African children.

Table 2: Age of Menarche in Studies of Girls from African Countries

Age at Menarche	Year of Study	Study Population	Authors
Nigeria			
14.1	1962	Priviledged Rural	Tanner and O'Keefe
14.5	1976	Rural	Oduntan et al
13.3	1976	Urban	Oduntan et al
13.8	1976	Urban	Oduntan et al
13.2	1979	Enugu	Ucha and Okorafor
Zaire			
13.2	1988	Urban well off	Kolasa et al
14.7	1988	Urban poor	Kolasa et al
Rwanda			
16.5	1963	Tutsi	Heintz
17.0	1963	Hutu	Heintz
Uganda			
13.4	1964	Rural Upper Class	Burgess and Burgess
Somalia			
13.1	1980	Urban	Gallo and Mestriner

Fewer studies have documented the time of onset of pubertal changes that occur in the breasts, pubic hair and axillary hair. Tanner (1962) originally prospectively described the progress through puberty and divided development into specific identifiable stages (Table 3).

This first study was performed on institutionalised British schoolgirls in the late 1960s (Marshall and Tanner 1969). It was longitudinal in design and accurately dated the pubertal changes that occur in height, weight, breasts and pubic hair in relation to each other. Marshall and Tanner's study has become the 'gold standard' with subsequent studies confirming this interrelationship which appears to be consistent. Development occurs in a fixed sequence regardless of the age at which puberty commences (Qamra 1991, Cameron 1993). The various Tanner stages for pubertal development in females are summarised in

Table 3. Menarche is variable but usually occurs late in breast stage III and vaginal bleeding in the absence of any breast development is regarded as pathological.

Table 3: Stages of puberty in Women (according to Tanner)

Tanner Stage	Breast	Pubic Hair	Axillary Hair
I	Pre adolescent : elevation of papilla only	Pre adolescent: vellus over pubes is no more developed than anterior abdominal wall	Pre adolescent: hair no more developed than on the chest
II	Breast bud stage: elevation of breast and papilla as a small mound	Sparse growth of long, slightly pigmented downy hair	Sparse growth of fine hair
III	Further enlargement of breast and areola	Considerably darker coarser and more curled.	Adult in quantity and type
IV	Projection of areola and papilla to form a secondary mound above the breast	Hair is adult type but area covered is smaller than most adults	
V	Mature stage: Projection of the papilla only due to recession of the areola	Adult in quantity and type with spread to the medial aspect of the thighs	

Adapted from Marshall and Tanner 1969

The present study was performed in order to update available data on puberty in South African women gathered from studies among a variety of South African population groups and to compare our findings with these previous studies in order to identify any change. In addition, the children's social environment was evaluated to see if it had any influence on the timing of puberty. This study is important because a decrease in the age of onset of the various stages of puberty would be expected as the socio-economic status of the population increases. We would expect that once socio-economic and therefore nutritional

equality between different communities exists, there would be little difference between the age at which children attain puberty. An absence in the trend toward a younger onset of puberty would be a cause for concern as this would imply that there has been no improvement in living conditions from the time of the original study. A relationship has also been shown to exist between an earlier age at menarche and an increased risk of breast cancer (Pike 1983), an increased risk of coronary heart disease (Colditz 1987), shorter adult height (Shangold 1989), earlier initiation of sexual activity (Soefer 1985), earlier first pregnancy, (Sandler 1984) and larger family size (Frisch 1978).

This implies that as the age at which children pass through puberty decreases, it becomes increasingly important to introduce both sexual education and the availability of contraception at a correspondingly earlier age in order to avoid the tragedies of teenage pregnancies.

CHAPTER 2
METHODS

Pupils from schools in the Cape Town and Port Elizabeth urban environs were invited to participate in the study. Three schools from New Brighton, Port Elizabeth, two from Langa, Cape Town and Black pupils from a private fee paying school in Wynberg, Cape Town were included in the study. All the girls were Xhosa which is the dominant Black race group in the two areas. New Brighton is a suburb belonging to the municipality of Ebayi a short distance outside of Port Elizabeth and consists mainly of children from lower income families. Langa is the nearest suburb to Cape Town centre with a predominantly Black population. It is well established with sub-economic houses that are built of bricks and thus property has become relatively expensive. The parents of girls at the private school were mainly of upper socio-economic status.

1. Consent

Consent to access the schools was obtained from the Department of Education and Training (the local education authority) as well as from the principal of each school. Consent forms which had been translated into Xhosa were distributed to all the girls in the class to take home to their parent or guardian and only those with signed consent were admitted to the study. The schoolgirls gave verbal consent and the few that objected to being examined were not included in the study. The protocol was approved by the Ethics Committee of the University of Cape Town.

2. Questionnaire

A questionnaire was sent with the consent form to the parent/guardian of each schoolgirl between the ages of 8 and 18 years. This was in Xhosa, their mother tongue, and consisted of a short explanation of the purpose of the study and a few questions pertaining to the pupil's social circumstances.

The questionnaire requested the following information:

1. Pupil's date of birth
2. Father's highest educational attainment and occupation
3. Mother's highest educational attainment and occupation
4. The childminder (i.e. the person who cared for the pupil after school hours)
5. Number of siblings
6. School standard

A copy of the questionnaire and consent form has been included as Appendix 1.

3. Clinical Assessment

The pupils were examined in an enclosed converted classroom. They had their weight and height recorded by a research sister before being examined by one of four registered gynaecologists involved with the project. Examination involved measuring skinfold thickness at the biceps and subscapular positions as well as recording the Tanner stage of the breasts, pubic and axillary hair development. The skinfold thickness measurements were only performed in girls in New Brighton because a preliminary analysis demonstrated good correlation between this and the body mass index. In Cape Town only the latter parameter was recorded. A teacher who spoke Xhosa was always in the room to reassure the children should it be necessary. The teacher also asked every pupil whether she had experienced menarche and, if so, the year and month of its occurrence.

4. Body Mass Index

The body mass index (BMI) of each child was calculated by dividing the weight (in kilograms) by the square of the height (in metres). The normal adult range is 19 to 25 kg/m^2.

5. Social Class

Assessment of social status of the children was performed. By convention, the pupils were classified according to father's occupation first and only if the mother were a single parent was her occupation used. The social classification used was that devised by Sclemmer and Stopforth (1979) from the Centre for Applied Social Sciences (CASS) of the University of Natal specifically to include occupations peculiar to South Africa.

Table 4: Description of Social Classes

Social Class	Description	Example
I	Professional	Judges, Doctors
II	Semi professional	Teachers, Nurses
III N	Skilled non manual	Clerks
III M	Skilled manual	Plumbers, Taxi drivers
IV	Semi skilled manual	Assembly line workers
V	Unskilled manual	Building labourers

Other methods of assessing the children's environment include child minder (the person who cared for the child outside school hours), the number of siblings and academic performance. The academic performance (or age for standard) was calculated by subtracting the pupil's grade (Sub A = 1 and Matric = 12) from the pupil's age. A pupil would be expected to start school age 6 or 7 and have an age for standard of less than seven if she had not been kept back at any stage.

6. Statistical Analysis

Biostatistical analysis was performed by the Medical Research Council in Cape Town. The data was analysed using the General Linear Models Procedure (Cary, 1989) applying the Wilcoxin two sample test to continuous data and the Kruskal Wallace test to three or more non-parametric values. Gabriel's test provided an analysis of variance indicating between which values there was significance (at $p = 0.05$).

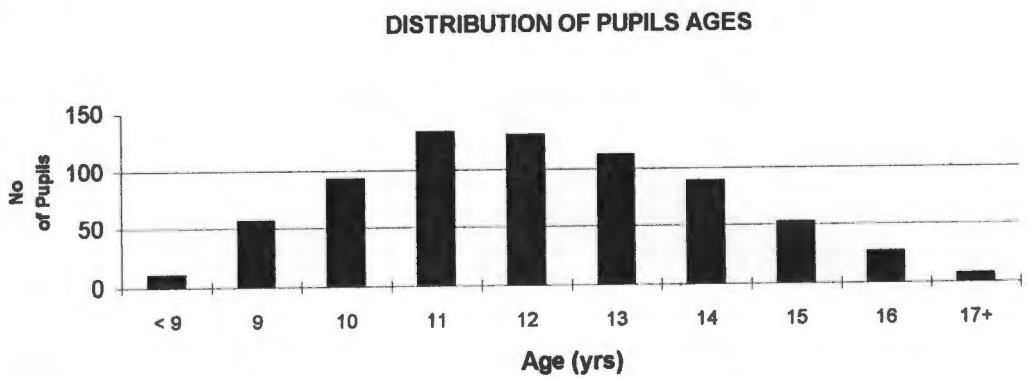
CHAPTER 3

RESULTS

A. Physical Parameters

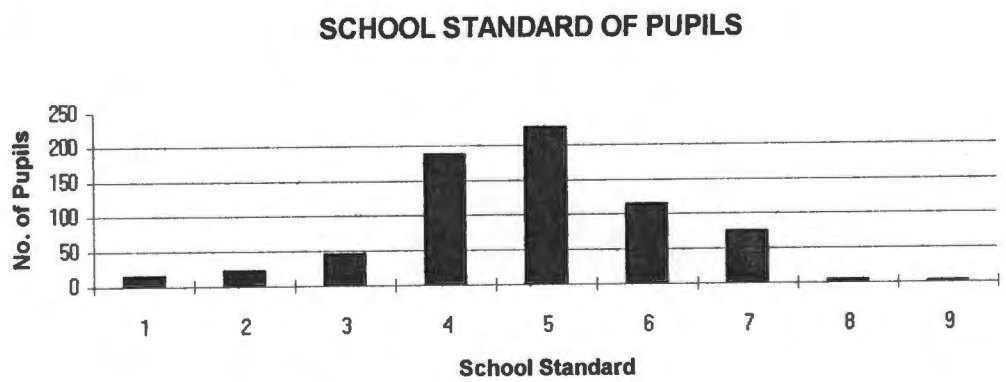
709 children were examined in total. 483 in the Council of Ebayi, just outside of Port Elizabeth and the remaining 226 in Cape Town. The age distribution of the children is illustrated in Figure 1.

Figure 1



The distribution of the girls in the various academic years at school is demonstrated in Figure 2.

Figure 2

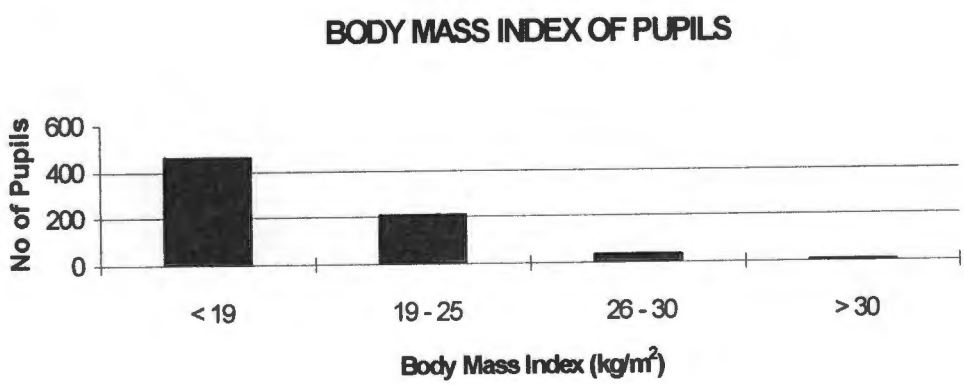


Most of the girls were aged 11 to 14 (standards 4 to 7), the most common ages to find children going through the stages of puberty in Tanner's 1969 study. The median age was 12.5 years. This is approximately one year before the mean age of menarche and close to the mean age of breast Tanner stage III in the original study.

1. Body Mass Index

The majority (459 schoolchildren) had BMIs below 19 kg/m^2 and the mean BMI was 18.3 kg/m^2 (see Figure 3). The body mass index was found to increase with the pupil's age as well as with the advancement of all three aspects of pubertal development (breast, pubic hair and axillary hair development). Body mass index did not correlate well with reported age at menarche ($p = 0.1777$). This was expected as menarche was determined retrospectively and the BMI was not known at the time menarche occurred. There was good correlation between skinfold thickness (of both subscapular and triceps areas) and the BMI ($p = 0.0001$) in the girls from Port Elizabeth and it was therefore decided not to continue measuring this parameter in the Cape Town girls.

Figure 3



Height correlated best of all the physical indices to age at menarche ($p = 0.0674$) and this confirms the finding that peak height velocity precedes menarche (Tanner 1969, Marshall 1981).

Figure 4

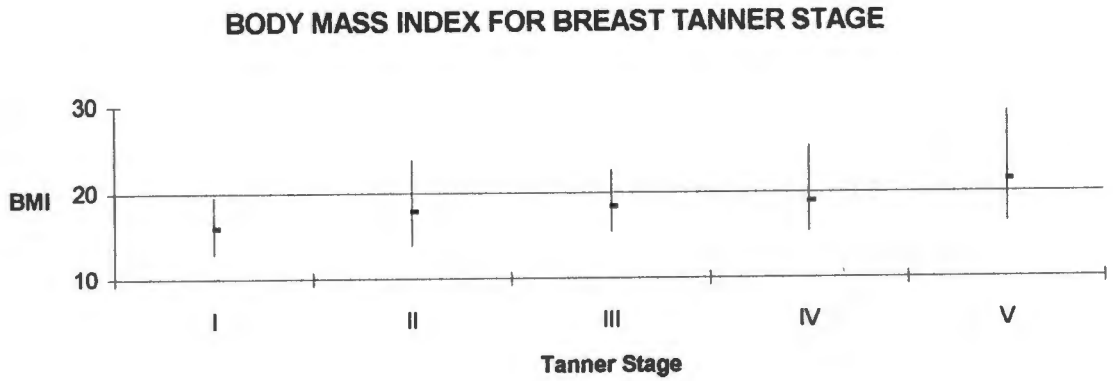
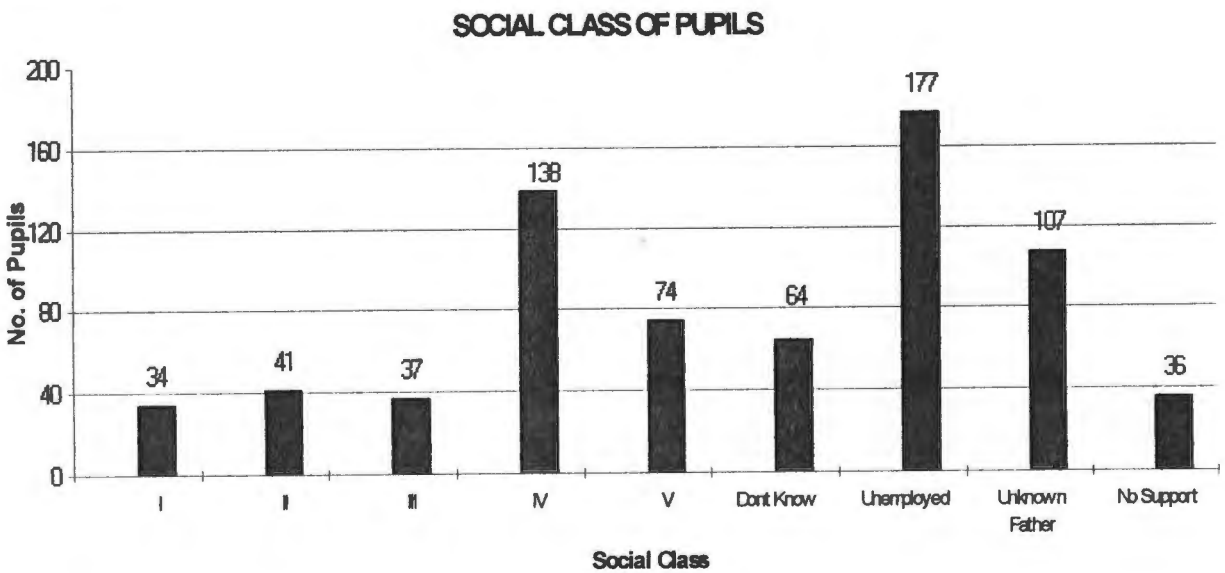


Figure 4 shows the mean BMI (with the 5th and 95th centiles) of girls at various stages of breast development. There is a steady increase in the body mass index with advancing breast development. The mean BMI of prepubertal and pubertal girls is below 20 kg/m^2 and only reaches the normal adult level with sexual maturity.

2. Social Class

The assessment of social status of the children is shown in figure 5.

Figure 5.



The majority of the children came from social class IV and V. A high proportion of the pupil's parents were unemployed (n= 177) and thus could not be classified. In 64 cases the parent's employment was unknown and was not completed in the questionnaire. Thirty six children had a father who was employed and separated from the child's mother but did not supply any financial assistance to the family. In 107 cases the father's whereabouts was unknown and the mother did not work. Although attempts were made to obtain a broad cross section of social classes, it proved difficult to recruit more girls from upper class families. Black South African schoolgirls are generally from the lower social classes and although private schools with a non-racial mixture of pupils were approached the number of Black schoolgirls present at these schools were insufficient to make up for the lack of numbers in the upper social classes.

3. Menarche

The mean age at menarche for urban Xhosa schoolgirls in the 171 post menarchal girls sampled was 13.67 years (2SD 11.25 yrs - 16.09 yrs). Clinically it may be more appropriate to view the normal age at menarche using the cumulative percentage of girls that have experienced menarche at a particular age (Table 5).

Table 5

PERCENT POSTMENARCHAL SCHOOLGIRLS BY AGE

Age (yrs)	%
<11	1.8
11 - <12	6.4
12 - <13	32.2
13 - <14	64.3
14 - <15	84.4
15 - <16	96.5
16+	100

4. Breast Development

The median age for each breast stage is seen in Table 6. As expected there is an increase in mean age with each stage of breast development but also a large degree of overlap between the various stages. A child aged 11 years could have breast stage I or stage IV and still be within the normal limits of pubertal development in the population studied.

Table 6

MEDIAN AGE FOR TANNER BREAST STAGE

	Age (yrs)		
Stage	-2SD	MEDIAN	+2SD
1	8.4	10.7	13
2	9.18	11.6	14.02
3	10.06	12.7	15.34
4	10.82	13.6	16.38
5	11.92	14.6	17.28

Tanner stages I and V are open-ended data in that they represent the prepubertal and the mature states respectively. As the study was cross-sectional in design the average age in these stages has no bearing on the age at which the children pass through puberty and therefore cannot be used to compare data.

As with menarche, clinically it is more useful to express breast development in terms of the cumulative percentage of the number of girls that have reached a certain stage in breast development in each age-group (Table 7).

Table 7

PERCENT GIRLS IN EACH BREAST TANNER STAGE BY AGE

Age (yrs)	Tanner Stage			
	II - V	III - V	IV - V	V
< 11	39.62	8.18	1.89	0
11 - < 12	71.43	33.08	15.53	3.01
12 - < 13	83.08	53.08	23.85	7.69
13 - < 14	95.54	80.36	58.39	27.68
14 - < 15	100	95.51	82.02	52.81
15 - < 16	100	100	84.54	67.31
16 +	100	100	100	75.76

From this it can be deduced that in this sample at age 13 - 14 years 95% of girls had started developing pubertal breast changes and 27% had adult breasts (Stage V).

5. Pubic Hair

The median age for each Tanner stage of pubic hair development is shown in table 8 .Mean pubic hair development and breast development followed each other very closely with not more than two months separating them at any particular stage.

Table 8

MEDIAN AGE PUBIC HAIR TANNER STAGE

Stage	Age (yrs)		
	- 2SD	MEDIAN	+2SD
I	9.57	10.75	11.93
II	10.15	11.44	12.73
III	11.34	12.71	14.08
IV	12.09	13.59	15.09
V	13.54	14.74	15.94

When comparing the cumulative percentage of girls in our study that have arrived at a certain Tanner pubic hair stage for age, with similar data from the Tanner breast staging, again there is a strong similarity and both breast and pubic hair stages appear to progress simultaneously. This is interesting as the only discrepancy was at the initiation of puberty, breast stage II is appears to be reached slightly later than pubic hair stage II (Table 9).

Table 9

PERCENT GIRLS IN EACH PUBIC HAIR TANNER STAGE BY AGE

Age (yrs)	Tanner Stage II - V	III - V	IV - V	V
< 11	49.69	8.81	2.52	0
11 - <12	75.17	38.35	14.29	2.26
12 - <13	87.69	55.38	26.15	5.38
13 - <14	95.45	82.14	56.25	22.32
14 - <15	100	94.38	77.53	47.19
15 - <16	100	98.08	84.64	63.46
16 +	100	100	96.97	66.67

6. Axillary Hair

There are three stages of development of axillary hair and as stages I and III are open ended, only stage II can be used for comparison. The mean age for the start of axillary hair changes is 12.2 years or approximately one year prior to the menarche. Table 10 gives the median values for each stage.

Table 10

MEDIAN AGE AXILLARY HAIR TANNER STAGE

Tanner Stage	-2SD	MEDIAN	+2SD
I	9.61	10.87	12.13
II	10.6	12.21	13.82
III	12.36	13.93	15.5

When compared to breast and pubic hair development the onset of stage II axillary hair is at a similar age (approximately 95% of children have entered

puberty by age 13 years). Mature axillary hair (stage III) however occurs approximately one year earlier than mature pubic hair or mature breasts (Table 11).

Table 11

PERCENT GIRLS IN EACH AXILLARY HAIR TANNER STAGE BY AGE

Age (yrs)	Tanner Stage	
	II - III	III
<11	40.25	3.77
11 - <12	74.44	24.06
12 - <13	81.54	30.77
13 - <14	92.86	53.57
14 - <15	97.75	74.16
15 - <16	100	78.85
16 +	100	87.88

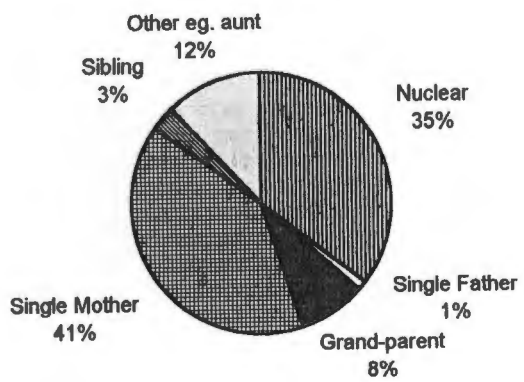
B. Social Parameters

1. Child minder

It is interesting to note the family structure of urban Xhosa schoolchildren (Figure 6). Only 35% of the girls lived in a nuclear family with both parents. Forty four percent had a single parent family (mainly a single mother) and most of the remainder were in the care of other family members such as grandparents and older siblings.

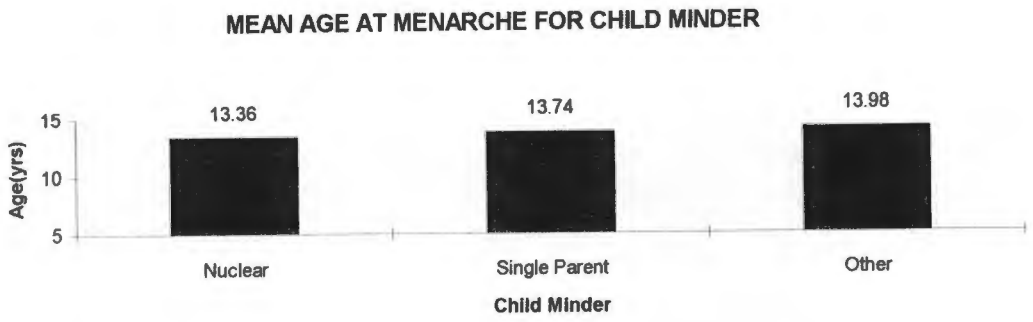
Figure 6

CHILD MINDERS OF PUPILS



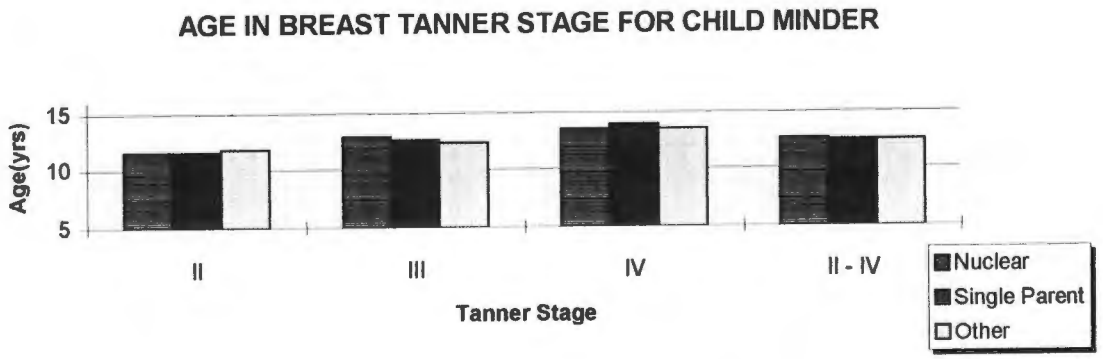
When comparing the mean age of menarche between children from nuclear and single parent families a significant difference between the groups is not demonstrated (Kruskal Wallace test; p = 0.1099). This is shown graphically in figure 7.

Figure 7



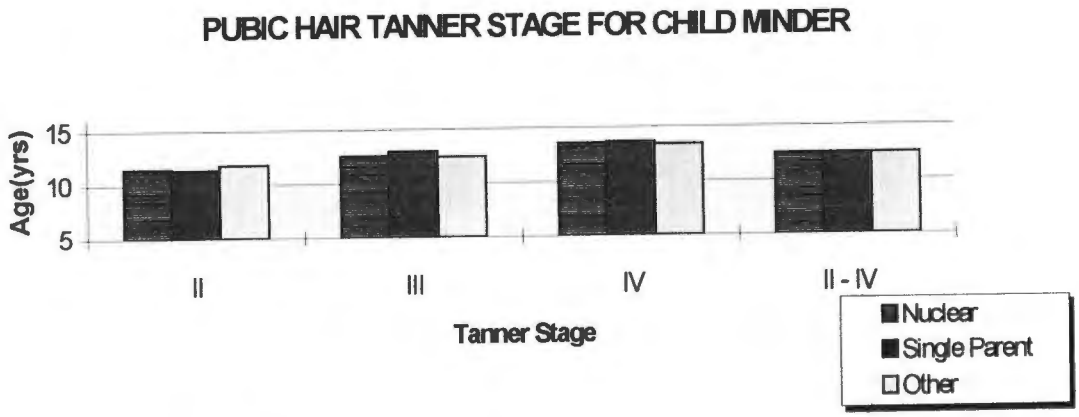
A similar trend is seen in the comparison between nuclear and single parent families with regard to the age the children pass through the various stages of breast and pubic hair development (figures 8 and 9). The children from the nuclear families appear to pass through puberty marginally earlier but the difference is not statistically significant. (Breast development: Kruskal Wallace test; p = 0.9497 and pubic hair development: Kruskal Wallace test; p = 0.9483)

Figure 8



	Stage II	Stage III	Stage IV	Stages II-IV
Nuclear	11.53	12.88	13.52	12.56
Single Parent	11.59	12.57	13.91	12.51
Other	11.78	12.39	13.51	12.51

Figure 9

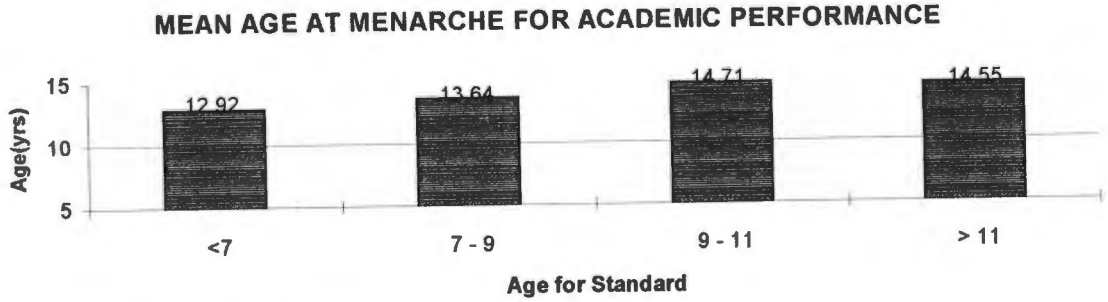


	Stage II	Stage III	Stage IV	Stages II-IV
Nuclear	11.45	12.61	13.60	12.50
Single Parent	11.31	12.90	13.70	12.40
Other	11.81	12.50	13.40	12.50

2. Academic Performance

The mean age of menarche was compared between groups of schoolgirls who were in an appropriate school standard for their age (age for standard <7) and those who had been kept back for more than one year (age for standard >7).. The age of menarche (figure 10) is significantly earlier in schoolgirls of the appropriate age for their school class when compared to their older classmates (Gabriels test; Alpha = 0.05, Confidence = 0.95).

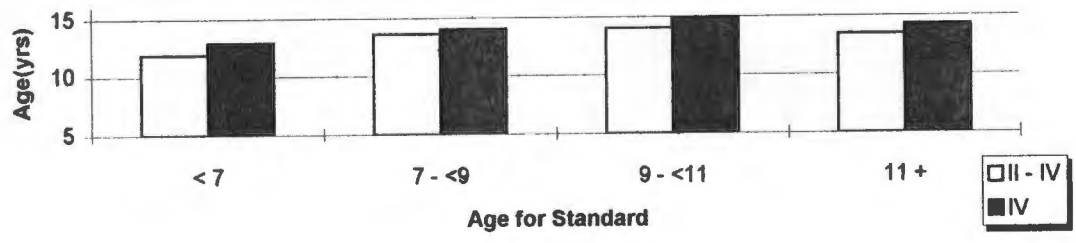
Figure 10



When comparing the average ages of breast changes through puberty (stages II - IV combined) a similar difference is seen between girls of appropriate age for their class and those behind academically. As with menarchal age, this difference is statistically significant (Gabriels test: Alpha = 0.05; Confidence = 0.95). Breast stage IV was also selected specifically for comparison as the younger girls had not been at school for long enough to separate them on the basis of academic performance (figure 11).

Figure 11

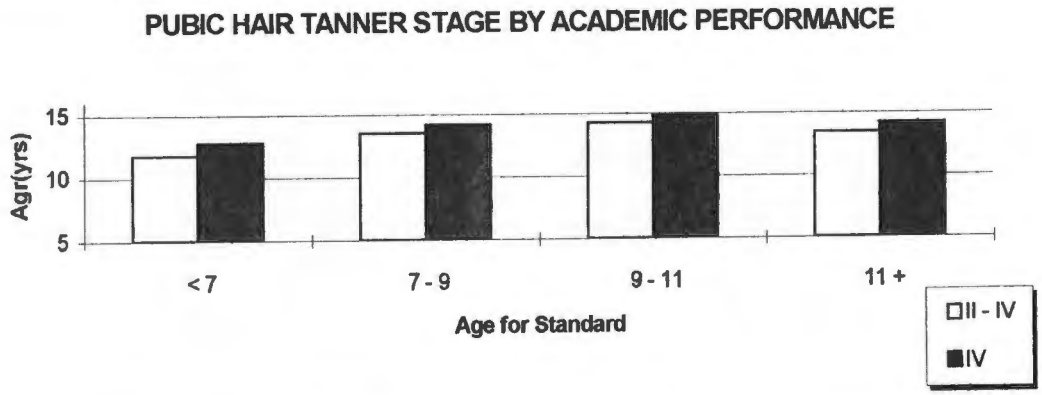
AGE AT BREAST TANNER STAGE FOR ACADEMIC PERFORMANCE



	< 7	7 - < 9	9 - < 11	> 11
Stage II-IV	11.90	13.58	14.03	13.39
Stage IV	12.87	14.02	14.90	14.17

This difference is seen again in pubic hair development stages II - IV combined (figure 12) and again, the difference is statistically significant (Gabriels test: Alpha = 0.05; Confidence = 0.95).

Figure 12

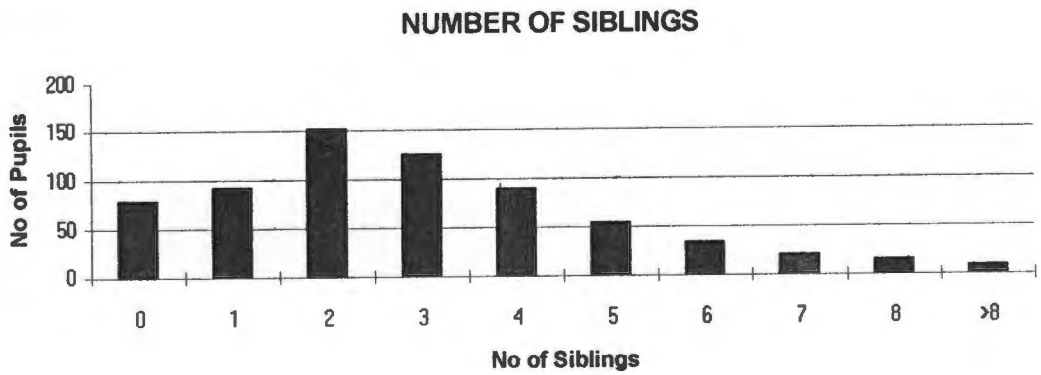


	< 7	7 - < 9	9 - < 11	> 11
Stages II- IV	11.80	13.48	14.29	13.39
Stage IV	12.77	14.21	13.00	14.20

3. Number of Siblings

Only 78 (11%) pupils came from families in which they were the only child and 48.4% of pupils had at least 3 siblings (family size of four children or greater). The distribution of the number of siblings is demonstrated in Figure 13 below.

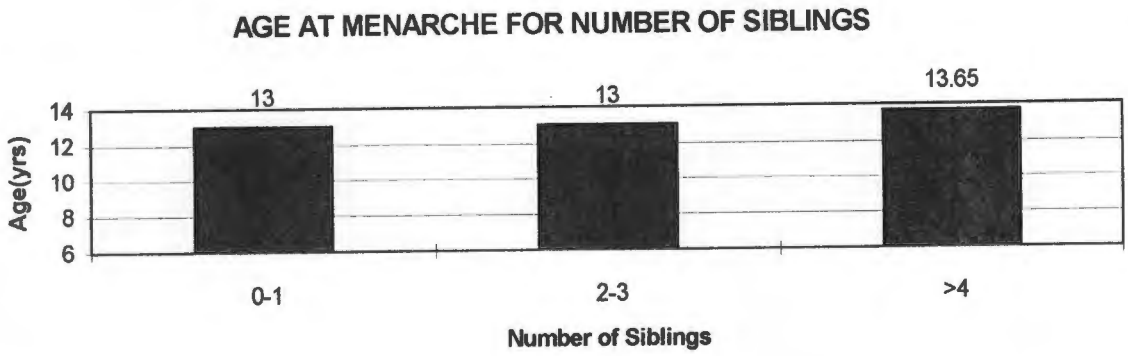
Figure 13



Pupils were divided into three groups. Those with none or one sibling, those with 2 or 3 siblings and finally those with four or more siblings. There was no

significant difference in the age of menarche, the age of any of the breast stages or pubic hair stages when comparing the three groups. The bar graph in Figure 14 depicts the average age at menarche for each of the groups. The figures for pupils with one or no siblings were not evaluated as there were insufficient data for statistical analysis (n=5).

Figure 14

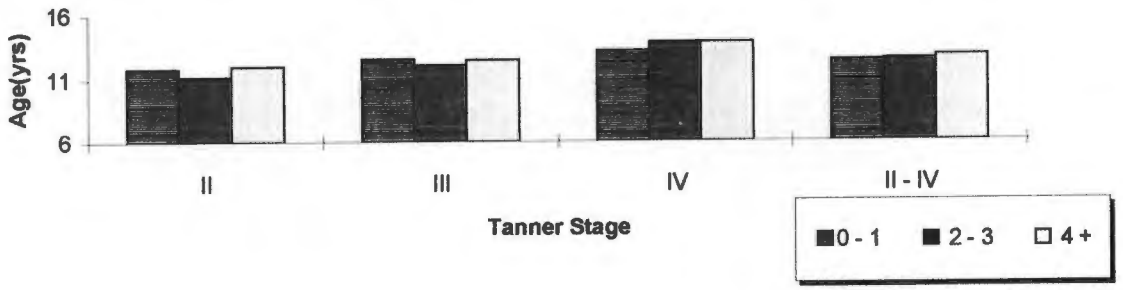


Difference between 2-3 and >4 not statistically significant. Kruskal Wallace test p = 0.5544

Figure 15 depicts the difference between the same groups for breast stages II to IV. Although for the combined breast stages II to IV there appears to be a trend, this difference is not statistically significant (Kruskal Wallace test; p = 0.0806).

Figure 15

AGE AT BREAST TANNER STAGE FOR NUMBER OF SIBLINGS

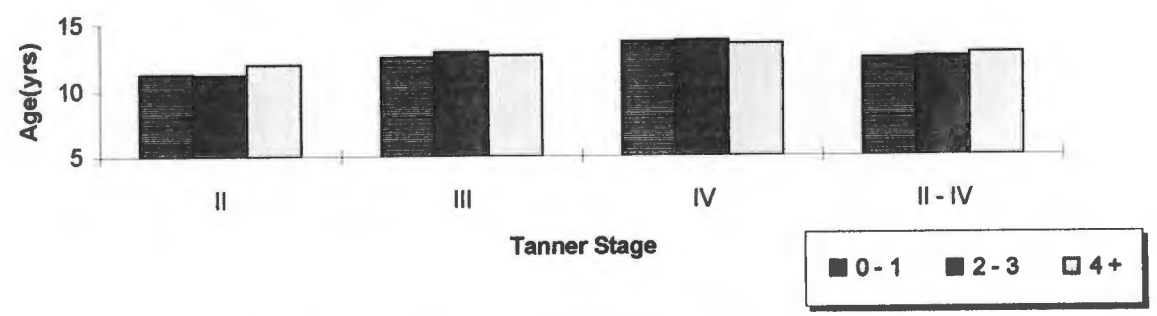


	Stage II	Stage III	Stage IV	Stages II - IV
0 - 1	11.78	12.50	13.20	12.36
2 - 3	11.17	12.10	13.80	12.43
4 +	12.00	12.40	13.80	13.73

A similar analysis for pubic hair in figure 16 (combining the results for stages II to IV) demonstrated a similar trend with a statistical difference that came close to being significant (Kruskal Wallace test; p = 0.0695).

Figure 16

PUBIC HAIR TANNER STAGE FOR NUMBER OF SIBLINGS



	Stage II	Stage III	Stage IV	Stages II-IV
0 - 1	11.28	12.50	13.60	12.30
2 - 3	11.19	11.19	13.70	12.40
4 +	12.00	12.50	13.40	12.70

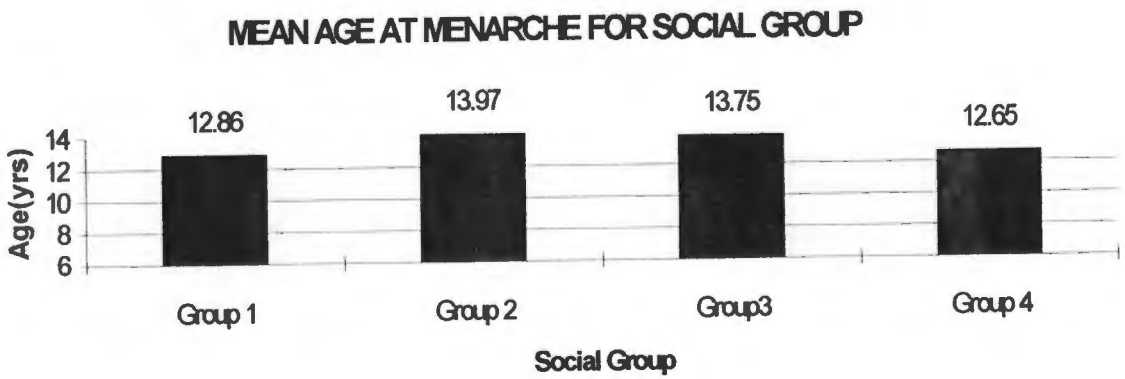
4. Social Class

All pupils were allocated to a social class according to the CASS classification (see Figure 5). In order to allow adequate numbers for comparison between social classes it was necessary to form social groups as follows:

Group 1 - Social Classes I, II, and III (n =112)
Group 2 - Social Classes IV and V (n = 212)
Group 3 - Parent unemployed or not supporting family (n = 320)
Group 4 - Parent's employment unknown (n = 64)

The average age of menarche was compared between the four groups in figure 17.

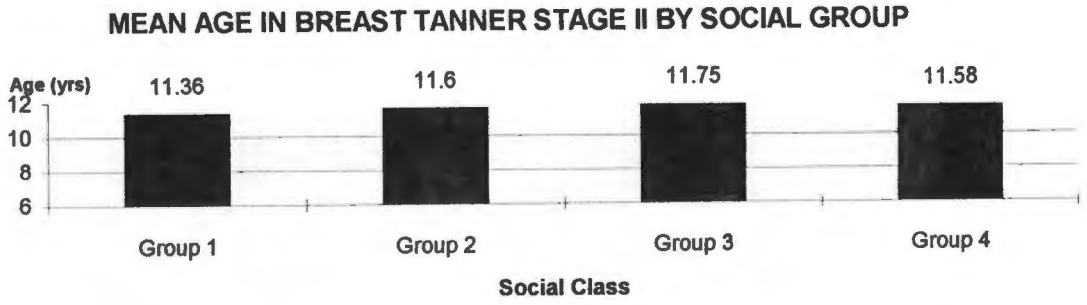
Figure 17



There is a significant difference between Group 1 and Groups 2 and 3 (Gabriels test: Alpha = 0.05; Confidence = 0.95). Group 4 was not included as the numbers are too few for statistical analysis. (n = 7)

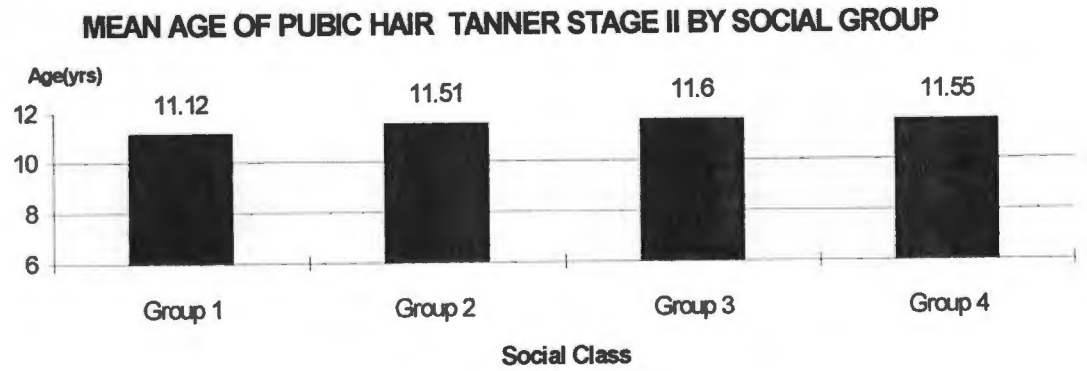
In the Figures 18 and 19 the age at initiation of breast and pubic hair development (Tanner stage II) is compared between the different social classes.

Figure 18



There is no statistically significant difference between the different social classes when looking at breast stage II (using Gabriels test at $p < 0.05$). The same applies to both pubic hair (stage II) and axillary hair (stage II).

Figure 19



C. Summary of Results

709 Xhosa schoolchildren aged 8 to 18 years were examined for pubertal development and this was compared with various aspects of their social environment.

The mean age at menarche was 13.67 years with a range within two standard deviations of the mean of 11.25 to 16.09 years.

By age 11 years 40% of the pupils had started breast development and 50% had pubic hair changes.

Body mass index increased with age and with breast development but did not correlate with reported age of menarche.

The majority of the schoolchildren were of lower social class and many (320 pupils) had parents that were either unemployed or not providing financial support for the family. Children from the upper social classes experienced menarche at a significantly younger age than those from the more disadvantaged classes (12.86 vs. 13.97 years).
No difference was evident between the different social classes when comparing breast or pubic hair development.

The mean age at menarche was earlier in children from nuclear families when compared with those from single parent families (13.36 vs. 13.47 years). This difference is not statistically significant. Similarly, the age at initiation of puberty (Breast stage II) is also earlier in nuclear families and again this difference is not significant.

Children in the appropriate academic standard for their age experienced menarche significantly earlier than the children who were old for their standard (12.92 vs. 13.64 years). Similarly the mean age for all breast stages and pubic

hair stages were significantly earlier in children in the appropriate academic standard.

The number of the pupil's siblings did not appear to have a significant effect on either the age of menarche or the age at which the children pass through puberty.

CHAPTER FOUR
DISCUSSION

A. Physical Parameters

1. Menarche

The mean age of menarche in our study of Xhosa schoolgirls was 13.67 years. In comparison with other South African studies a tendency toward earlier menarche is seen. It is worth noting that in the South African context Xhosa schoolgirls have reached a mean age of menarche similar to so-called Coloured girls of twenty years ago and South African Indian girls of nearly forty years ago (See table 1).

A detailed study of pubertal growth of girls in the Chandigarh province in North India was undertaken by Qamra (1991a) and, as both South Africa and India are third world countries, it is suitable for comparison with the present study. The percentage of girls who had experienced menarche in each age group is shown in the table 12.

Table 12: Comparison of age at menarche between Indian and Xhosa girls

Age in Years	% Menarche Present Study	% Menarche Indian USES	% Menarche Indian LSES
<11	1.8	5.4	0.0
11-<12	6.4	17.4	8.2
12-<13	32.2	56.1	20.0
13-<14	64.3	80.0	57.7
14-<15	84.4	95.5	81.7
15-<16	96.5	100	96.6
>16	100	100	100

USES = Upper Socio-economic Status LSES = Lower Socio-economic Status

The striking similarity between the age of menarche of the South African girls (the vast majority from a lower socio-economic environment) and the economically deprived Indian girls demonstrates that economic factors are

probably more important than race in determining age at sexual maturity. Frisch (1977) associates poor socio-economic conditions with poor nutrition, hard work and disease. The undernourished female has later menarche and earlier menopause as well as a higher frequency of irregular and anovulatory cycles. The onset and maintenance of menstrual cycles are associated with the attainment of a minimum weight for height representing a critical 'fat store' (Frisch and MacArthur 1974).

2. Breast Development

The sequence of normal pubertal development begins with the appearance of breast buds in 85% of girls (Wheeler 1991). Oestradiol secreted by the ovary is the main hormone responsible for breast changes, whereas androgens secreted by both the adrenal glands and the ovaries result in pubic and axillary hair growth. The time from appearance of the breast bud to the onset of menarche appears to be constant at 2.3 ($^{+}/-$ 0.1) years regardless of the age at which breast development begins (Rosenfeld 1991) provided no intercurrent insults occur.

In the present study by age 11 years more girls had shown pubic hair changes (49.69%) compared with breast changes (39.62%). Below in table 13 the present data have been compared with Qamra's (1991a) data from India.

Table 13: Percentage Girls in Breast Stage II for Age in Different Cultural Groups

Age in Years	Percent Breast Stage II Present Study	Percent Breast Stage II Indian (USES)	Percent Breast Stage II Indian (LSES)
<11	39.62	59.9	32.6
11-12	71.43	82.6	57.0
12-13	83.08	95.1	92.5
13-14	95.54	100	97.5
14-15	100	100	100
15-16	100	100	100

USES = Upper Socio-economic Status LSES = Lower Socio-economic Status

Despite the marked similarity in the onset of menarche between the Xhosa and the Indian group of LSES, most of the Xhosa girls seem to start breast changes at an earlier age. The initiation of breast development for most of the Xhosa girls is between ages 11 and 12 years whereas for the poorer Indian girls it is after the age of 12 years. The majority of upper class Indian girls have already started breast changes before the age of 11 years. The reason for this difference is unknown but one can postulate that either genetic factors or an increased BMI in the Xhosa girls may be responsible for the earlier onset of puberty (Frisch and Revelle, 1970).

Comparison between the index population and a similar cross-sectional study by Cameron (1993) is demonstrated in table 14 below. In this study Black schoolgirls were examined in a rural school at Vaalwater in the Northern Transvaal and in private schools in Soweto, Johannesburg.

Table 14: Mean Age in Tanner Breast Stages in South African Populations

Breast Tanner Stage	Mean Age (yrs) Present Study	Mean Age (yrs) Vaalwater (rural)	Mean Age (yrs) Soweto (urban)
Stage 2	11.6	11.6	10.1
Stage 3	12.7	12.8	11.3
Stage 4	13.6	14.2	12.1
Stage 5	14.6	16.6	13.6

The mixed social population of Xhosa girls lies between the two extreme Black groups in Vaalwater and Soweto. It is interesting to see that the initiation of breast development in the Vaalwater community is at approximately the same age as the Xhosa girls but that they take two years longer to reach maturity. Qamra (1991a) found a much less dramatic difference in time (less than 6 months) taken to pass through puberty by upper and lower socio-economic groups in India. Marshall and Tanner however state that the average time taken for breast development is 4 years with a range of 1.5 to 9 years. It would seem

possible then, that a lower socio-economic state or a poorer nutritional state may not only delay the onset of puberty but also delay the transition through it.

3. Pubic Hair Development

The onset of pubic hair development occurs slightly later than that of breast development in normal girls (Marshall and Tanner, 1969).The growth of pubic hair is under the influence of both ovarian and adrenal androgens and its progress through puberty appears to follow the breast closely. In the present study pubic hair appears to start slightly earlier than breast development. This is not in keeping with the findings of most other investigators (Tanner 1969, Qamra 1991, Cameron 1993). This may be an idiosyncratic finding perhaps due to the study being cross-sectional with fewer girls in breast stage II and pubic hair stage I being sampled (n=33). In cases of extreme exercise and weight loss pubic hair may precede breast development (Warren, 1980).

Comparison with Qamra's (1991a) Indian study in table 15 shows a similar trend to breast development in that the Xhosa girls average ages are below the higher socio-economic Indians but not as delayed as the girls from the more disadvantaged community.

Table 15: Percentage Girls in Pubic Hair Stage II for Age in Different Cultural Groups

Age in Years	Percent Pubic Hair Stage II Present Study	Percent Pubic Hair Stage II Indian (USES)	Percent Pubic Hair Stage II Indian(LSES)
<11	49.69	51.8	24.5
11-<12	75.17	60.9	46.8
12-<13	87.69	88.1	70.0
13-<14	95.45	100	80.0
14-<15	100	100	100
15-<16	100	100	100
16+	100	100	100

When examining the results of the present study in comparison with the South African studies at Vaalwater and Soweto (Cameron 1993) in table 16, once again the Xhosa girls fit between the two socio-economic extremes. The schoolgirls in the Transvaal seem to reach maturity (stage V pubic hair) far later than the Xhosa girls. The mean age for pubic hair stage V in Marshall and Tanner's group (1969) was 14.41 years and it occurred shortly before breast maturity. This is more in keeping with the findings in the Xhosa girls in the present study.

Table 16: Mean Age Pubic Hair Tanner Stages in South African Populations

Pubic Hair Tanner Stage	Present Study	Vaalwater (rural)	Soweto (urban)
Stage II	11.44	12.12	10.08
Stage III	12.71	13.51	11.72
Stage IV	13.59	15.22	13.05
Stage V	14.74	18.83	16.14

4. Axillary Hair Development

Changes in axillary hair are not frequently observed in studies on pubertal development. The stimulus for axillary hair growth is regarded as being similar to that for pubic hair and thus the changes in puberty should not be dissimilar to that for pubic hair. In Table 17 axillary hair changes of the pupils in the index study are compared with that of Indian girls of low and high socio-economic class (Qamra 1991a).

Table 17: Percentage Girls in Axillary Hair Stage II for Age in Different Cultural Groups

Age in Years	Axillary Hair Stage II Present Study	Axillary Hair Stage II Indian (USES)	Axillary Hair Stage II Indian (LSES)
<11	40.25	19.6	8.2
11-<12	74.44	39.1	24.5
12-<13	81.54	80.5	37.5
13-<14	92.86	98.0	42.5
14-<15	97.75	100	75.5
15-<16	100	100	93.6
16+	100	100	-
Mean (yrs)			

USES = Upper Socio-economic Status LSES = Lower Socio-economic Status

The mean ages for axillary hair stage II is delayed in both Indian groups. This may be due to the fact that the amount of body hair varies widely between different race groups and is therefore a poor indicator of progress through puberty in some populations.

B. Environmental Influences

1. Child Minder

Black African social structure has evolved rapidly through the process of urbanisation from the pre-industrial extended patrilinear family to one in which families are often forced to live apart for many months at a time. The major factor responsible for this is the difficulty in finding employment. This is reflected in the findings of this study as 41% of the children are cared for by a single mother. Although the study does not reveal the number of single mothers with unmarried partners who may also be contributing to the family finances, the pupil's mother perceives herself as a single parent and this in itself may have a bearing on both the child and the mother. The sociological consequences of this are great particularly in a lower socio-economic group as the mother now becomes the bread winner and children have to be cared for by neighbours

while the mother works. Should the mother become ill, this will result in a reduction in the family earnings. Several studies have shown that, not surprisingly, women who combine domestic responsibilities with work outside the home may experience considerable stress (Klein 1960) and that this may have an effect on the emotional development of the child.

As seen in figure 6 above, there is a trend to an earlier menarche in the nuclear family when compared with the single parent family (13.36 yrs vs. 13.74 yrs) but this difference does not reach statistical significance. When examining the data on breast and pubic hair there is no difference between the two groups for the mean ages at each Tanner stage. It appears therefore that the family structure itself does not have an effect upon the development of the child. In the Black community it is often more difficult for a man to find employment than his wife and therefore a nuclear family may still have the mother as the sole breadwinner. On the other hand it is common for parents to be separated for a large part of the year, each parent working in a separate town and yet they combine their incomes in the support of their children. The children, by tradition, remain with their mother. Under these conditions the effect of a child-minder is unlikely to have any bearing on nutrition and therefore pubertal development.

2. Number of Siblings

A child's social environment is also determined to a large degree by the number of siblings that are present in the family. It is postulated that the larger the family, the less food there is available on a limited family income and therefore one might expect a higher degree of nutritional deficiency in the children of a larger family as opposed to a smaller one.

There are however a large number of variables that affect this hypothesis. Firstly, some of the large families may have a relatively high income and secondly, the oldest child of a large family may have been well fed at an early age while the family was still small, but the youngest of a large family would have experienced the brunt of the families food shortage during her prepubertal

growth and thus be nutritionally deficient at the time of starting puberty. It is also possible that a younger child may benefit from the incomes of older children who have started working and are contributing to the family financial resources.

In the present study the median family size was three children (index child plus two siblings) but 33% of the families consisted of five or more children. The smaller families tended to consist of younger girls. This is demonstrated by the fact that only five postmenarchal girls had less than two siblings. These smaller families may well become a larger family of the future as the mother has more children.

3. Academic Standard

The existence of a significant relationship between social class background and level of educational attainment has been a long standing concern of social scientists and politicians. In Britain, a child's school career was decided by a single examination at age 11 years. This process was stopped because it was discovered that children from middle class families performed better on average than their working class counterparts, and thus more middle class children were sent to grammar schools as opposed to technical schools (Douglas 1964). Despite the introduction of comprehensive schools, middle class children still seem to have the edge in the end of school examinations such as the ordinary and advanced level examinations ('O' and 'A' levels) (Halsey et al 1980).

The influence of the home on the school environment is multi-faceted. Children from middle class homes are more likely to have a parent at home to ensure they keep up with their work, a quiet room with which to study and the availability of the relevant books in the home. Middle class parents are more likely to be confident when dealing with school staff and therefore raise problems and discuss them with the teachers (Douglas 1964) as well as being literate themselves, they are more likely to have educational aspirations for their own children.

In South Africa, political unrest has had a large impact on children's schooling including their attendance at class as well as the destruction of school facilities and equipment. At one of the schools in New Brighton I addressed a class of schoolchildren. There were two children to a desk sharing textbooks and in order to get as many children into one classroom as possible some of the children were sitting on window sills. The classroom had no roof as it had been burned down during an episode of political unrest the previous year. Only exceptionally bright children could learn adequately under these circumstances. It is important, therefore, to realise that children who are in a lower class at school than expected have not necessarily failed academically but may have come from a rural environment that did not offer adequate schooling or they may have lost time at school from political disruption. A further consideration is that upper class parents are more likely to find permanent employment and therefore to remain in one town. Socially disadvantaged and less educated parents may be forced to move frequently in order to look for employment further hampering their children's progress at school.

In all three parameters tested (menarche, breast development and pubic hair development), girls who were behind at school had a significant delay in their progress through puberty. This may be because social and political pressures placed upon growing Black teenagers in South Africa require good nutrition and a stable home environment in order to ensure educational progress. This therefore reflects on their physical development.

Margolis (1970) in his study on South African urban 'coloured' girls also noted this trend and suggested that there may be a psychological effect, the older girls in the class not starting their first menses until it had become accepted practice in their social micro-environment.

4. Body Mass Index (BMI)

The body mass index is a reliable indicator of nutritional status. In 1970 Frisch postulated the hypothesis of a critical body mass required before the onset of

menarche. This postulate was refuted by Frisch herself who started looking at other physical parameters that may be associated with nutritional status and thus have a bearing on pubertal development. By extrapolating from girls who were malnourished Frisch and MacArthur (1974) applied a technique to calculate a percentage of fat mass from total body water and body weight. A percentile graph was established from normal pubertal girls and a cut off of 22% total body fat was established below which menses were not likely to be present.

The increase in BMI during late puberty in females is mainly a result of an increase in fat mass secondary to which is twice that of males by the end of puberty (Cheek, 1974). This is so dramatic that in a Zambian study (Ng'andu NH 1992) it has been suggested that weight for height measurements such as BMI should be adjusted in pubertal children according to the mean menarchal age of the population, as the different ages at which populations pass through puberty will have an effect on this parameter.

More recently it has been discovered that sex hormones are not only responsible for the increase in weight in puberty but also have an effect on the fat distribution (Hammer et al 1991). The deposition of fat on the hips is directly related to the concentration of sex steroids and gonadotrophins (de Ridder et al 1990). This implies that weight itself probably does not determine age at menarche but is a manifestation of exposure to oestrogen and that this fat is deposited peripherally (on the hips) rather than centrally (in the abdomen).

5. Social Class

The standard classification of social class is the one used by the Registrar General of the United Kingdom. It consists of five classes with the social class III divided into skilled manual and skilled non-manual labour. This classification is not suitable for a South African Black population because many of the occupations are not mentioned and others have different social implications to the standard classification. The CASS classification (1979), from the University

of Natal has attempted to place unique African occupations such as sangoma or traditional healer into specific social categories.

The effect of social class on health has been reviewed extensively. There is an increase in perinatal mortality rates, increase in mortality (men aged 15-65 years) and in rates of self reported illness or morbidity in the lower compared with upper classes (Blaxter 1976, Morris 1979).

Social class has also been shown to have an effect on the age at which children reach puberty. Comparisons made between children from different countries (Burrell et al 1961, Blanders-van Halewijn 1968, Malcolm 1968) have confounding factors such as racial differences, local diseases, climate and altitude, all of which have been regarded as having an influence on age at puberty. Other studies have used children from different towns within a country usually comparing a rural to an urban environment (Kulin et al 1982, Cameron 1993) which again has the disadvantage of allowing these factors to influence the results.

The present study has taken a single race group from two towns 800 kilometres apart and divided this group into the different social classes in order to reduce these external variables as much as possible. The findings demonstrate that girls in higher social class start puberty and experience menarche earlier than their lower social class peers. This difference does not appear to have been as dramatic as has been reported in studies that have employed heterogeneous population groups. This is supported by a study performed on South African Indian schoolgirls (Kark 1956) and the study in North India (Qamra 1991) in which results similar to the present study were found.

Table 18: Age at Menarche in Different Social Classes

Social Group	Kark - 1956 Age at Menarche	Qamra - 1991 Age at Menarche	Present Study Age at Menarche
USES (Class 1,2,3)	13.44 yrs	12.0 yrs	12.86 yrs
LSES (Class 4,5)	13.71 yrs	12.8 yrs	13.96 yrs

USES = Upper Socio-economic Status LSES = Lower Socio-economic Status

All three studies were performed in a single population group divided on the basis of social class. In all the studies the difference in age at menarche between the upper and lower classes was statistically significant.

C. Study Design

The design of the present study was cross-sectional as the schoolgirls were each seen once only and the information with regard to their pubertal development was recorded in relation to their age. Longitudinal studies follow a fixed population of children at set intervals and record the changes that occur during this time and calculate mean time of entry into each stage of puberty.

The advantage of cross sectional studies is that they can sample a large number of children in a relatively short space of time and also result in a bigger sample of the index population. The problem with this method is that entry into a particular stage of puberty can not be assessed but the mean age in a particular pubertal stage is calculated. When comparing longitudinal with cross sectional studies the mean age at entry to a stage of puberty will obviously be earlier than the mean age of the pupils in the same stage. By calculating the percentage of girls that have passed into a particular stage at a given age, comparison between cross sectional and longitudinal studies can be achieved. This does not however apply to age at menarche as this date can usually be remembered by the children.

Longitudinal studies have the advantage of being able to estimate the mean age of entry into a stage of puberty as well as look at other parameters such as peak height velocity and weight gain which cannot be done with cross sectional studies. The more frequently the population is studied the more accurate the study will be in terms of timing the stages of puberty. These studies are however more time consuming as the children need to be followed up from prepuberty through to maturity and one has to be careful to select a stable population as it is likely that many children will leave the school or town. Most longitudinal studies therefore require the addition of more pupils during the course of the serial examinations in order to maintain sufficient numbers of children. These are called mixed-longitudinal studies which are essentially longitudinal in design but the individual children do not necessarily remain for the entire duration of the study.

Most of the more recent studies are community based drawing children from either schools or villages. This will give a better representation of the population than, for instance, hospital based studies. The present study was controlled for urban schoolgirls of a single race in order to exclude possible variables that may influence the age at which the girls passed through puberty. There was a possibility of selection bias in this study as the girls were volunteers and this may have excluded any girls with abnormally early or late puberty who were too embarrassed to be examined. Girls who were already sexually active may have feared discovery of this fact or been concerned that the aim of the project was to identify sexually transmitted diseases. This would have discouraged them from entering the study. In one school there was resistance from one politically influential teacher because he thought that we secretly wanted to document HIV infection in schools. We received no support from that school. Our method of selection also excluded girls who did not go to school for any reason and it is possible that the most socially disadvantaged girls were not part of the project. A longitudinal study would have been preferable to a cross sectional one but this could not be performed due to time constraints and practical problems such as a population that is unstable with few pupils remaining in one place long enough.

CHAPTER 5
CONCLUSION

This study has shown that the age at which Black urban schoolgirls experience menarche has continued to decrease over the last forty years. The reason for this is most certainly an increase in socio-economic status and improved nutrition in the more recent study populations. It would be of considerable concern if this trend was not present as this would imply an absence in improvement of living standards. Future studies are important to ensure that this trend continues as in most First World countries the age of menarche is one year earlier than the present study population.

It has also demonstrated that other indicators of the quality of the environment in which the child lives such as poor social class and poor academic achievement are associated with delayed physical maturation. In order to improve the ability of members of poorer communities to contribute to the economy, the provision of schooling alone is inadequate and this needs to be supplemented with adequate nutrition (perhaps in the form of schoolfeeding programs) in order to encourage these children to attain their genetic potential.

As these parameters improve, the children will start puberty at an increasingly early age and one can expect consequences such as an earlier initiation of sexual activity, earlier first pregnancy and larger family size. There must therefore also be a concomitant increase in education about sexuality and distribution of contraceptive methods in order to counteract these trends.

APPENDIX 1

(Questionnaire sent to pupil's parents or guardian)

Mzali,

Ndingu gqirha e Yunivesithi Yase Kapa. Sizama ukuba sifumane umehluko pakathi kwabantwana abagulayo ukuze siphumelele kufuneka sichole bonke abantwana abaphilileyo. Sigqambe esi sikolo ukuze sixhilonge abantwana.

Akhukhonto ezakwenzakalisa umntwana wakho ngokhubahlola akuzothathwa magazi. Ukuba kufumaneke into engalunganga emntwaneni wakho siyakukuxelele. Ukuze sikwazi ukwenza sifuna imvume yakho kunye nokuba uphendule imibuzo.

1. Ngubani igama ne fani yomntwana wakho.....
   Uzalwe nini umntwana.....
   Uphele ku standard bani umntwana.....
   Ngubani okugcinelayo umntwana ebusuku nangempela veki.....

2. Umama wakhe uphele kwibanga liphi.....
   Umama wakhe uyilena ekholejini okanye yunivesithi.....
   Umama womntwana uyaphangela na.....
   Usebenza msebenzi mni.....

3. Utata wakhe uphele kwibanga liphi.....
   Utata wakhe uyilena ekholejini okanye yunivesithi.....
   Utata womntwana uyaphangela na.....
   Usebenza msebenzi mni.....

4. Banghapi abantwana bakho.....
   Banghapi abantwana abadala kuna lona.....

Ndiyavuma.....ukuba umntwana wami ukuba ahlolwe ngodokotela abavela esisikolweni esphakamaileyo Yunivesithi Yase Kapa.

Dr D D Largier
Groote Schuur Hospital

Appendix 2

Translation of Appendix 1

Dear Parent,

I am a doctor from the University of Cape Town. I wish to perform a study looking at the growth and physical development of healthy schoolgirls in order to help identify disease. Such a study is to be performed at your daughter's school.

No attempt will be made to hurt your daughter in any way and the examination does not include acquiring any samples of blood. The examination cannot be performed without your consent. If you are happy for your daughter to be included in the study I would ask you please to complete the questions and sign your name below.

1. What is your child's name?.....
   What is her date of birth?.....
   What standard at school is she?.....

2. What standard did the child's mother attain at school?.....
   Did the mother attend college or university?.....
   Is the mother employed?.....
   What work does she do?.....

3. What standard did the child's father attain at school?.....
   Did the father attend college or university?.....
   Is the father employed?.....
   What work does he do?.....

4. How many children are there in the family?.....
   How many children are older than this one?.....

I, ... agree to allow my child to be included in the study and be examined by the doctors from the University of Cape Town.

Dr D D Largier
Groote Schuur Hospital

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