The effects of schistosomiasis on spontaneous play activity in Black schoolchildren in endemic areas

An ethological study

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Summary

An ethological study was undertaken in two primary schools in Natal to assess the effect of schistosome infections on the spontaneous activity of schoolchildren in endemic areas. Results indicate that there is selective exposure of more active children to the disease. In low-level infections with *Schistosoma haematobium* (<1000 eggs excreted in a 2-hour midday period) or *S. mansoni* (<1000 eggs/g dry weight of stool) there is little evidence of a decrease in energetic activity under normal conditions. In subjects with higher egg counts or infections with both schistosomes activity levels generally fall, especially under hot, humid weather conditions, when the fall in activity is greater than that for control subjects.

Research into the effects of schistosomiasis on activity has yielded confusing and often contradictory results. Failure to achieve clarity may be attributed to two problem areas:

**Adequate performance measures.** Performance has been measured in terms of work productivity in adults, activity potential in the form of oxygen uptake during a laboratory task, physical fitness in anthropometric terms, and physical fitness through running races.1 If, as recent research suggests, activity potential is affected in severe *S. mansoni* infections,2 the relationship between this and actual performance needs to be clarified and appropriate performance measures selected.

**The nature of schistosomiasis itself.** In Africa *S. mansoni* and *S. haematobium* infestations often occur in the same areas and individuals; the severity of each type varies considerably, and individuals may be infected with either or both. Appropriate standards need to be selected.

The present study was addressed to these research problems and took the form of an ethological study of spontaneous play activities of schoolchildren in two endemic areas. An ethological study typically has an extended initial descriptive stage in which measures are selected and tested and hypotheses generated. The second phase deals with the specific testing of these hypotheses. This study dealt with several aspects of behaviour, but only those relating to activity will be discussed here.

Hypotheses

The procedure and some of the results of the descriptive phase have been published elsewhere.3,4 The descriptive phase was conducted at a primary school in the Adams Mission area near Durban, where *S. haematobium* is prevalent and *S. mansoni* almost completely absent.5 The major hypotheses concerning activity emerging from the descriptive phase are as follows and apply only to *S. haematobium*.

**Infected subjects generally show higher activity levels than control subjects.** In 2 of the 3 studies most of the infected subjects showed higher activity levels than control subjects, particularly in the category of energetic activity. This category referred to activities involving overt expenditure of effort such as running, skipping and jumping, and excluded walking and shuffling. Two interpretations of this finding are possible: (i) high activity in the infected subjects may be a result of the infection; and (ii) it might be a reflection of selective exposure to the parasite by the more active children in a community.

**Activity levels drop in subjects with high egg counts or long-term infections.** When a group of subjects with infections of less than 1 year’s duration and a mean egg count of 800 excreted in a 2-hour midday period was compared with subjects with long-term infections and a mean egg count of 5040 excreted in a 2-hour midday period, activity levels were found to be lower in the latter. This suggested that the severity or the duration of the schistosomiasis infection was a factor in causing impairment.

**Infected subjects show lower activity scores under more stressful conditions.** When observations took place in the afternoon1 as opposed to the early morning, activity levels dropped more in infected subjects than in control subjects. The same effect was observed during a heat wave when humid weather conditions prevailed.4

Procedure

**Selection of an appropriate activity measure for more extensive hypothesis testing**

Because the energetic level of activity seemed to be the most informative measure of activity differences between groups, a small electronic meter was developed to monitor energetic activity. This consisted of a pulse counter with a digital read-out. On the counter a small weight which moved vertically activated a reed switch. Movements in the vertical plane only were recorded, because these include all actions which made up the energetic activity category in the descriptive phase; running, jumping and skipping were recorded while walking was not. The prototype of the meter was tested for validity and reliability and found to be satisfactory. A Spearman rank order reliability coefficient of 0.92 was obtained on 25 pairs of meters. Fifty meters were built encased in shatterproof perspex, and worn on
The subjects
Subjects were selected by members of the Research Institute for Diseases in a Tropical Environment; egg-counting techniques and categorization into different levels of infections were used as described by Schutte et al. Behaviour was measured without knowledge of the infection status of the subjects. Medical reports were made available from a health assessment of the children conducted concurrently (P. Naiker—unpublished data).

Studies were made in 2 primary schools in areas with different schistosomiasis patterns. In the first study 33 subjects infected with S. haematobium were matched for age, sex and approximate build with control subjects from the same class at Adams Mission Primary School. These were different subjects from those studied in the descriptive phase. The infected subjects had varying levels of S. haematobium infection, although most had an average egg count of less than 1 000 excreted in a 2-hour midday period.

The second study took place at Embogodweni Primary School, where both S. haematobium and S. mansoni infestation were prevalent. There were four groups of subjects: an uninfected control group (28 subjects), a group with S. haematobium infestation only (27 subjects), a group with S. mansoni infestation only (24 subjects) and a group with both S. haematobium and S. mansoni infestations (39 subjects).

Methods
Belts containing meters were tied on the children at the start of the lunch break. The children were then free to pursue their normal lunchtime activities and were unaware that activity was being monitored. The duration of the lunch break was 1 hour at Adams Mission and 45 minutes at Embogodweni.

The Adams Mission study was intended as an in-depth investigation of energetic activity and social interaction. Energetic activity was monitored for approximately 23 separate hours per subject in a wide variety of weather conditions over a 4-month period. In contrast the Embogodweni study took place over a 3-week period in fairly uniform weather conditions. No social interaction data were taken and energetic activity was monitored for an average of four lunch breaks per subject. Subjects with disease other than enlargement of the liver and abnormalities in the rectum were excluded from this study.

Results
The results for boys and girls are presented separately because the pattern is the same although the scores differ. The scores of the two schools are not directly comparable because of the different lengths and structuring of the time (Table I).

Adams Mission
There are no significant differences between the mean activity scores at Adams Mission, although the mean for the infected group is higher for both boys and girls. The finding is, however, consistent with the selective exposure hypothesis. The hypothesis was supported by the social interaction data which showed that the infected children were more often members of the main play groups, and led and organized play activities more often. The significantly smaller coefficient of relative variation implies that the infected group was more homogenous with respect to activity, suggesting that there was some impairment because the highest scores of the infected subjects were not as high as those of some of the control group members.

Regression analysis was considered to investigate the hypothesis that severity of infection is a factor causing impairment, but was rejected for the following reasons:
1. A scattergram showed that if any relationship existed between egg count and activity score, it was curvilinear and would require further transformation before regression analysis.
2. It seemed unlikely that regression analysis would reveal any significant trends in view of the scarcity of moderate and high-level infections, coupled with the low rank order correlation between egg count and activity in the Adams Mission sample.
3. The data from the Adams Mission and Embogodweni studies could not be combined because they differed in respect of reliability, environmental circumstances, time span and pattern of infection. Within each study male and female scores would have to be analysed separately because the mean activity scores for males were consistently higher. Sample sizes would therefore be very low.
4. It would be naive to expect a one-to-one relationship between egg counts and activity when personality factors, the presence of other parasites and different nutritional standards might account for individual differences in activity.

In order to investigate the hypothesis that impairment is evident in infected subjects under adverse weather conditions, an analysis of variance programme was run on the University of Natal computer using four factors thought to affect activity. The analysis of variance technique was thought to be appropriate because it is reasonable to assume that the distribution of activity scores is normal in the populations (male and female) from which the samples were drawn. Furthermore, in view of the significance of the observed four-factor interaction, deviations from normality would be unlikely to reduce this result to non-significance.

For this analysis all subjects having physical impairment other than schistosomiasis were excluded from the sample. The four factors were sex, severity of S. haematobium infection, midday temperature and midday wind force. A highly significant four-factor interaction was found to be operating (F ratio = 793.3). In order to interpret this, a series of three-dimensional graphs were drawn with temperature and wind velocity as the control factors and the activity scores producing the behaviour surface. Three severity condition surfaces were compared: (i) uninfected subjects (N = 25); (ii) infected subjects with egg counts of less than 1 000 (N = 20); and (iii) infected subjects with egg counts greater than 1 000 (N = 10).

The surfaces for the severity 1 and severity 2 graphs were very similar, but the severity 3 graph showed a very different surface. The severity 3 subjects were less active on the days with the highest temperatures (over 25°C) and wind conditions of 36-100

| TABLE I. SUMMARY OF ACTIVITY SCORES (PER HOUR) AT ADAMS MISSION |
|-----------------|-----------------|-----------------|
|                 |                 | Coefficient of relative variation |
|                 |     |     |     |
|                  | N   | Mean | ²n   |      |
| Girls           |     |     |     |      |
| Infected        | 16  | 790.74 | 162.46 | 20.25 | P = 0.03 |
| Uninfected      | 16  | 694.15 | 234.32 | 34.41 |      |
| Boys            |     |     |     |      |
| Infected        | 15  | 1006.17 | 228.77 | 23.22 | P = 0.08 |
| Uninfected      | 15  | 994.37 | 362.91 | 33.81 |      |
| Total           |     |     |     |      |
| Infected        | 31  | 894.98 | 224.80 | 25.13 | P = 0.0129 |
| Uninfected      | 31  | 839.42 | 338.49 | 40.32 |      |

In all tables the difference between mean activity scores for infected and uninfected groups has been tested using the Mann-Whitney U test. Unless otherwise stated the difference is not statistically significant at the 5% confidence level.
m/s. On days with moderate wind and moderate temperature conditions their activity levels were higher than those of the other two groups.

**Embogodweni**

The results for the Embogodweni study were grouped in two ways: (i) according to the type of schistosomiasis present; and (ii) according to severity within each type.

The mean activity score for the group with only *S. haematobium* infestation was higher than the control group mean in both boys and girls, as in the Adams Mission study (Table II). The group with *S. mansoni* infestation only showed a similar pattern. Activity levels dropped, however, in subjects infected with both schistosomes. Once again the control groups had higher relative variation coefficients than the *S. haematobium*-only groups and the other infected groups as well. These findings are consistent with the selective exposure hypothesis for both *S. haematobium* and *S. mansoni* and suggest impairment of performance in subjects with double infections.

**Table II. Mean Activity Scores (per 45 min) for Groups with each Type of Schistosome Infection**

<table>
<thead>
<tr>
<th></th>
<th>Uninfected controls</th>
<th><em>S. haematobium</em> only infections</th>
<th><em>S. mansoni</em> only infections</th>
<th>Double Infections</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td>561.6</td>
<td>643.2</td>
<td>738.1</td>
<td>569.6</td>
</tr>
<tr>
<td>Girls</td>
<td>560.7</td>
<td>575.3</td>
<td>586.4</td>
<td>544.0</td>
</tr>
</tbody>
</table>

Mean activity scores for different levels of *S. haematobium* infestation were tabulated (Table III) and the inverted U trend for the activity scores was found to be significant in the case of the girls. The drop in scores between the groups with mild and moderate infection was also significant for the girls (*P* = 0.02).

**Table III. Mean Activity Scores (per 45 min) for Different Levels of S. Haematobium Infection (measured as Eggs/g dry weight of stool)**

<table>
<thead>
<tr>
<th></th>
<th>Uninfected controls</th>
<th>&lt;1000 eggs</th>
<th>1000-5000 eggs</th>
<th>&gt;5000 eggs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td>561.6 (<em>N = 14</em>)</td>
<td>599.1 (<em>N = 22</em>)</td>
<td>577.1 (<em>N = 10</em>)</td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>560.7 (<em>N = 14</em>)</td>
<td>616.9 (<em>N = 23</em>)</td>
<td>542.3 (<em>N = 8</em>)</td>
<td></td>
</tr>
</tbody>
</table>

The inverted U trend is significant (*P < 0.05*) in the case of the girls (Ferguson’s non-parametric trend test for non-monotonic trends). The drop in scores for girls with an egg count of over 1000 is significant (*P = 0.0192*) when tested with the Mann-Whitney U test.

Only 2 of the boys had *S. mansoni* egg counts of more than 500 eggs/g dry weight of stool, so no comparison could be made, but the egg counts for the girls formed the basis for a three-level grouping (Table IV). The activity scores dropped when egg counts were over 1000/g dry weight of stool.

**Discussion**

The main findings from this study and their implications for research and control are as follows:

**Selective exposure**

Higher mean scores on a measure of energetic activity have been found in all infected groups studied in both phases of the investigation when the majority of the subjects had reasonably low egg counts. The possibility still exists that schistosomiasis actually produces higher activity levels, but this interpretation is not supported by the social interaction data on the in-depth study at Adams Mission; it appears more likely that there is a selective exposure factor operating whereby active, gregarious children have a higher probability of being infected through play activities or household duties involving contact with natural water. The implication here is that children who are most valuable to a community in terms of work and organizing ability are at risk. For research purposes a selective exposure factor implies that the impairment effect of schistosome infections is probably being masked when the uninfected groups are used as controls, and the proper research design should be a before-and-after treatment design where subjects are their own controls. Two studies with this type of design have indicated an impairment effect.9,10

**Appropriate measures**

The findings from this study report support the view that the effects of the parasite on the human host are not likely to be highly damaging in general.9 Metaphorically speaking, it is not in the interests of the parasite to be highly damaging to the human host. In practical research terms, clear evidence of impairment in the host’s behaviour is likely to be found in extremes — in the few severely infected individuals in the population, or in extreme levels of activity in mildly infected individuals.

As regards spontaneous activity, significant effects were found in the average duration of energetic activity as opposed to simple mobility in the descriptive phase. The activity meter proved to be an efficient measurement technique. In productivity studies in working adults, work in excess of the demands of the situation would seem to be an appropriate measure, as in the bonus pay measure used by Fenwick and Figenschou.10 Perhaps the most important methodological inference from this study is the need for an extended descriptive phase in investigating the effects of the disease on human subjects, who may well adapt behaviourally to the presence of a parasite.

**Differential effects of type and severity of schistosomiasis**

*S. haematobium* has been extensively investigated in this study. In mild infections (<1000 eggs) there is little evidence of impairment of the mean activity level, but there is a suggestion of a lowered ceiling to the amount of energetic activity displayed. This derives from the significantly smaller relative variation coefficient in the generally mildly infected children in the Adams Mission sample and the same pattern at the Embogodweni school. In moderate infections (1000-5000 eggs) the evidence points to a drop in energetic activity generally and particularly under the hot, humid conditions which prevail on the Natal coast in summertime. Under these climatic conditions subjects with moderate infections are affected to a greater degree than uninfected or mildly infected subjects.

For subjects with heavy infections (over 5000 eggs) the numbers were too small in the samples studied in the second phase of the research to yield anything but anecdotal evidence. Records kept on these individuals, however, indicate that appearance and behaviour are usually affected; they look tired, irritable and unsociable.
In the case of *S. mansoni* the evidence is less extensive, but the pattern appears to be similar to that of *S. haematobium*, with a lowered ceiling of activity among mildly infected subjects and a drop in mean activity level in those with an egg count of over 1000. Subjects with both *S. haematobium* and *S. mansoni* infestations have a lower mean activity than those with one type only.

These findings have considerable implications in determining public health priorities. The evidence suggests that control measures such as the introduction of piped water becomes a public health priority when both types of parasite are present in an area or when egg counts of over 1000 are prevalent, because the development of the most active children in the community is likely to be infected. The question of medical treatment of the individual is more complex, but it seems probable that *S. haematobium* begins to affect behaviour seriously when egg counts of over 5000 are being recorded.

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Research Institute for Diseases in a Tropical Environment for practical assistance and helpful discussion and to Frank Sutton for technical assistance. I am grateful to the principals, staff and pupils of the schools concerned for co-operation during the observation period. The research was supported by the University of Natal Research Fund and the South African Medical Research Council.

REFERENCES

Tuberculosis prevalence survey in the Daveyton (Benoni) urban Black community

P. B. FOURIE, LEONORA H. AUSTOKER

Summary

A sample of urban Blacks from Daveyton, Tvl, randomly selected to fully represent the parent community, was investigated for bacteriological prevalence of chest abnormalities associated with tuberculosis among adults, as well as for hypersensitivity to tuberculin in children. Radiological evidence of tuberculous lesions was demonstrated in 4.8% of subjects, half of whom were regarded as active cases. In the light of a bacteriological prevalence of 0.7% the radiological prevalence may be an overestimate, particularly since the 1978 incidence rate according to notification figures tends to support the prevalence survey estimates.


A survey of Blacks residing in the urban area of Daveyton, near Benoni, Tvl, was aimed at determining: (a) the prevalence of tuberculosis infection in children of all ages up to 18 years old; (b) the prevalence of pulmonary tuberculosis in persons 15 years old or older. Prevalence is defined as the number of cases (either infected or diseased) existing in a population at a particular point in time. Incidence, on the other hand, is defined as the number of cases (either infected or diseased) which arise during the course of 1 year in the population at risk.

The following aspects of the survey are dealt with in this article: (a) the composition of the screened sample and the degree to which it represents the parent population; (b) tuberculin sensitivity in children as determined by Mantoux tests; and (c) the bacteriological and radiological status of adults.

Subjects and methods

In June 1978 the population of Daveyton was given as 83 515. Of this number, 38 757 (46%) were less than 18 years old and the remaining 44 758 (54%) were 18 years old or older.

The first phase of the survey, conducted in November 1978, involved adults older than 15 years as well as all non-scholars, predominantly of preschool age. The sample was randomly selected from 13 areas according to procedures described elsewhere. A total of 2087 persons, or 3.6% of the total non-schoolgoing population of approximately 58 000, was registered. An acceptable similarity existed between the selected sample, the

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