ORIGINAL ARTICLE

Age related reference ranges of respiratory rate and heart rate for children in South Africa

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Arch Dis Child 2006;91:330-333. doi: 10.1136/adc.2005.085290

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Accepted
21 December 2005
Published Online First
6 January 2006

Background: The authors have recently presented reference ranges for heart rate and respiratory rate in healthy resting schoolchildren, aged 4-16 years, in the United Kingdom. There are no similar ranges for children in the developing world.

Aims: To undertake a study in Cape Town, South Africa, to establish whether the UK ranges may be applied to socioeconomically disadvantaged groups.

Methods: Data on 346 children in a township school were recorded; their height, weight, heart rate, and respiratory rate were compared to the UK ranges.

Results: The two groups plotted closely together by height and weight on the UK 90 growth reference charts. There was no difference in heart rate between the two groups, and a difference of 0.46 breathes per minutes in respiratory rate, which is not felt to be of clinical significance.

Conclusion: The reference ranges of heart and respiratory rate derived in the UK may be applied to children in developing world situations.

We have recently challenged the ranges of heart rate (HR) and respiratory rate (RR) that are quoted in medical texts¹⁻³ and life support courses,⁴⁻⁵ citing the lack of evidence on which these ranges are based.⁶ We derived reference ranges for RR and HR in healthy schoolchildren in the United Kingdom, aged from 4 to 16 years, and presented these as medians with 95% reference interval (2.5th, 97.5th centiles). While these ranges are helpful for children in the UK, by themselves they provide no information about the ranges of these values in other countries. One such country is South Africa, where many sectors of the paediatric population suffer from high rates of poverty, malnutrition, and chronic diseases (including HIV/AIDS).⁷⁻⁹

We undertook a study to determine whether the physiological ranges that we derived in the UK could be applied to socially disadvantaged schoolchildren in South Africa.

METHODS

The Chris Hani Memorial School is a charity funded informal school in the Langa township (a historically disadvantaged area) of Cape Town. It educates 392 black children aged 5-16 years who have not had their birth registered and therefore are unable to enter the state school system.

The Ethics Board at the University of Cape Town (UCT) was approached for ethical approval. However, the Board's opinion was that ethical approval and consent were not required. Preliminary visits to the school by LAW allowed explanation of the project to the children and teachers. Letters were sent to all parents, offering them the opportunity to decline to allow their child to participate. No refusals were received.

Data collection

All children were seen in their school by a single investigator (LAW), in the presence of a female nurse chaperone, in a one month period. Children were brought out of their classrooms and left to sit quietly outside the study room for five minutes.

The child sat fully clothed in a well lit classroom and their RR was counted over 60 seconds. They then had their HR measured for 60 seconds using a Datex S5 Lite monitor. A

finger probe was used in all cases. Recording did not commence until a suitable trace with a regular, pulsatile waveform was achieved continuously for 20 seconds. Data were transferred real time to a computer, using Datex software: recordings were made at 5 second intervals for 60 seconds. The mean of these recordings was registered as the child's HR. Ambient temperature was recorded in the room at the same time.

Children then had their standing height recorded using a Leicester height meter, and weight using analogue metric scales calibrated by the department of medical physics at the Red Cross Children's Hospital. All equipment was the same as had been used in the UK arm of the study.

Children who were unwell on the day of the study (but were well enough to attend school) were still included in the sample, as were children with diagnosed or undiagnosed medical conditions. No attempt was made to identify these children in the database.

Data analysis

The heights and weights of the children were plotted on the UK 90 growth charts,¹⁰ to determine whether they could be considered to be similar to a UK population. Each plot was at the mid point of that year on the centile chart (that is, the median weight for 6 year olds was plotted at 6.5 years on the chart). Height was plotted as mean value, and weight as median.

For the physiological values at each age, median, inter-quartile range (IQR), and range were derived and plotted against the reference ranges derived in the UK.⁶ Age was considered to be age in years at the last birthday. The data were therefore considered as 12 separate frequency distributions, from 5 to 16 years (the 4 year old age group in the UK was ignored for these analyses). Two way analysis of variance was undertaken to determine any difference in the values of each of these parameters between the two countries. Analysis was undertaken on SPSS software.

Abbreviations: HR, heart rate; RR, respiratory rate

Table 1 Age and sex distribution (n = 346)

Age (y)	Male	Female	Total (%)
5	15	13	28 (8.1)
6	21	20	41 (11.9)
7	9	15	24 (6.9)
8	12	12	24 (6.9)
9	6	14	20 (5.8)
10	13	10	23 (6.7)
11	22	16	38 (11.0)
12	13	13	26 (7.5)
13	16	13	29 (8.4)
14	16	17	33 (9.5)
15	8	20	28 (8.1)
16	13	19	32 (9.3)
	164	182	

RESULTS

All children who were present on the days of data collection took part in the study—a total of 346 (88%). None of the children were known to have any medical conditions. Table 1 shows the age and sex distribution; 182 were female (52.6%). Table 2 shows the age ranges and means. The smallest group was the 9 year olds (n = 20); the number of 6 year olds was 41.

The mean ambient temperature was 25°C. The UK sample had failed to show a relation between the ambient temperature and the physiological values, and no relation was evident in this sample.

Height and weight

The height and weight of both sexes plotted mostly between the 25th and 50th centiles of the UK 90 growth reference charts. In girls, 15 and 16 year olds approached the 75th centile for height and weight. Boys showed similar curves, but at a slightly lower centile: for weight, they tracked towards the 25th centile until the older age group, where 14–16 year olds touched the 50th centile. Boys were slightly shorter than girls, plotting close to the 25th centile throughout all ages.

Heart and respiratory rate

Table 3 shows the median HR and RR. They are plotted, with IQR and range, against UK centiles in figs 1 and 2.

Two way analysis of variance was undertaken, and showed that there was no significant difference between the groups by HR ($p = 0.286$). With regard to RR, there was a significant difference, with the South African children having a mean 0.42 breaths per minute higher RR than their UK counterparts ($p < 0.0005$); this difference was minimal under age 10, and almost 0.9 bpm after age 10 years.

DISCUSSION

All children in this study live at sea level, therefore there will be no effect of altitude on these results. The study sample live in one of the poorest areas of Cape Town; while no attempt has been made to quantify the socioeconomic status, it is reasonable to state that these children are from a deprived

Table 2 Group size; range, mean, and median in each one year age group (n = 346)

	Male	Female	Total
Range	6–22	10–20	20–41
Mean	13.7	15.2	28.8
Median	13.0	14.5	28.0

Figure 1 Heart rate (beats per minute) versus age; South Africa median, IQR, and range against UK 2.5th, 97.5th centiles. **Figure 2** Respiratory rate (breaths per minute) versus age; South Africa median, IQR, and range against UK 2.5th, 97.5th centiles.

background. However, the school that they attend is charity funded and may, therefore, provide a degree of poverty alleviation not seen by many children in this country.

Height and weight

The growth of children in parts of the developing world has been studied extensively,^{11–17} as has the change in growth of such children when they emigrate to more advanced nations.^{18–21} With some minor ethnic variation, such children typically adopt the growth patterns of their adopted country. Socioeconomic status, not ethnic origin, is believed to be the major determinant of growth.^{13 22 23} Growth is also known to be adversely affected by the presence of chronic medical conditions.^{22 24 25} The UK sample in this study failed to show a relation between height or weight and the HR or RR; similarly, there was no relation evident in this sample.

It was hoped to plot the South African children against a larger cohort of height and weight data from that country. However, no such data were available at the time of this study. The paediatric growth charts in current use are based on American values.

The children in this study are socially disadvantaged and have a high incidence of chronic medical conditions.^{7 8} Despite this, they lie between the 25th and 50th centiles of the UK 90 growth reference standards (although these standards for weight may now be incorrect with the increase in obesity in UK children^{26 27}), being slightly smaller and lighter as a whole than their UK peers.

What is already known on this topic

- Reference ranges for heart rate and respiratory rate have been derived for healthy UK children
- Similar data do not exist throughout the developing world

In the UK sample on whom the current RR and HR reference ranges were derived,⁶ both sexes plotted between the 50th and 75th centiles for height and weight (with girls being slightly taller and heavier). As both samples plot close together around the 50th centile of the UK 90 charts, they may be considered similar enough by growth to undertake further physiological analysis between the two groups.

Respiratory rate and heart rate

With regard to HR and RR, there are no current reference ranges for children in South Africa (or in the developing world generally). There are some data on RR in children with a variety of acute medical conditions, most notably respiratory infections²⁸ or malaria.²⁹ However, these are of no help in determining reference values for "normal" healthy children.

This study compared the measured HR and RR to the reference ranges for 4–16 year old UK children. With regard to HR, there was no difference between the two groups: there are up to four beats per minute differences at the extremes of age, but these occur in opposite directions, and are not felt to be clinically significant at this level. For RR, a significant difference exists, with the South African children having a mean 0.42 breaths per minute higher RR than the UK group (becoming most apparent after 10 years of age where it is over 0.8 breaths per minute). This difference is statistically, but not clinically, significant; measurement of less than one breath per minute is not possible and, pragmatically, the two groups may be considered to have identical RR.

It is accepted that measurement over a one minute period may miss some of the minute to minute variation in the values of HR and RR in these children. A sample of just under 10% of the study group (n = 32) had their measurements repeated after 5 and 10 minutes: there were no significant differences in the values recorded in these children at any of these times (RR varied by a mean of under 1 bpm; HR less than 5 bpm).

This population of South African children may be considered to share the same reference range of HR and RR as those studied in the UK; these ranges are shown in the figures and have recently been published.⁶ The ranges are applicable at sea level.

Table 3 Heart and respiratory rate medians, South African children (n = 346)

Age (y)	Heart rate (bpm)*	Respiratory rate (bpm)†
5	91	22
6	86	22
7	92	21
8	84	20
9	90	19
10	84	18
11	82	19
12	80	17
13	78	17
14	79	16
15	78	16
16	72	15

*bpm, beats per minute; †bpm, breaths per minute.

What this study adds

- Reference ranges for heart rate and respiratory rate for socioeconomically deprived children in South Africa have been derived

Conclusion

This paper has compared the RR and HR of schoolchildren aged 5–16 years in two distinct populations: a South African township and UK city. We have established that, despite their socioeconomic and health disadvantages, the resting physiology of the South African children is no different to the UK derived reference ranges. These reference ranges may be used as the "normal" ranges of healthy 5–16 year old children at rest.

ACKNOWLEDGEMENTS

We are indebted to the pupils and staff of Chris Hani Memorial School for their kindness and willingness in this study.

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Competing interests: none

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IMAGES IN PAEDIATRICS.....

doi: 10.1136/adc.2005.086348

Appendiceal appearances: the great imitator

A 7 year old boy presented with a four week history of nocturnal back pain, weight loss, lethargy, intermittent temperatures, and new onset of scoliosis. On examination, he was clinically anaemic and cachectic, with widespread lymphadenopathy. There was an ill defined fibrous feeling mass overlying the right 7th–10th postero-lateral rib area. The thoracolumbar scoliosis was positional and related to discomfort on movement. There was no organomegaly and abdominal examination was unremarkable. Haemoglobin was 87 g/l, white blood cell count was normal, and INR was 1.5. Childhood malignancy was suspected.

The antero-posterior chest radiograph showed a mild dorsal scoliosis with lateral soft tissue swelling overlying the 9th–10th ribs. MRI scan showed a 6×4×4 cm partly solid partly cystic lesion lying postero-lateral to the right lobe of the liver and immediately lateral to the upper pole of the kidney (see fig 1). This abscess also resulted in associated changes to the right intercostal muscles.

Surgical intervention revealed a perforated retrocaecal appendix, liver adherence to the ribs and diaphragm, and an abscess in the posterior aspect of

the right liver lobe. The liver abscess pus was negative on culture and the child recovered fully following a course of intravenous antibiotics.

Recognised presenting features of acute appendicitis may be minimal or absent in children and may imitate childhood malignancy.¹ Radiologists have a major role in suggesting complicated inflammatory disease of the appendix as a cause.

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Competing interests: none declared

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Figure 1 MRI scan of the thorax (T2 weighted image) illustrating abscess. Note the associated thoracic wall changes.