ASCARIASIS AND DIGESTIBILITY: A STUDY IN CAMEROONIAN CHILDREN

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INTRODUCTION

In tropical and subtropical areas, intestinal parasitism is frequently associated with protein-energy malnutrition [1, 2]. The interactions between parasitic infections and nutritional disorders must be understood since they have practical implications for overall health policies.

It is well established that some intestinal parasitoses, such as coccidiosis and giardiasis, are accompanied by a malabsorption syndrome [3, 4]. Studies of the relationship between malabsorption and *Ascaris lumbricoides* [5] have, however, yielded some contradictions.

Some works [6, 7] have suggested that the intestinal malabsorption observed in children affected with *Ascaris lumbricoides* can lead to a deficient nutritional status. More recent studies have questioned the exclusive role played by this parasite [8]. Some authors consider that treatment for this parasite is useless in promoting better absorption and growth [9].

Intestinal parasitism and moderate forms of protein-energy malnutrition are widespread in Cameroon [10]. The purpose of this study was to measure the specific effects of *Ascaris lumbricoides* on absorption under well-defined circumstances. Measurements of D-xylose absorption and digestibility before and after deworming were carried out on well-nourished children receiving a well-balanced diet.

METHODS

Subjects

The study was carried out at Omvan, a small village near Yaoundé. Sixteen children, nine boys and seven girls, who were seven years of age and living in a boarding-school, participated in this experiment. The children were selected according to three criteria:

1. The initial clinical examination revealed no evidence of disease or nutrient deficiency.
2. The anthropometric measurements (table 1) were very close to Harvard standard values for weight and height and to Wolanski standard values for arm circumference [11]. All the anthropometric measurements were carried out by the same staff using the same regularly controlled equipment, according to the standardized methods described by Jelliffe [11].
3. Intestinal parasitism assessed with Kato's method [12] revealed that all the individuals suffered from *Ascaris lumbricoides* and that, relative to other parasites, the worm burden of this helminth was the highest (table 2). It was not possible to isolate any cases who had ascariasis alone without any other parasitoses.

Diets

Meals were taken at regular hours: 7.30, cereals; 12.30,

TABLE 1. Anthropometric data for children before and after deworming

	Before deworming	After deworming[c]
Number of children	16	16
Age (months)	82 ± 15	85 ± 13
Weight (kg)	21.8 ± 3.8	21.3 ± 3.7
Height (cm)	116.6 ± 11.1	118.9 ± 9.4
Arm circumference (cm)	17.2 ± 1.5	16.8 ± 1.4
Head circumference (cm)	51.2 ± 1.2	51.5 ± 1.1
Weight for age[a]	97.3 ± 9.4	92.9 ± 9.4
Height for age[a]	97.4 ± 5.0	98.0 ± 4.0
Weight for height[a]	102.7 ± 7.8	96.1 ± 5.8
Arm circumference for age[b]	96.8 ± 6.7	93.8 ± 6.3
Arm circumference/ head circumference	0.336 ± 0.028	0.326 ± 0.026

a. Mean ± SD, expressed as a percentage of Harvard standards [11].
b. Mean ± SD, expressed as a percentage of Wolanski standards [11].
c. All differences in values before and after deworming are statistically significant.

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TABLE 2. Prevalence of helminth ova in stool

Helminth	Prevalence	Mean load for 10 mg faecal matter	Range
Ascaris lumbricoides	16/16	336	11-860
Trichuris trichiura	13/16	106	24-388
Ancylostoma duodenale	1/16	4	-
Necator americanus	4/16	11	4-20
Enterobius vermicularis	1/16	6	-

TABLE 3. Caloric value of diet and mean daily nutrient intake before and after deworming of children

Nutrient intake	Before deworming	After deworming
Daily individual intake		
Dry matter (g)	376 ± 53[a]	389 ± 28[a]
Nitrogen (g)	9.33 ± 0.99[a]	8.67 ± 0.60[b]
Fat (g)	53.2 ± 6.2[a]	52.9 ± 3.9[a]
Energy (kcal/kg BW)	79	83.4
Protein (g/kg BW)	2.7	2.5
Metabolizable energy		
From fat (%)	27.8	26.8
From carbohydrate (%)		61.0
From protein (%)	13.5	12.2

a, b. Mean value ± SD; for each parameter mean values with no common superscript are significantly different.

boiled rice, fish and peanut sauce, and fruit (orange); 16.30, fritter; and 19.30, noodles, tomato sauce, hard-boiled egg, and fruit (orange).

The food intake was adjusted for body weight and satisfied the dietary requirements of each child. Table 3 shows the composition of the diet and the daily intakes, which are very close to those observed in balanced diets: the children received an average of 79 kcal/d/kg of body weight, which corresponds to the WHO recommended 82 kcal/d/kg [13]. The energy concentration of the ration has been calculated using Atwater coefficients. The nitrogen intake (table 3) is higher than the safe level, amounting to 148 mg N/kg/d. The children consumed an average of 0.42 g N/d/kg of body weight, with meat, peanut sauce, and eggs providing 48 per cent of the nitrogen intake. Drinking water was freely distributed.

After a five-day adaptation period, nitrogen balance studies were carried out for six days. Three months later all children were treated by administering six 100 mg tablets of Vermox (mebendazole) over three consecutive days. The effectiveness of deworming was confirmed ten days later by a microscopic examination of stool specimens. Then, after successful therapy, the children were provided with the same diet for a second five-day adaptation and six-day balance period.

Specimen collection

Urines were collected in 24-hour blocks, with a mean for each child of 755 ml/d before deworming and 1,055 ml/d after deworming ($t = -3.87$); they were preserved by the addition of 0.25 per cent of a 10 per cent solution of thymol in isopropanol before freezing. One gram of carmine was used as a marker at the beginning and the end of each balance period. Faeces were stored at −20° C. The calculated nitrogen (N) balances are apparent and do not take into account cutaneous and other minor N losses; the same is true for the calculation of apparent absorption, excluding endogeneous losses. Apparent absorption was calculated by subtracting total excretion from total intake and expressing the difference as a percentage of intake.

D-xylose urinary excretion test

D-xylose urinary excretion was observed for five hours following the intake of 0.5 g of D-xylose per unit of body weight. The results are expressed as a percentage of ingested quantities.

Analytical methods were as follows:

- water content: dessication in a drying-room at 105° C until a constant mass is reached [14].
- total nitrogen content: in accordance with Kjeldahl's method after sulphuric mineralization in the presence of a selenium catalyst [14].
- total lipid content: extraction by petroleum ether in a Soxhlet apparatus for 10 hours without previous hydrolysis [14].
- D-xylose content: D-xylose is changed by furfural to give a pink coloration with p. bromoaniline acetate [15].

Statistical analysis

The significance of differences between means was estimated by Student's t-test for paired data according to Snedecor [18]. A value of $p < 0.05$ was considered significant.

RESULTS

During the three-month interval between measurements, the children lost weight and their arm circumference became thinner (table 1). It was not possible to reconstruct the events that led to this situation since the 16 children were on three weeks' vacation and had left the boarding-school before the second digestibility measurement was taken. However, they could undoubtedly be considered well-nourished despite this slight deficiency.

Of the 16 children, eight showed an *Ascaris* burden of over 300 eggs for 10 mg of faeces, and two of them showed a worm burden of over 500 eggs. The remaining eight children showed a worm burden ranging from 100 to 300 eggs, that is, they were not highly infected. *Trichocephalus* was observed in the faeces of 13 children, ten of whom showed a burden of less than 75 eggs for 10 mg. Only one individual showed a trifling quantity of *Ancylostoma* eggs.

The main daily consumption of dry matter and fat were similar during both experimental periods. A significant decrease ($p<0.05$) in the absolute mean nitrogen intake was observed in the second period (table 3); this difference was no longer observed when nitrogen intakes were expressed in terms of grams per unit of body weight. This observation concerning nitrogen must have been due to variations in the nitrogen content of the foodstuffs despite the fact that the protein requirements were consistently met, with 13 per cent of calories supplied by proteins.

Digestibility measurements, the D-xylose urinary excretion test, and nitrogen balances did not differ significantly (table 4) before and after deworming. No cases of steatorrhea were observed, all individual faecal lipid losses being lower than 3.5 g/d [17]; the mean excretion of a six- to nine-year-old healthy child amounts to 1.5 g per day [18, 19]. Deworming did not involve any change in the faecal nitrogen losses, respectively 74 mg/kg/d and 71 mg/kg/d. The D-xylose test results indicate normal intestinal absorption, well above the usual 20 per cent [20].

TABLE 4. Changes in apparent absorption of nutrients, urinary excretion of D-xylose, and nitrogen retention before and after deworming of children

	Before deworming	After deworming[a]
Absorption (percentage of intake)		
Dry matter	95.5 ± 0.9	95.1 ± 1.0
Total lipid	95.4 ± 1.3	96.1 ± 0.8
Nitrogen	82.6 ± 3.5	82.6 ± 3.8
Urinary excretion of D-xylose (percentage of intake)	25.6 ± 5.8	26.0 ± 10.5
Nitrogen retention		
G/day	2.96 ±0.87	3.09 ±0.87
Percentage of intake	31.8 ± 9.1	35.4 ± 8.7

a. Mean value ± SD: none of the differences in values before and after deworming are statistically significant.

DISCUSSION

The mechanisms through which ascariasis could lead to an unbalanced nutritional status by decreasing intestinal absorption are numerous [21]: mechanical and irritant action [22], inhibitory effect of ascarase [23], competition for host's nutrients, and alterations in the intraluminal conditions of the small bowel [24].

Despite the numerous effects likely to cause measurable nutritional disorders, the relation between ascariasis and malabsorption is still questionable. Scrimshaw [25] and Briscoe [26] point out that the contribution of ascariasis to malnutrition has often been overestimated. Most of the research on ascariasis has been conducted in the malnourished populations of poor countries, so that the significance of digestibility measurements in these populations should be viewed with some reservation.

The influence of protein-energy malnutrition on intestinal absorption is well known [27, 28]. Tropical jejunitis, widespread in the developing countries, even in healthy subjects, leads to intestinal malabsorption measurable with the D-xylose test [29, 30]. It is certain that *Ascaris* infection in children with protein-energy malnutrition can lead to marked nutrition impairment when a high parasite load is associated with a low protein intake [6]. But it is difficult in such a situation to determine the specific effect of *Ascaris* because intestinal absorption is modified by synergistic phenomena. This study was, therefore, made using sufficiently nourished children receiving an adequately balanced diet in order best to pinpoint the effects of ascariasis.

The results obtained though the D-xylose test do not permit detection of changes in the intestinal mucosa. The mean value for D-xylose excreted in urine before deworming (25.6 per cent) was considerably higher than the 16.1 per cent observed in nine moderately malnourished children in the same environment [31]. This result confirms the

absence of steatorrhea before deworming in all the subjects in the present study.

The faecal nitrogen losses were normal. Before deworming, the nutrient absorption values were very satisfactory and similar to those observed by Brown [32] for five children who were mildly affected by *Ascaris lumbricoides* and moderately malnourished. The nutrient absorption values were, on the other hand, higher than those observed by Tripathy [6, 7] whose subjects were on low protein diets.

A comparison between apparent N absorption measured in this study and that observed in dewormed Cameroonian adults who showed small anthropometric deficiencies and received an adequate diet [33] indicates that, despite the worm burden, the children had better nutrient absorption values than the adults. The apparent N absorption was 82.6 per cent for children and 66.6 per cent for adults. This observation suggests that the influence of recurrent acute and chronic gastrointestinal infections is more obvious than the influence of a mild *Ascaris* burden.

An analysis of our results does not reveal an overall unfavourable effect of mild ascariasis on intestinal absorption. It would, therefore, seem that the lack of agreement in the results obtained by the different authors is attributable to the diversity and intensity of the infections as well as other nutritional and disease factors. Such factors may also account for similar differences in the results of nutritional rehabilitation efforts.

Gupta et al. found it impossible to improve the nutritional status of infected children suffering from malnutrition without eradicating the parasite [34]. Freij, who treated malnourished children (with a weight for age of 82 per cent of the standard) and mildly infected young children, did not detect any nutritional improvement [9]. Stephenson, on the contrary, revealed, after deworming, a significant increase in the skinfold-thickness of children who were highly infected with *Ascaris* and previously malnourished with a weight for age of 79.6 per cent of the standard [35].

The most significant effects of ascariasis on intestinal absorption are always found in the most severely infected subjects. Thus, even when infected subjects are malnourished, it is necessary to have detected a heavy load of ascarides to find also reduced absorption. Ascariasis adds its effects to those of other intestinal infections and protein-energy malnutrition. Pre-school children are usually the most vulnerable, and it is for this segment of the general population that medical attention must be a priority. Individual cases of symptomatic ascariasis, whether in children or adults, should be treated. However, expenditures for *Ascaris* treatment are not warranted except in the case of severe infections. Instead, public health efforts should be directed at improved environmental sanitation and personal hygiene, particularly the sanitary disposal of faeces and hand-washing, which will reduce or eliminate not only *Ascaris* but also other intestinal parasites and infections.

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