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Risser sign - trends in a South African black population

Mayet, Ziyaad

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1. INTRODUCTION

1.1 Scoliosis

1.1.1 Definition

Idiopathic scoliosis is a common and potentially severe musculoskeletal disorder of unknown aetiology. It is described as a three dimensional deformity of the spine, that is characterized by both vertebral rotation and a structural lateral curvature of more than 10º, as measured by Cobb's angle. (1,8)
Figure 1 illustrates the deformity.
Figure 2 illustrates the measuring of Cobb's angle. It is the angle subtended by the highest and lowest vertebrae involved in the deformity.

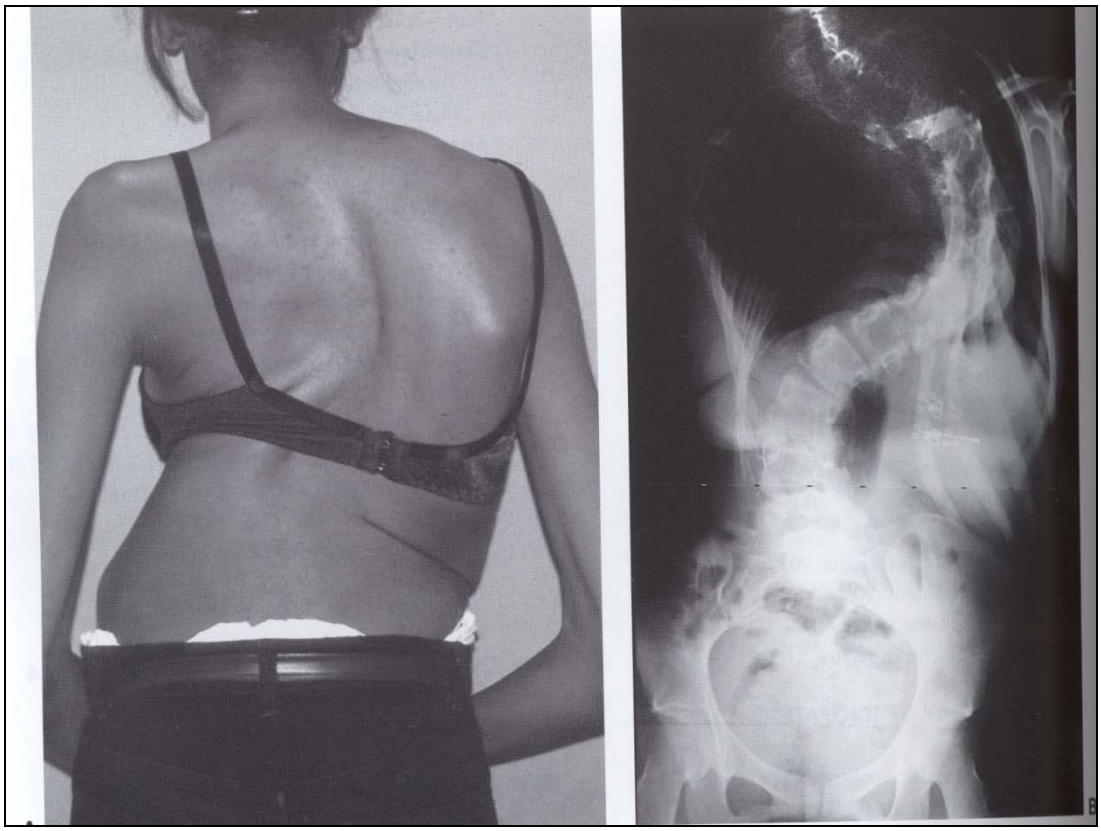


FIGURE 1 The scoliotic deformity

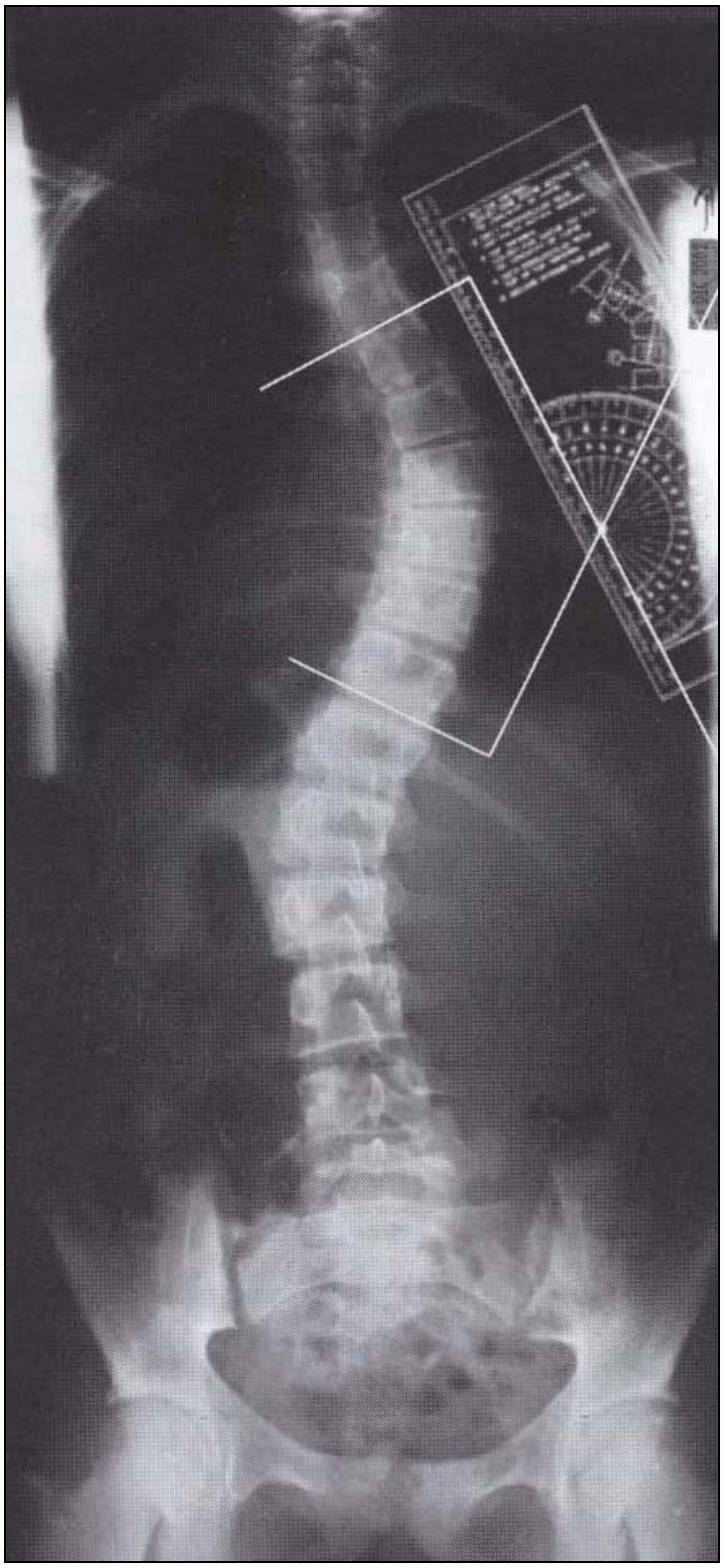


FIGURE 2 Measuring Of Cobbs Angle

1.1.2 Management of scoliosis

Management of scoliosis is largely dependent on the magnitude of the curve which is determined by the Cobb's angle, as follows:

- a curve less than 20º is observed
- a curve of 20º-40º is managed by bracing
- a curve greater than 40º is managed by corrective surgery

The decision, however, is complicated by the fact that scoliosis is a disorder of growth and is governed by the Hueter-Volkman principle which states that the rate of growth of the physis is determined by the amount of pressure placed across it. This means that as the spine undergoes longitudinal growth, the magnitude of the curve progresses. (2)

The decision-making of modality of treatment is determined not only by what the Cobb's angle is

now, but also what it will be in the future. Therefore predicting the growth potential left for a child is important. This is estimated from the following measures of maturity: (9)

- chronological age
- menarche and the presence of other secondary sexual characteristics
- metabolic markers
- radiological skeletal age measures

1.2 Skeletal age estimation

The purpose of estimating skeletal age is to be able to ascertain whether the pubertal growth spurt has occurred or not. The pubertal growth spurt is referred to as the period of the peak height velocity (PHV). This is when the rate of growth is at its maximum. Therefore the progression of the scoliotic curve is at its maximum too. The age at

which the peak height velocity occurs is called the peak growth age (PGA).

None of the predictors of skeletal age correlates perfectly with PHV, or PGA. In predicting skeletal age, a reasonable approach would therefore be to use a combination of the above methods to improve accuracy. (2)

1.2.1 Chronological age

Chronological age is of no significance in estimating maturity, it is bone age that is important. Chronological age has been shown to be a poor estimate of bone age with about 50% of children having a difference between the two. The accuracy of chronological age is further compromised by the fact that many pathological conditions affect bone age, and this further increases the difference. (1)

1.2.2 Secondary sexual characteristics

Menarche is a readily identifiable sign which usually occurs after the PHV. However, it is markedly variable compared to skeletal age measures, which is worsened by the fact that early menstrual periods are often quite irregular. This means menarche is a reliable sign that growth velocity is decreasing, but it is too variable for accurate assessment. (2)

1.2.3Metabolic markers

Skeletal growth is thought to be reflected in many metabolic markers. DHEA and DHEA-S rise initially at adrenarche, followed by estradiol, IGF-1, alkaline phosphatase, osteocalcin and calmodulin. Boys also demonstrate large increases in testosterone. These were found to be useful if serial measurements were done to assess for

increases or decreases. IGF – 1 especially was found to correlate well with curve behavior in scoliosis, however the DSA method of skeletal maturation was found to be superior. (2)

1.2.4 Radiological Markers

Skeletal age determinations are based on the radiological assessment of normal children, and involves the growth of various regions and how this correlates to chronologic age. The use of groups of children, rather than individuals, smoothes the accelerations or decelerations that occur in the individual. (2)

1.2.4.1 Types of Radiological Markers

There are many types of radiological markers, each based on the growth of different regions of the body. Arguably, the most familiar of these is the

Greulich and Pyle atlas which involves qualitatively matching the subject's hand and wrist x-ray against a series of gender specific standards. These standards are based on a collection of radiographs taken on normal children from white middle classed homes in Cleveland between 1927 and 1942. This collection was compiled for the Cleveland longitudinal study of growth and development, and is known as the Brush-Bolton collection. (3)

The Greulich and Pyle method assesses hand and wrist films which correspond to a gender specific standard in the atlas, and a certain bone age. It is universally available. There is however some amount of difficulty in matching patients x-rays to standards in the atlas and substantial user variability was found. This could partly be attributed to the fact that the hand and wrist do not necessarily mature at the same rate. The Tanner-

Whitehouse method attempts to address this by assigning separate scores to the radius, ulna and bones of the hand.(2) This was found to be a cumbersome method and was simplified into the DSA method by Tanner *et.al.* in 2008. The DSA method was found to correlate excellently with the curve-acceleration phase in scoliotic patients. (10,11)

Besides the two methods mentioned above, there are a number of other methods involving other regions of the body. Each of these has its own advantages and limitations. However, in the management of scoliosis, all of the methods require the addition of another radiograph. This is probably the reason why the Risser sign is the most widely used method in the treatment of scoliosis. Because it involves ossification of the iliac apophysis, it is found on the standard spinal radiographs of scoliosis.

1.3 Risser sign

1.3.1 What is the Risser sign ?

The Risser sign was first described by JC Risser following a ten year follow up of scoliosis patients beginning in 1936. He described the ossification of the iliac apophysis, and separated them into five stages, as shown in Figure 3. Stage 1 begins with the ossification of the iliac apophysis starting at the anterior superior iliac spine (ASIS). It then progressively ossifies towards the posterior superior iliac spine (PSIS). The iliac blade is divided into 4 quadrants, with Risser stages 1-4 signifying ossification through the various quadrants.(4) Stage 5 finally involves fusion to the ilium. This is called capping of the ilium. This was found to coincide with the end of spinal growth, and therefore the end of progression of scoliosis curve. (4)

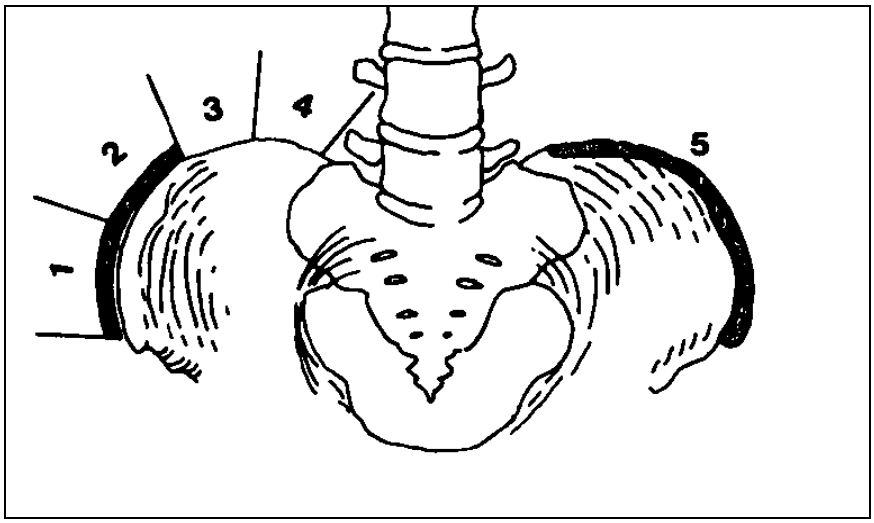


FIGURE 3 The Risser Stages

Risser found that completion of stage 5 occurred at an average of 14 years in girls (range 10-18 years) and 16 years in boys (range 10-20 years). He also found that iliac apophysis ossification took an average of one year to complete (range 7 months to 3 years).(4)

Scoles *et.al.* conducted a review of radiographs from the Brush – Bolton collection. They showed that maturation of the iliac crest together with clinical observations of secondary sexual maturation permit an accurate assessment of

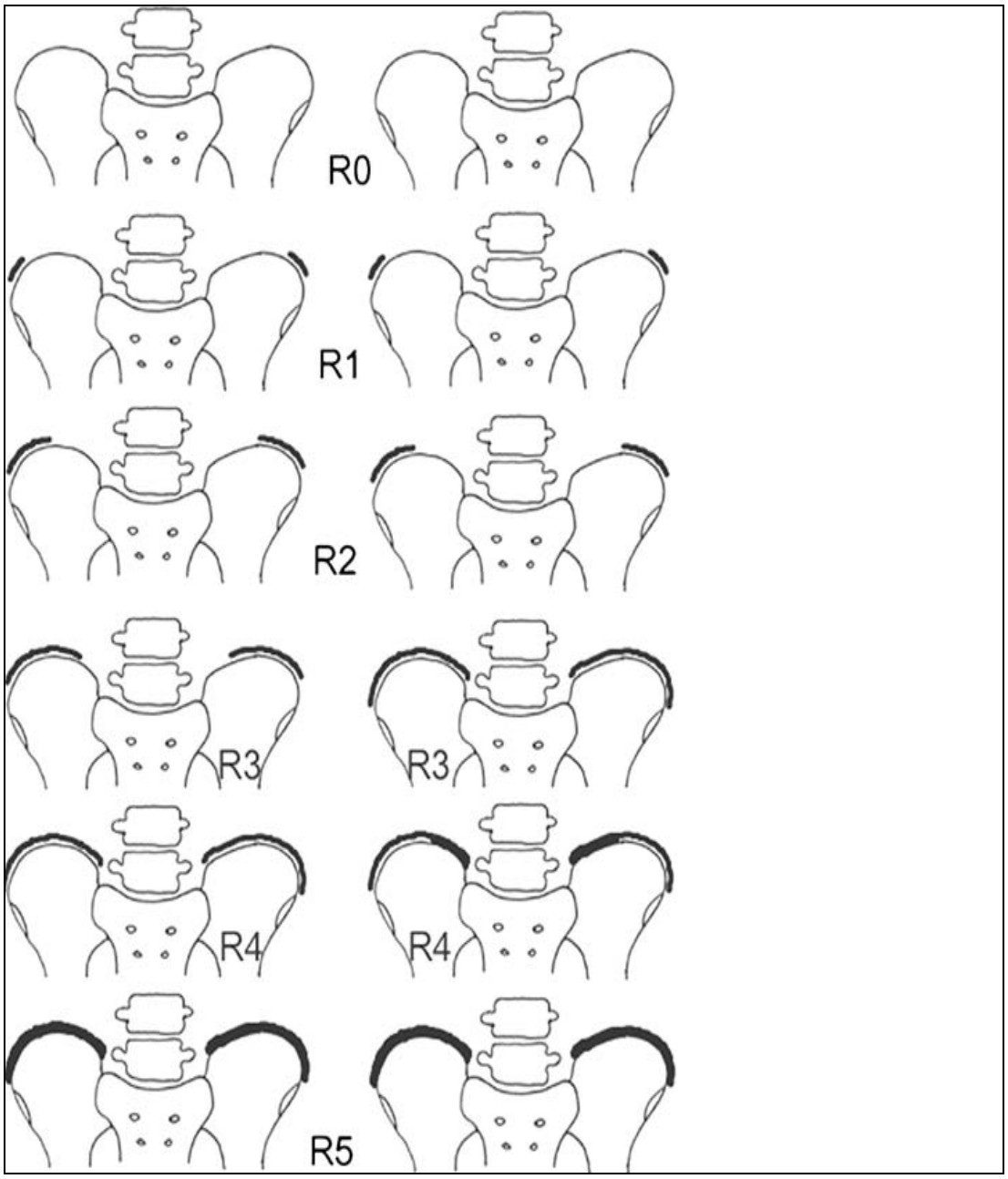
skeletal maturation. However, more importantly it provided us with standards for chronological ages for the Risser sign in a normal population. These findings are shown in Appendix A. (3)

1.3.2 Difficulties with the Risser sign

The Risser sign is found to typically occur after the PHV in 85% of patients and is thought not to correlate well with skeletal age. (2) It also correlates differently in boys and girls. Some authors have found that girls at Risser stage 4 have little remaining growth , while boys have substantial growth and may continue to have substantial curve progression.(2) However, others have shown girls to have substantial curve progression between Risser stages 4 and 5.(5)

Another drawback of the Risser sign lies in its reporting. The Risser stages as reported earlier were proposed by JC Risser, and is the staging

system in use in the United States. It is also the system in use in our country. However the system has been modified in France & other European countries. This system divides the ilium into 3quadrants, with progressive ossification denoting stages 1-3. Stage 4 denotes posterior fusion, while stage 5 denotes complete fusion (see Figure 4). The systems when compared shown only 50,8% of agreement. The French system under valued the Risser staging in the disagreements. Despite this, both systems are referred to by the same name. This is a source of miscommunication and a cause of confusion in literature, as well as patient treatment. (12)



A **B**

FIGURE 4 The Risser Stages in United States (A) and France (B)

The final limitation lies in radiograph interpretation. The posterior part of the apophysis is hidden behind the sacrum, which leads to errors in interpretation. (12)

This tends to be worse on PA rather than AP radiographs (see Figure 5 and 6). (2) T. Kotwicki published a paper on this while this study was already in progress. He showed improved accuracy in interpretation by using lateral radiographs, which could be analyzed using lateral Risser modifiers . (12)

None of the above has proven to be fully accurate as a predictor of spinal growth, & curve progression. However, the Risser sign is the most frequently used to assess a patient's growth potential, after first being described in 1958 by J.C.Risser. (14)

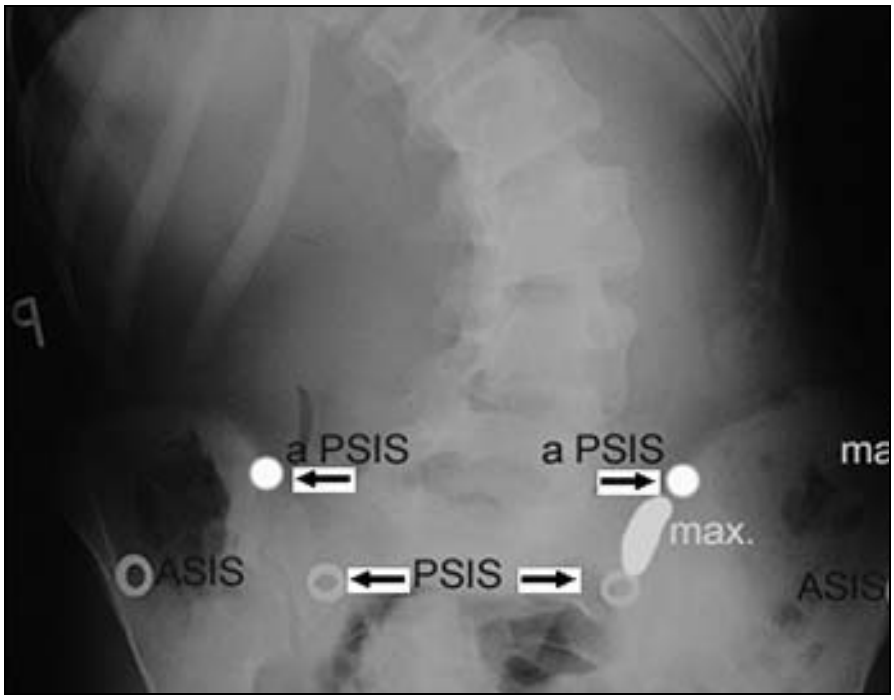


FIGURE 5 Radiograph with metal markers placed at ASIS and PSIS

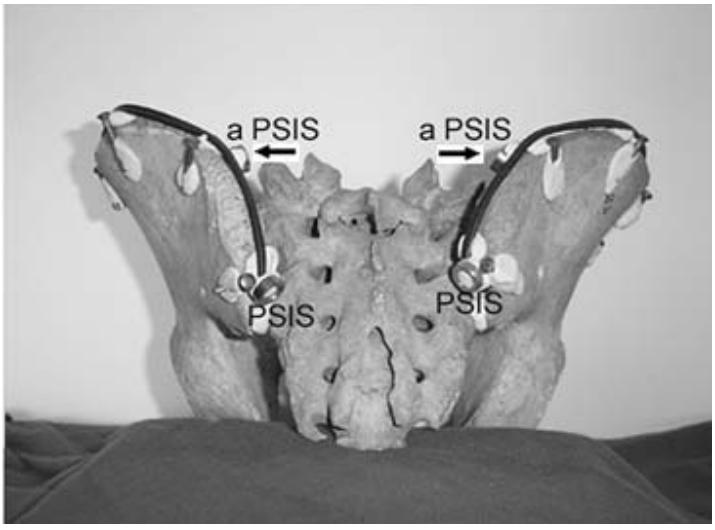


FIGURE 6 Model seen from posteriorly with markers placed at ASIS and PSIS

1.4 Impact of ethnicity on skeletal age estimation

“The standards can be expected to fit reasonably well other children of comparable genetic environmental background, but there is no reason to expect that they will fit any other group.”
This quote from the skeletal age atlas of Greulich and Pyle highlights the fact that published trends of maturation and skeletal age may not be applicable to every population. In fact, Risser himself found differences in maturation between a scoliotic population in New York, as compared to his original population in Los Angeles, with the New York population having delayed maturation. He attributed this to the colder New York climate. (4)
Another meta-analysis on age at menarche in Europe showed that geographic latitude had an influence, with more northern latitudes occurring

later. This was also attributed to climatic differences. (7)

Race has also proven to be another factor affecting timing of indicators of maturation. Ontell *et.al.* studied skeletal age in a heterogeneous population in California. They found differences between different ethnic groups, with the black population having a tendency to mature faster than other ethnic groups. (13)

Sexual maturity data based on the Tanner staging and secondary sexual characteristics was collected & assessed by the Third National Health & Nutrition Examination Survey in the US. The findings were that even black girls & boys started to mature earlier, all children completed maturation at approximately the same age. (6)

1.5 Aims

The null hypothesis is that the Risser sign is a biological factor, & as such is under environmental & genetic control. This means a discovery of trends that differ from those published by Scoles *et.al.*

2 MATERIALS AND METHODS

2.1 Description of study and exclusion criteria

A retrospective assessment of radiographs was done of radiographs of AP view of the pelvis. This was done for radiographs of patients in the 8-20 year old age group. Ethnicity was assumed from the name of the patient , and the address. Radiographs were assessed for the Risser stage. Sex was noted from the x-ray request forms.

2.2 Sites of study

The study was conducted at the following sites :

2 Chris –Hani Baragwanath hospital

3 Charlotte Maxeke Johannesburg Academic hospital

4 Helen Joseph – Raheema Moosa hospital complex

5 Klerksdorp-Tshepong-Potchefstroom-Witrand (KTPW) hospital complex

Permission was sought, and granted, from the hospital managers of each hospital to gain access to radiographs in the radiology records departments. Ethics approval was also granted by the University of the Witwatersrand (see Appendix B).

2.3 Exclusion criteria and assessment of radiographs

Radiographs were independently assessed by 2 observers. This was done to account for any interobserver variability that could occur. The first observer was I, a third year registrar in orthopaedics. The second observer was a third year registrar in radiology. The second observer was blinded to the assessments of the first observer. All radiographs, on which the 2 observers disagreed, were then assessed by the co-

coordinator of the study who is a senior spinal surgeon. His assessment provided the final Risser staging for that radiograph.

All radiographs where skeletal abnormalities were apparent were excluded from the study. Data was recorded on a data sheet (see Appendix C). No personal or identifying details of patients were recorded. This was in keeping with ethics committee requirements.

2.4 Statistical methods

All data was compiled into an Excel (Microsoft) spreadsheet, from where it was used for statistical analysis using the Stata program. Means were calculated for each Risser stage. This was done for both sexes in each of the ethnic groupings.

These were then compared to those of Scoles *et.al.* using the student T-test. A *p* value of <0,05 was defined as significant. Further comparisons were

also made between the ethnic groupings. The T-test was used as it best catered for the univariate nature of the analysis. It also catered for the small population sizes in some of the groups. (15)

3. RESULTS

3.1 Overview of radiographs assessed

A total of 743 radiographs were assessed for the Risser staging. Of these, 271 were found to be from Risser stage 0. These were excluded from further assessment as it was felt to be a meaningless statistic. This was because of the large period over which it occurs. This was also done in the study by Scoles *et.al.*

Of the remaining 472 radiographs, 9 were found to have skeletal abnormalities on the x-ray (see Figure 7). This left 463 radiographs for assessment. These were separated into the different ethnic groups & sexes. Figure 4 shows the breakdown of reviewed radiographs. Radiographs belonging to the Indian

& Chinese groups were thought to be too few for further analysis, and were excluded.

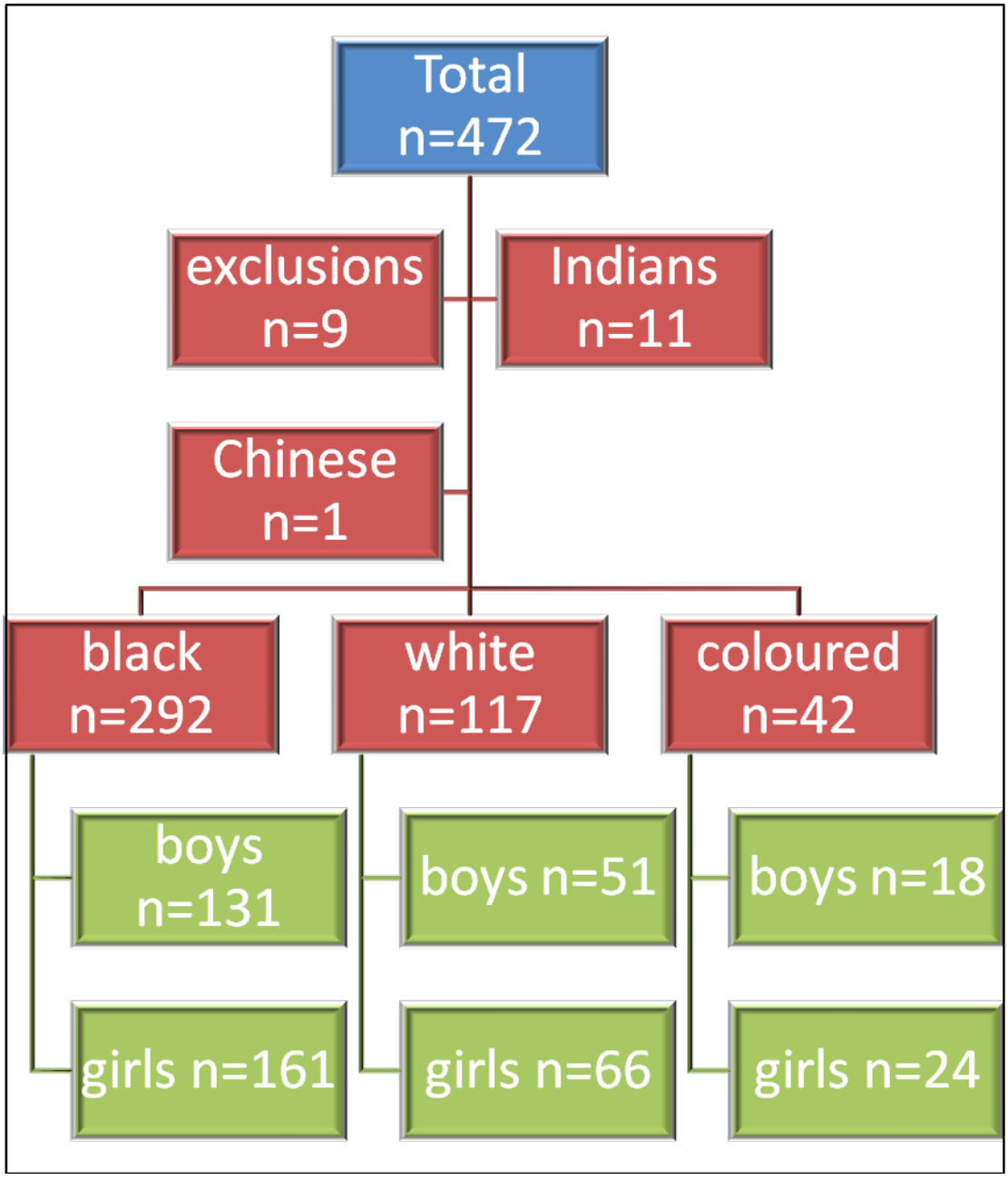


FIGURE 7 Overview of radiographs assessed

3.2 Interobserver variability

Of the 463 radiographs assessed for the Risser sign, there were 12 radiographs for which there were disagreements between the observers. This gave variability between the observers of 2.6%. These radiographs were assessed by a senior spinal surgeon, who determined the final Risser stage assignment.

3.3 Trends in the black population

In the girls, Risser stage 1 starts at an average of 13 years 2 months. This occurs slightly before the population of Scoles *et.al*, however this is not significant. Risser stage 3 occurs at an average of 15 years 2 months, which is later than the population of Scoles *et.al.* Risser stage 4 shows no significant difference. Risser stage 5 occurs at 17

years, and is later than the population of Scoles *et.al* . Table 1 shows the means for each stage.

In the boys Risser stage 1 occurs before the population of Scoles *et.al* , at 14 years and 11 months. Risser stage 2 shows no difference. Risser stages 3, 4 and 5 occurs after the population of Scoles *et.al* . However, Risser stage 3 occurs at 17 years 5 months. This is after the average for stages 4 and 5. Table 1 shows the means for each stage.

Table 1 Mean Chronologic Age (yrs.mo) for the Black Population

		Scoles *et al*			BLACKS					
Risser's Sign	*Gender*	*n1*	*μ1*	*s1*	*n2*	*μ2*	*s2*	*df*	*t(crit)*	*T*
1	Girls	53	13.8	1.1	30	13.28	1.89	81	1.98969	1.9354278
2	Girls	71	14.3	1	7	14.38	1.84	76	1.99167	-0.1955591
3	Girls	65	14.7	0.11	15	15.36	1.26	78	1.99085	-4.0961511
4	Girls	171	16	1.2	37	15.81	1.62	206	1.97155	0.9286216
5	Girls	114	16.11	1.3	72	17.03	1.51	184	1.97294	-5.2005355
1	Boys	39	15.2	1.2	31	14.11	1.89	68	1.99547	3.6932378
2	Boys	58	15.11	1.2	12	15.42	1.53	68	1.99547	-0.8731232
3	Boys	40	16.3	1.4	14	17.55	1.64	52	2.00665	-3.3314302
4	Boys	102	16.11	1.11	40	16.75	1.3	140	1.97705	-3.1811882
5	Boys	93	18	0.9	34	17.31	1.63	125	1.97912	3.2936217

3.4 Trends in other population groups

Table 2 shows the means for white girls & boys. In the girls, there is a trend towards starting Risser stage 1 earlier, although this is not significant. Risser stage 3, 4 & 5 however occur later as compared to the population of Scoles *et.al.* In the boys again stage 1 starts earlier, but stages 4 & 5 ends later. Here again, the mean for Risser stage 4 occurs before that for stage 5. In this population grouping, numbers of radiographs were more of a problem. This is most evident in Risser stage 2 for girls, which had only 1 radiograph for analysis.

Table 2 Mean ChronologicAge (yrs. mo) for the White Population

		Scoles *et al*			WHITES					
Rissers Sign	*Gender*	*n1*	*μ1*	*s1*	*n2*	*μ2*	*s2*	*df*	*t(crit)*	*T*
1	Girls	53	13.8	1.1	4	13.19	1.89	55	2.00404	1.1003224
2	Girls	71	14.3	1	1	16.08	1.84	70	1.99444	-1.7675957
3	Girls	65	14.7	0.11	7	15.32	1.26	70	1.99444	-3.4127442
4	Girls	171	16	1.2	17	15.79	1.62	186	1.9728	0.74273
5	Girls	114	16.11	1.3	37	16.7	1.51	149	1.97601	-2.6830652
1	Boys	39	15.2	1.2	9	11.066	1.89	46	2.0129	9.7300808
2	Boys	58	15.11	1.2	2	15.792	1.53	58	2.00172	-0.8636146
3	Boys	40	16.3	1.4	10	16.242	1.64	48	2.01063	0.1364706
4	Boys	102	16.11	1.11	14	17.06	1.3	114	1.98099	-3.1332818
5	Boys	93	18	0.9	16	16.811	1.63	107	1.98238	4.3879666

Table 3 shows the means for the coloured population. Risser stage 1 occurs earlier for both girls and boys. No other stage shows a significant difference. Numbers, however, are a very big problem in this group. None of the groups have more than 10 radiographs.

Table 3 Mean Chronologic Age (yrs.mo) for the Coloured Population

		Scoles *et al*			COLOUREDS					
Rissers Sign	*Gender*	*n1*	*μ1*	*s1*	*n2*	*μ2*	*s2*	*df*	*t(crit)*	*T*
1	Girls	53	13.8	1.1	5	11.5	1.51	56	2.00324	4.6263114
2	Girls	71	14.3	1	2	14.375	1.237	71	1.99394	-0.1044288
3	Girls	65	14.7	0.11	6	14.458	1.443	69	1.99495	1.2478415
4	Girls	171	16	1.2	4	16.229	1.754	173	1.97377	-0.4116454
5	Girls	114	16.11	1.3	7	16.595	1.511	119	1.9801	-1.087946
1	Boys	39	15.2	1.2	4	13.39	1.509	41	2.01954	3.1179038
2	Boys	58	15.11	1.2	2	16.33	1.649	58	2.00172	-1.5435696
3	Boys	40	16.3	1.4	5	16.0667	1.624	43	2.01669	0.4126237
4	Boys	102	16.11	1.11	3	15.722	2.017	103	1.98326	0.6237607
5	Boys	93	18	0.9	4	17.937	0.567	95	1.98525	0.1308153

Table 4 shows a comparison of the black and white populations in South Africa. There were no statistical differences between the groups except for Risser stage 1for boys. The white boys show a

mean of 11 years for Risser stage 1. This was earlier than any other group.

Table 4 Comparison of Mean ChronologicAge (yrs. mo) of the Black & White Populations

		BLACKS			WHITES					
Rissers Sign	*Gender*	*n1*	*μ1*	*s1*	*n2*	*μ2*	*s2*	*df*	*t*	*Pr>|t|*
1	Girls	30	13.28	1.89	4	13.19	1.89	32	0.09	0.9322
2	Girls	7	14.38	1.84	1	16.08	1.84	6	-0.87	0.4195
3	Girls	15	15.36	1.26	7	15.32	1.26	20	0.06	0.9554
4	Girls	37	15.81	1.62	17	15.79	1.62	52	0.04	0.9717
5	Girls	72	17.03	1.51	37	16.7	1.51	107	1.02	0.3098
1	Boys	31	14.11	1.89	9	11.06	1.89	38	2.54	0.0152
2	Boys	12	15.42	1.53	2	15.79	1.53	12	-0.31	0.7610
3	Boys	14	17.55	1.64	10	16.24	1.64	22	1.40	0.1756
4	Boys	40	16.75	1.3	14	17.06	1.3	52	-0.74	0.4647
5	Boys	34	17.31	1.63	16	16.81	1.63	48	0.04	0.9651

Graphical representations of all results are shown in figure 8 and 9.

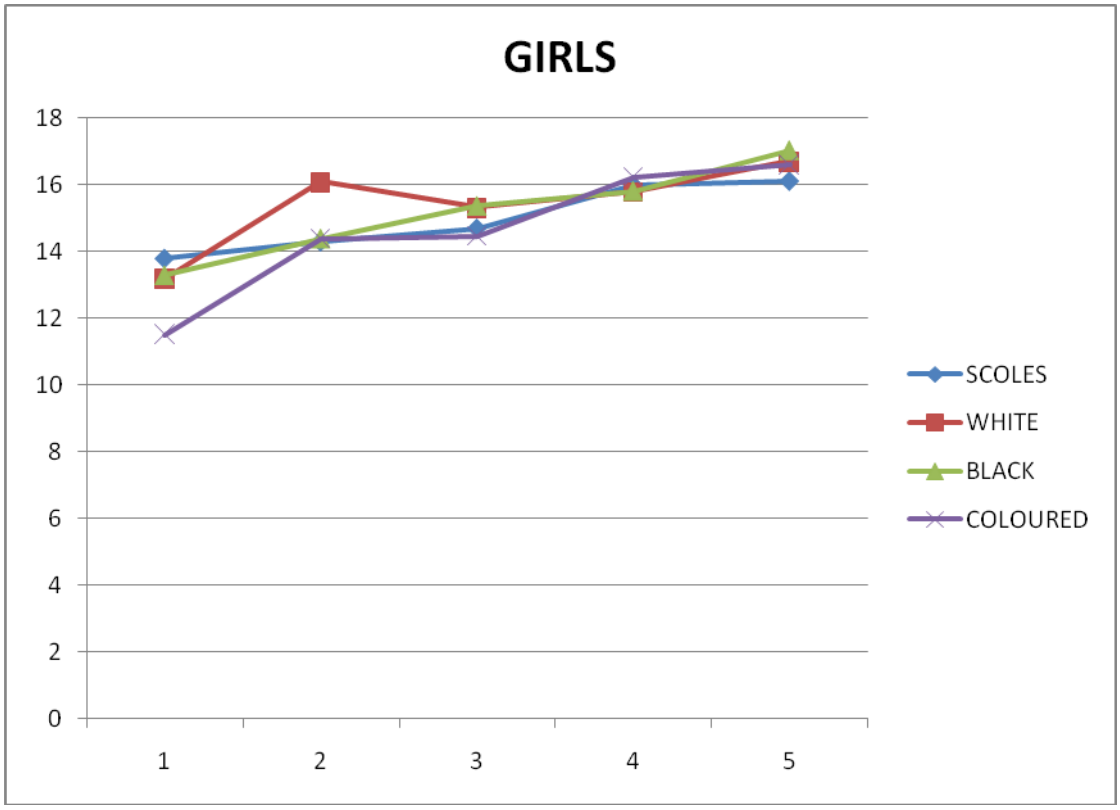


FIGURE 8 Plot of mean ages at each Risser stage for girls, in each population group

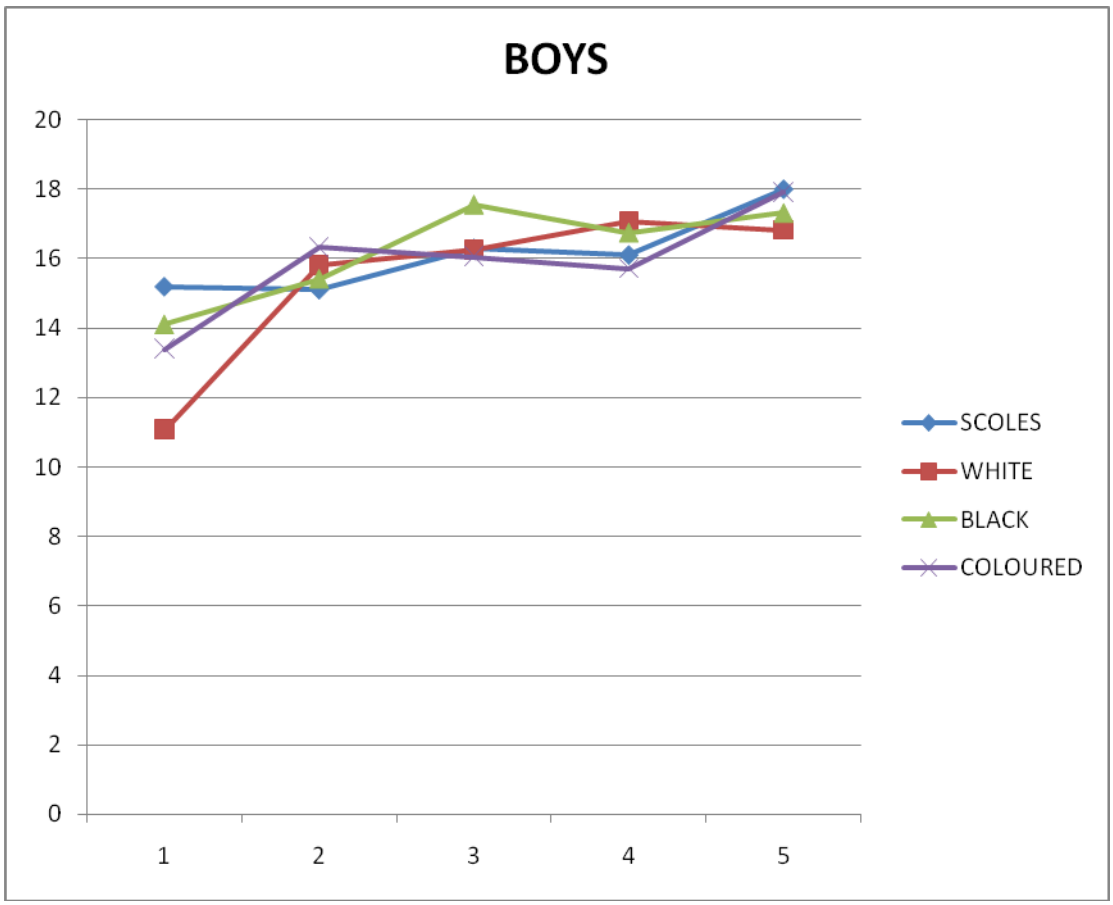


FIGURE 9 Plot of mean ages at each Risser stage for boys, in each population group

4. DISCUSSION

The Risser sign was first described by J.C.Risser in a paper in 1957, which was entitled, “The iliac apophysis: An invaluable sign in the management of scoliosis.” Despite drawbacks, it still remains an invaluable sign, and is still widely used by spinal surgeons.

4.1 Interobserver variability

One of the reasons the Risser sign remains in use is the fact that it is readily visible on the standard set of scoliosis radiographs. There is no need for an extra radiograph.

Another reason is the ease of assessment of radiographs, and the ease of assignment of a Risser stage. This was evident in our finding of only a 2.74% disagreement between the 2 observers. These disagreements occurred for 2 reasons. The

first reason is that the presence of bowel gas sometimes obscured the view of the iliac apophysis. This was more of a problem on abdominal radiographs, which made visualization of the posterior segments difficult. It was also noted that most of the abdominal radiographs were done for abdominal pain, & presented with bowel distension. Figure 10 shows such a patient with distended bowel due to volvulus, where the iliac apophysis is obscured.

The second reason for disagreements was that ossification does not always proceed linearly & stepwise between the quadrants, & sometimes quadrants were left unossified, or were “skipped”. Where this occurred, the most posterior portion that was ossified was used for assignment of the Risser stage. An example of this can be seen in Figure 11. This phenomenon was noted by Risser also, as he found that, “after the usual capping or

the appearance of ossification anteriorly & laterally on the iliac crest, further development may occur posteriorly, leaving a space, or gap, to be filled in later."(3)

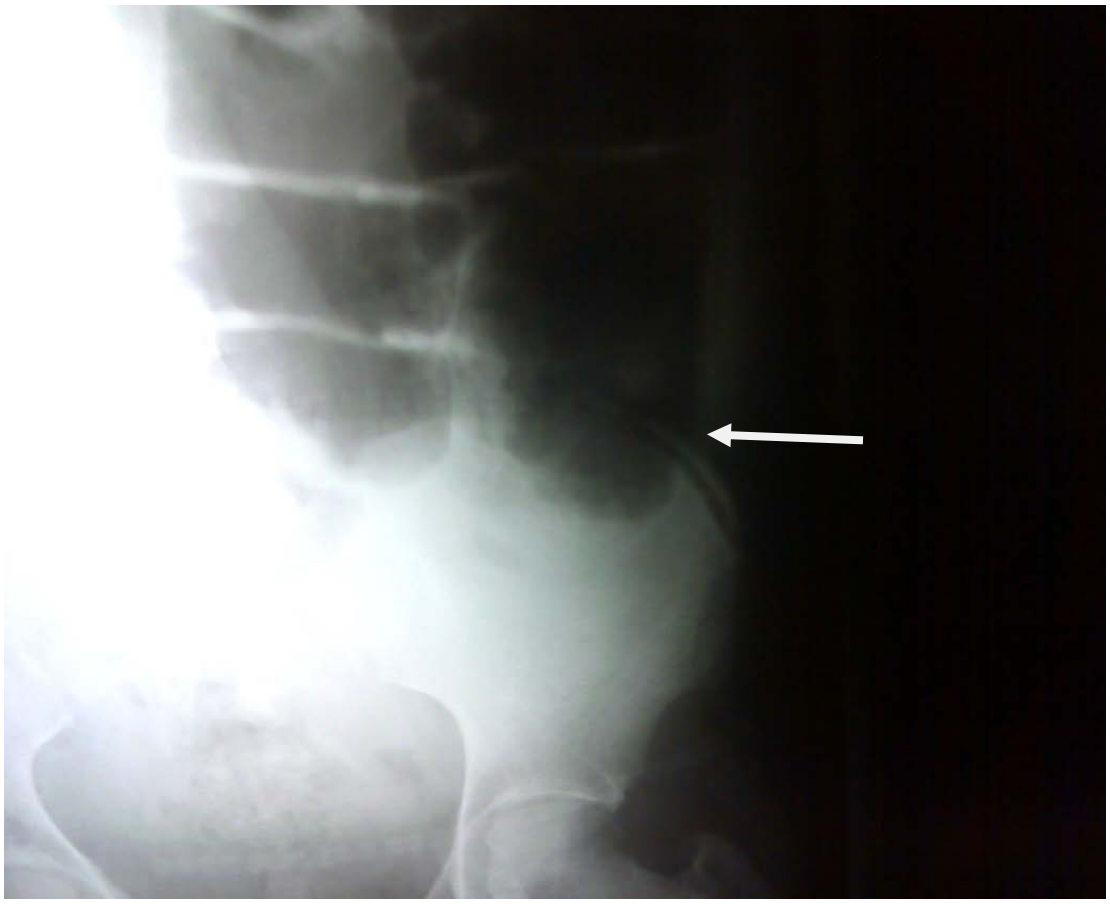


FIGURE 10 Presence of bowel gas obscuring apophysis

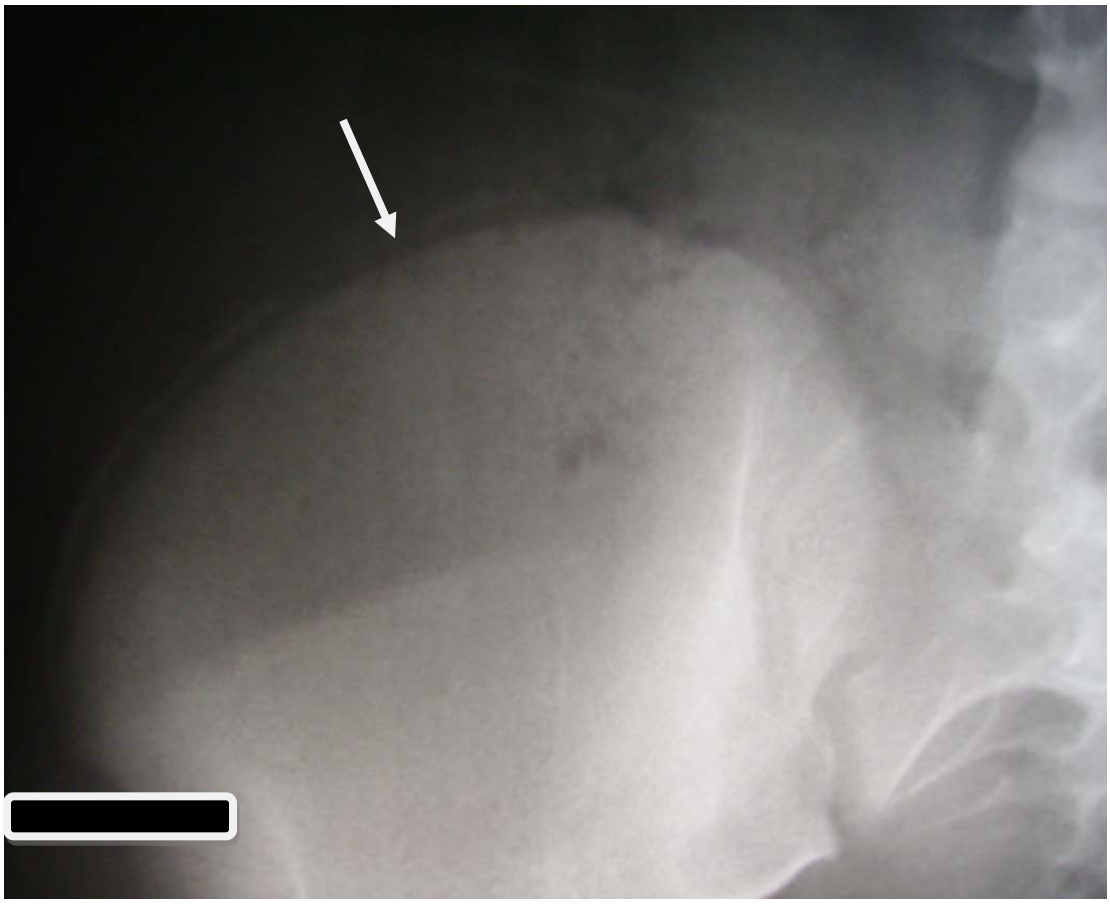


FIGURE 11 Unossified or skipped portion of iliac apophysis

4.2 Trends in the black population

Ossification started earlier in the black population, however it ended later. This was more pronounced in boys than girls, & actually reached statistical significance. This is suggestive of a more prolonged course of ossification in the South African black population as compared to the population of Scoles *et.al.*

There was however an anomalous finding for Risser stage 3 for boys. It occurred after the averages for Risser stages 4 and 5. This group of individuals had a smaller number of radiographs, which may account for the problem. 9 out of the 15 radiographs had ages that were 12 years or older. The numbers for Risser stages 2 and 3generally were a problem. This indicates a possibility that ossification passes quickly through these stages. It

is therefore possible that for Risser stage 3 in black boys we found a large number of radiographs that had delayed or prolonged ossification.

4.3 Trends in other population groups

In the white population a similar trend was found. Ossification started earlier and ended later. Again this was suggestive of a prolonged course. Here too there was an anomalous finding in that in boys Risser stage 4 occurred after Risser stage 5.this was again thought to be due to the small numbers. Numbers in the coloured group were even more of a problem, and radiographs were very limited. Even though they started earlier, no meaningful conclusions could be drawn.

The comparison between black and white populations in South Africa was interesting in that they had similar trends. The only group that differed was Risser stage 1 for boys. The white

group had only 9 radiographs for assessment, 5 of which had ages below 12 years. This similarity between the groups suggests that climatic conditions might be more important than genetics for Risser staging.

Figure 9 shows that the plots for the black and white boys are almost identical, & also shows their similarities. These plots also have a steeper gradient as compared to those of Scoles *et.al*, which indicates a more prolonged course. The plots for the girls in Figure 10 show similar trends as the boys, although it is not as clear, and the plots tend to lie much closer together.

4.4 Limitations of the study

Most of the limitations of the study stem from the fact that it used radiographs that were available in records departments. This meant a limited number of radiographs only were available. This meant

smaller numbers for certain groups. This underpowered the study, particularly in the white and coloured groups.

A second limitation of using radiographs in records is that it is just a snapshot in time. Individuals do not have serial radiographs, to allow charting of the exact time for each stage. This is not as critical in Risser stages 1-4 as individuals spend only a limited amount of time in each stage. However, for Risser stage 0 that time is too large for any conclusions to be drawn. Similarly, with Risser stage 5, we are unable to know when it was reached, or for how long the individual had been there.

The third limitation was in the study design, which did not cater for socioeconomic differences. Allowing for this would have made the study more difficult to carry out logistically and would have made ethical clearance more difficult to attain.

There is no literature available currently that deals with the effect of socioeconomics on Risser staging, and even though reason suggests that it might, we chose not to tackle this issue based on this.

The fourth limitation is the failure to check intraobserver variability. This was not done as most of the radiographs used in the study were destroyed by the records departments and could not be recovered, as the radiograph collection for this part of the study was attempted almost 20 months after initial data collection started. The idea was subsequently abandoned, as only a few of the original radiographs could be found. None of the papers that were previously quoted had checked for intraobserver variability.

5. CONCLUSIONS

Different trends were found in the South African black population, as compared to that of Scoles *et.al.* This was more significant in males than females. The start of ossification came earlier, but the end came later. This suggested a more prolonged course.

Similar trends were also found between black & white South Africans, which suggests the importance of climatic influence over genetic control.

6. REFERENCES

1) Morrissy and Weinstein :Lovell & Winter's pediatric orthopaedics,6th Ed.,p35-65 & 693-762, Lippincott Williams & Wilkins
2) Sanders J.O. : Maturity indicators in spinal deformity, JBJS-A 2007 89:14-20
3) Scoles, Salvagno, Villalba, Riew : Relationship of iliac crest maturation to skeletal and chronologic age, Journal of pediatric orthopaedics 1988 8(6):639-644
4) Risser : The iliac apophysis:an invaluable sign in the management of scoliosis, Clinical Orthopaedics 1958 11:111-119
5) Sanders, Browne, McConell, Margraf, Cooney and Finegold : Maturity Assessment & curve progression in girls with idiopathic scoliosis, JBJS-A 2007 89:64-73
6) Sun, Schubert, Chumlea, Roche, Kulin, Lee, Himes and Ryan : National estimates of the timing of sexual maturation & racial differences among US children, Pediatrics 2002 110(5):911-919
7) Grivas, Vasiliadis, Mouzakis, Mihas & Koufopoulos : Association between adolescent idiopathic scoliosis prevalence & age at menarche in different geographic latitudes, Scoliosis 2006 1(9)

8) Hung, Cheung, Lam, Ng, Tse, Guo, Lee & Cheng : Osteopaenia: a prognostic factor of curve progression in adolescent idiopathic scoliosis, JBJS-A 2005 87:2709-2716
9) Biondi, Weiner, Bethem & Reed : Correlation of Risser Sign & bone age determination in adolescent idiopathic scoliosis, Journal of pediatric orthopaedics 1985 5:697-701
10) Sanders J.O, Khoury J.G, Kishan S, Browne R.H, Mooney J.F III, Arnold K.D, McConell S.J, Bauman J.A, Finegold D.N : Predicting scoliosis progression from skeletal maturity:A simplified classification during adolescence, JBJS-A 2008 90:540-553
11) Wang, Qui, Ma, Xia, Zhu & Zhu : Histologic, Risser sign, & digital skeletal age evaluation for residual spine growth potential in Chinese female idiopathic scoliosis, Spine 2007 32(15):1648-1654
12) Bitan F.D, Veliskakis K.P, Campbell B.C : Differences in the Risser grading systems in the United States & France, Clinical orthopaedics and related research 2005 436:190-195
13) Ontell, Ivanovic, Ablin, Barlow : Bone age in children of diverse ethnicity,

American Journal of Radiology 1996 167:1395-1398
14) Wang, Qui, Ma, Xia, Zhu & Zhu : Histologic, Risser sign, and digital skeletal age evaluation for residual spine growth potential in Chinese female idiopathic scoliosis, Spine 2007 32(15):1648-1654
15) Prescott, P Encyclopedia of Statistical Sciences 2006 13:8371-8376

7. APPENDICES

Appendix A Mean chronologic ages for boys and girls as found by Scoles *et. al.*

TABLE 2. *Chronologic age (yrs, mo) by Risser's sign*

Risser's sign	Girls			Boys			Difference in means (mo)	*t* Test value
	n	Mean	SD	n	Mean	SD		
1	53	13,8	1,1	39	15,2	1,2	18	5.9[a]
2	71	14,3	1,0	58	15,11	1,2	20	8.3[a]
3	65	14,7	0,11	40	16,3	1,4	20	6.4[a]
4	171	16,0	1,2	102	16,11	1,11	11	6.4[a]
5	114	16,11	1,3	93	18,0	0,9	13	7.3[a]

[a] Significant at $p < 0.05$.

Appendix B Ethics clearance certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49 Mayet

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER M080112**
PROJECT	The Risser sign trends in a SA Black population
INVESTIGATORS	Dr Z Mayet
DEPARTMENT	Orthopaedic Surgery
DATE CONSIDERED	20080125
DECISION OF THE COMMITTEE*	Approved unconditionally

Unless otherwise specified this ethical clearance is valid for 5 years and may be renewed upon application.

DATE 08.04.02 **CHAIRPERSON** .....
(Professor P E Cleaton Jones)

*Guidelines for written 'informed consent' attached where applicable

cc: Supervisor : Professor M Lukhele

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University.
I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to a completion of a yearly progress report.**

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix C Data collection sheet

The Risser Sign-Data Form for statistics

No : _____

Age : _____

Ethnic group : _____

Risser stage : 0 1 2 3 4 5