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ARTIGO

Relationship between protein-energy malnutrition, vitamin A, and parasitoses in children living in Brasília

Relação entre desnutrição energético-protéica, vitamina A, e parasitoses em crianças vivendo em Brasília

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Abstract *It is still controversial whether intestinal parasitic infections can influence the nutritional status of children. The relationship between protein-energy malnutrition, vitamin A and parasitic infections was evaluated in 124 children. The food intake estimated by recall method was generally low and poor. Seventy five percent of the children were infected with intestinal parasites. The mean±SD weight-for-age and height-for-age Z-score were skewed one standard deviation to the left, when compared to normal standards. An association was found between protein-energy malnutrition and* Giardia lamblia*, but not with* Ascaris lumbricoides *or* Hymenolepis nana *infection. Only* Giardia*-infected children had a decreased weight-for-age and weight-for-height Z-score. Hypovitaminosis A was a major nutritional problem, but no relationship between this deficiency and parasitic infection was found. Our data indicate that low and poor food intake were the major cause of protein-energy malnutrition among the children, and except for* Giardia*, this was not influenced by parasitic infections.*

Key-words*: Protein energy-malnutrition. Vitamin A. Iron. Intestinal parasitic infection.* Ascaris lumbricoides*.* Giardia lamblia*.* Hymenolepis nana*.*

Resumo *É controverso se parasitismo intestinal interfere no estado nutricional. A relação entre desnutrição energético-protéica, vitamina A e parasitoses intestinais foi avaliada em 124 crianças. A ingestão alimentar estimada pelo método recordatório mostrou-se deficiente em quantidade e qualidade. Setenta e cinco porcento das crianças estavam parasitadas. A média±DP do Z-escore do peso-para-idade e altura-para-idade da população estudada desviou-se aproximadamente um DP para a esquerda em relação aos padrões normais. Encontrou-se associação entre desnutrição energético-protéica e parasitismo por* Giardia lamblia*, mas não por* Ascaris lumbricoides *ou* Hymenolepis nan*a. Somente crianças infectadas por Giardia mostraram deficiência do peso-para-idade e peso-para-altura avaliado pelo Z-escore. Hipovitaminose A foi um importante problema nutricional, mas não houve relação entre esta deficiência e parasitoses intestinais. Nossos dados indicam que deficiência na quantidade e na qualidade da ingestão foram os principais problemas causando desnutrição-energético protéica, e exceto para* Giardia*, não foi influenciado pelo parasitismo por helmintos intestinais.*

Palavras-chaves: *Desnutrição energético-protéica. Vitamina A. Ferro. Parasitas intestinais.* Ascaris lumbricoides*.* Hymenolepis nana*.* Giardia lamblia*.*

Protein-energy malnutrition and intestinal parasitic infections are common problems in those populations characterized by low socioeconomic status and low level of public health sanitation[2 36]. *Ascaris lumbricoides* infection is often associated with malnutrition, but it is difficult to clarify whether the relationship is causative or casual, since both are ubiquitous in such conditions of poverty and poor sanitation[2].

Several data suggest that parasite infections can affect the nutritional status of infected people, by modifying the key stages of food intake, digestion and absorption[35]. Parasites can adversely affect the host food intake by decreasing, increasing[9] or changing the preference for food, as in patients with pica[16]. They can affect sensory, neural and hormonal factors that are considered to modulate food intake[9], and can cause

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anorexia[1], or vomiting[2]. It was found that trophozoites of *Giardia lamblia* may damage the brush borders of enterocytes and impair the activity of mucosal enzymes, particularly the disaccharidases[2], causing carbohydrate and fat malabsorption[10]. Abnormalities were observed in the intestinal tract mucosa in *Ascaris lumbricoides*-infected children through jejunal biopsy[39], which disappeared rather rapidly after deworming treatment, accompanying by the improvement of the nitrogen retention, d-xylose absorption and steatorrhea[39]. However, it is still controversial whether such alterations influence the nutritional status of children when tested in field studies. While some studies have shown a beneficial impact of antiparasitic treatment on the nutritional status and growth of children, others have not achieved the same results[20 22]. It was observed that periodically deworming *Ascaris lumbricoides*-infected children may improve their nutritional status[18 43], and that a single course of antiparasitic treatment increased arm skinfold[37] and improved growth[38]. Cerf et al[7] showed a significant negative correlation between the burden of *Ascaris* and nutritional status, but exclusively in the population submitted to low nutritional intake and living in conditions of poor health care facilities. Moreover, periodic treatment of *Giardia lamblia* improved the weight gain of treated children[18]. On the other hand, Freij et al[15] observed no impact on anthropometric indices after ascariasis treatment, Geengberg et al[17] showed that a single dose of piperazine was an unsuccessful method to promoting growth, Gupta and Urrutia[19] have not found any effect on nutritional status after deworming *Ascaris lumbricoides*-infected children for one year, and Kightlinger et al[27] observed that children with the heaviest worm burdens had growth scores very similar to the lightly and non-infected ones. Thus, it is not yet clear whether parasites can influence the nutritional status of children. A major difficulty in interpreting these results is the fact that several parasites and nutritional deficiencies can coexist and influence each other. For instance, hypovitaminosis A, a problem of public health among young children living in areas of poverty that can led to blindness and death[30], can be caused by impairment of vitamin A absorption due to *Ascaris lumbricoides* or *Giardia lamblia* infections[28], while iron-deficiency anemia has been associated to infection by *Ancylostomidae, Trichuris trichiura* and *Schistosoma mansoni* [3 31 34].

In conditions of poverty and low level of sanitation when multiple deficiencies coexist, the consequences of interactions between multiple nutritional deficiencies and multiple intestinal parasites are not clear, and these associations have not yet been assessed in the same population. This work aimed to evaluate the relationship between protein-energy malnutrition, hypovitaminosis A and intestinal parasitic infections in children living in poor social conditions in Brasilia.

STUDY GROUPS AND METHODS

All the 124 children, younger than 6 years old, of both sexes, living in Varjão, a slum area in Brasilia, Brazil, were evaluated for their nutritional status and presence of parasites in their stool in a cohort study performed in 1983. In this small community, the children were submitted to the same social, cultural, economic and environmental influences. The family incomes were similar, and in the area they lived there was no supply of treated water or public sanitation.

All the children were evaluated by a clinical examination. The weight, height and head circumference were measured using standard anthropometric measurement[46] by the same observer (MIM-J). The nutritional status was evaluated by the standard deviation score (Z-score)[46], percentile[46] and Waterlow classification[41]. The 50th percentile of the growth charts of the National Center for Health Statistic (NCHS), USA, was used as normal standard[21]. Sixty-eight out of 124 children were younger than three years old and their head circumference was analyzed using the 50th percentile from the NCHS chart[21]. The food intake was estimated for energy, protein, retinol and iron by the 24 hour-recall method for 104 children using the IBGE (Brazil) nutrient composition table[23], and the FAO/WHO criteria for daily recommended intake[12 13 14]. Dietary intake of carotenoid precursors and preformed vitamin A were computed together and expressed as retinol equivalent intake. Sixteen breast-fed babies receiving human milk together with supplementary food were excluded from the analysis. Therefore only the results of the intake of 88 children were considered.

The intestinal parasites were detected in the stools of 102 children using four different tests: sedimentation test of Hoffmann, Pons and Janer, Baermann test for larvae, Faust test for protozoa cysts[32], and Kato-Kats test[25]. The latter was also used for calculating the burden of *Ascaris lumbricoides*. All stool samples were submitted to the four tests. The 24-hour samples of stools collected in a plastic bag were weighed. The number of *Ascaris lumbricoides* infecting each child was estimated by the number of eggs counted in 1g of stool (detected by the Kato-Kats method), multiplied by the weight of the stools collected during 24 hours; divided by 200,000 (number of eggs expelled by each female *Ascaris lumbricoides*), multiplied by 2 (proportion between male and female of *Ascaris lumbricoides*), according to the equation proposed by WHO[45]: number of parasites = [(number of eggs per gram of stools X weight of stools from 24h)/200,000] x 2.

The presence of 5 or less parasites was considered as light infection, from 6 to 25 as moderate and over 25 worms as heavy infection[45].

Samples of 2 to 5ml of peripheral venous blood were obtained and sera were kept at -20°C until used. Levels of vitamin A in serum from 122 children were evaluated in duplicate for individual sample by the colorimetric method employing the Carr Price reaction using trifluoroacetic acid (TCA) as a chromogen, and were expressed as µg of retinol per 100ml[5]. Hemoglobin was detected in duplicate samples of blood immediately after collection from 121 children by the cyanmethemoglobin method, and was expressed as g per dL of blood[11].

The statements of the Helsinki Declaration[44] and of the Health Ministry of Brazil for research in human subjects were strictly followed throughout this investigation. All children received 200,000 U vitamin A *per os* and their parasite infections were treated as soon as they were detected.

Statistical analysis was performed by one way ANOVA and subsequent Student-Newman-Keuls multiple comparison when the samples showed a normal distribution, or by Kruskall-Wallis test followed by Dunn's method of multiple comparisons to compare non-gaussian distributed samples. The Mann-Whitney test was performed to compare two non-gaussian distributed samples. Chi-square test was used to compare proportions. Correlation between variables was assessed by Spearman coefficient. All results with a p value < 0.05 were considered statistically significant. The SigmaStat Jandel's statistical software (Jandel Scientific, San Rafael/ California, USA, 1992) was used for the analysis.

RESULTS

The mean weight-for-age and height-for-age Z-score of all children were skewed about one standard deviation to left in relation to NCHS reference standard, as shown in Table 1, while the mean weight-for-height was not different from that of the NCHS reference standard. There was no statistical difference in the mean Z-score between ages (Table 1).

Figure 1 shows the distribution of the population according to percentiles of anthropometric indices. The height-for-age showed the distribution skewed toward the lower percentiles, with 46% (57/124) of the children below the 10th percentile, and 22.6% (28/124) below the 3rd percentile (Figure 1A). The weight-for-age was also skewed toward lower values, with 30.6% (38/124) of the children below the 10th percentile, and 12% (15/124) below the 3rd percentile (Figure 1B). The weight-for-height showed a homogeneous arrangement with 7.3% (9/124) below the 10th percentile and 2.4% (3/124) below the 3rd percentile (Figure 1C). The same skew toward the lower percentiles was observed in head circumference, with 61.8% (42/68) of the children below the 10th and 47% (32/68) below the 3rd percentile (Figure 1D). Application of the Waterlow classification showed that 8.9% (11/124) of the children were stunted.

Table 1 - Weight-for-age, height-for-age and weight-for-height Z-scores and serum retinol concentration according to age of children younger than 6 years old living in Varjão, a slum area in Brasilia, Brazil.

	Age (year)						
	<1	1-2	2-3	3-4	4-5	5-6	Total
Weight-for-age							
N	15	26	25	20	22	16	124
mean Z-score*	-0.98	-1.07	-0.97	-0.40	-0.91	-0.78	-0.86
SD	1.18	1.07	0.96	0.63	0.76	1.13	0.97
below -2 Z-scores (%)	20	11.5	12	0	4.5	12.5	9.7
Height-for-age							
N	15	26	25	20	22	16	124
mean Z-score*	-1.54	-1.38	-1.59	-0.83	-1.15	-0.98	-1.21
SD	1.28	0.89	0.99	0.66	0.89	1.17	1.04
below -2 Z-scores (%)	40	19.2	24	5	18.1	12.5	19.4
Weight-for-height							
N	15	26	25	20	22	16	124
mean Z-score*	0.21	-0.37	-0.16	0.35	-0.17	-0.21	-0.09
SD	0.74	0.86	0.94	0.81	0.71	0.89	0.85
below -2 Z-scores (%)	0	3.8	0	0	0	0	0.8
Retinol (µg/mL)							
N	15	26	24	19	22	16	122
median**	15.6	19.0	20.1	16.8	18.3	18.5	18.31
25 percentile	13.2	16.6	16.2	13.5	15.8	16.0	15.47
75 percentile	19.9	25.6	23.4	20.7	20.9	23.7	22.21
below 10µg/100µl (%)	6.7	0	4.2	5.3	0	0	2.45

Table of NCHS was used as standard reference.

N = number of children

* ANOVA (p > 0.05)

** Kruskal-Wallis test (p > 0.05)

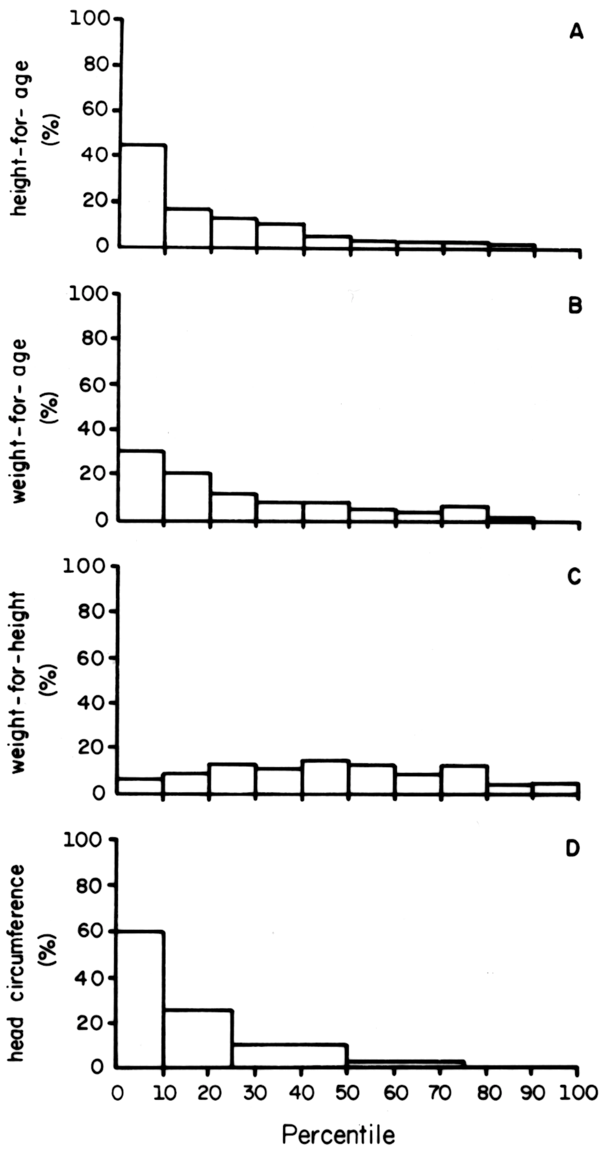

Figure 1 - Distribution in percentiles of A) height-for-age (n=124), B) weight-for-age (n=124), C) weight-for-height (n=124) and D) head circumference (n=68) for children younger than 6 years old, living in Varjão, a slum area in Brasília, Brazil. Growth charts of National Center for Health Statistic, USA, were used as the normal standard.

The predominant diet of these children was rice and beans. Sixty eight percent (60/88) of the children ingested less than 80% of daily recommended intake of energy, while 61% (54/88) of them had an intake of more than 100% daily recommended intake in protein.

Anemia (hemoglobin concentration below 11g/dL) was detected in 16.5% (20/121) of the children, all younger than 30 months of age. In 12.4% (15/121) of the children, hemoglobin concentration was between 10-11g/dL, and in 4.1% (5/121), it was between 7-10g/dL. The lowest hemoglobin concentration was found in children aged between 6 months and 1.5 years ($p<0.001$, ANOVA) (Figure 2).

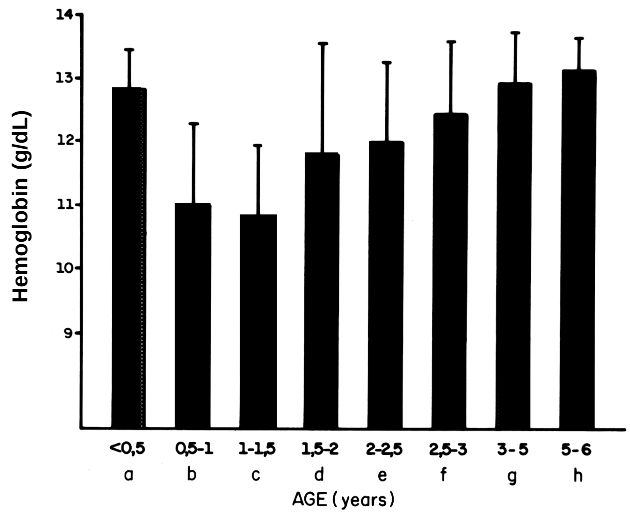

*Figure 2 - Mean concentration of hemoglobin (g/dL) of 121 children living in Varjão, Brasilia, Brazil, distributed by age. The children were distributed by ages in the following groups: a) 0 - 0.5 years old (n=5); b) >0.5 - 1 years old (n=10); c) >1 - 1.5 years old (n=12); d) >1.5 - 2 years old (n=14); e) >2 - 2.5 years old (n=11); f) >2.5 - 3 years old (n=13); g) >3 - 5 years old (n=40); h) >5 - 6 years old (n=16). The values are expressed as mean ± SD. Groups **b** and **d** are statistically different from groups **g** and **h**, and Group **c** is different from Groups **a**, **f**, **g** and **h** (p<0.001, one way ANOVA and subsequent Student-Newman-Keuls method for multiple comparisons).*

Fifty percent (10/20) of children with hemoglobin concentration below 11g/dL had *Ascaris lumbricoides*, 25% (5/20) *Giardia lamblia*, 15% (3/20) *Hymenolepis nana*, 20% (4/20) were polyparasitized, and 30% (6/20) had no intestinal parasites. Prevalence of parasitic infection in 27 children with the same age (below 30 months old) and with hemoglobin concentration ≥11g/dL were: 33.3% (9/27) for *Ascaris lumbricoides*-infected, 25.9% (7/27) for *Giardia lamblia*, 7.4% (2/27) for multiple parasites, while 48.15% (13/27) had no parasite. No difference was found in the mean concentration of serum retinol and the anthropometric indices in the groups with normal (≥11g/dL) and low (<11g/dL) hemoglobin concentrations.

Iron intake was below 80% daily recommended intake in 68 out of 88 (77%) children. In 11 out of 12 (91%) children with hemoglobin concentration below 11g/dL and that received no human milk, the daily recommended intake of iron was lower than 60%.

Parasites were present in the stools of 75.5% (77/102) of the examined children (Table 2). *Ascaris lumbricoides* was the most prevalent parasite, being present in 47% (48/102) of the children. The estimated load of *Ascaris lumbricoides* varied from 2 to 114 worms, 56.3% (27/48) of the children showing a light burden, 27.1% (13/48) a moderate one, and 16.7% (8/48) a

Table 2 - Prevalence according to age of parasites in stool of children younger than 6 years old living in Varjão, a slum area in Brasilia, Brazil.

	Frequency													
	age													
	<1y		1-2y		2-3y		3-4y		4-5y		5-6y		total	
Parasite	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Absent	7/11	63.6	9/22	40.9	4/21	19.0	2/19	10.5	4/18	22.0	1/11	9.1	27/102	26.5
A. lumbricoides	3/11	27.3	9/22	40.9	10/21	47.6	12/19	63.2	8/18	44.5	6/11	54.5	48/102	47.0
G. lamblia	1/11	9.1	6/22	27.3	6/21	28.6	7/19	36.8	6/18	33.3	5/11	45.5	31/102	30.4
H. nana	1/11	9.1	1/22	4.5	3/21	14.3	7/19	36.8	7/18	38.9	3/11	27.3	21/102	20.6
T. trichiuris	0/11	0	0/22	0	2/21	9.5	4/19	21.0	0/18	0	1/11	9.1	7/102	6.9
S. stercoralis	0/11	0	0/22	0	0/21	0	0/19	0	0/18	0	1/11	9.1	1/102	0.98
> 1 parasite	1/11	9.1	3/22	13.6	4/21	19.1	10/19	52.6	6/18	33.3	6/11	54.5	30/102	29.4

A. lumbricoides = Ascaris lumbricoides; G. lamblia = Giardia lamblia;

H. nana = Hymenolepis nana; T. trichiuris = Trichuris trichiuris

S. stercoralis = Strongyloides stercoralis

y = years

heavy burden of *Ascaris lumbricoides*. There was no difference in the mean ± SD of weight-for-age Z-score in children with light (-0.76 ± 0.98), moderate (-0.60 ± 0.82) or heavy (-0.74 ± 0.44) burden of *Ascaris lumbricoides* ($p > 0.05$, ANOVA), and no correlation was found between the age and the burden of *Ascaris lumbricoides* ($p > 0.05$, Spearman correlation). Eggs of *Ascaris lumbricoides* and *Hymenolepis nana* were detected in children from 9 months old onwards, and cysts of *Giardia lamblia* from 11 months old. The prevalence of intestinal parasites according to children's age is shown in Table 2. Cysts of *Giardia lamblia* were also highly prevalent, with 30.4% (31/102) of the children infected. In 29.4% (30/102) of the subjects more than one parasite were observed (Table 2). The percentage of parasitized children below -2 SD Z-score for weight-for-age, weight-for-height and height-for-age is showed in Table 3.

Table 3 - Percentage of children younger than 6 years old living in Varjão with weight-for-age, height-for-age and weight-for-height < -2 SD Z- score according to parasitic infection.

	Children below -2 SD Z-score (%)					
	weight-for-age		height-for-age		weight-for-height	
Non-infected	11.1%	3/27	22.2%	6/27	0%	0/27
Only *A. lumbricoides*	8.7%	2/23	21.7%	5/23	0%	0/23
Only *G. lamblia*	25%	3/12	16.6%	2/12	8.3%	1/12
Only *H. nana*	0%	0/8	12.5%	1/8	0%	0/8
A lumbricoides + G. lamblia	8.3%	1/12	16.6%	2/12	0%	0/12
*>1 parasite**	0%	0/18	0%	0/18	0%	0/18

A. lumbricoides = Ascaris lumbricoides; G. lamblia = Giardia lamblia;

H. nana = Hymenolepis nana; T. trichiuris = Trichuris trichiuris

S. stercoralis = Strongyloides stercoralis

* > 1 parasite except *Ascaris lumbricoides + Giardia lamblia*

Among the parasites detected, only *Giardia lamblia* influenced the weight-for-age and weight-for-height. Children infected exclusively with *Giardia lamblia* showed weight-for-age Z-score lower than that of children exclusively infected with *Ascaris lumbricoides* ($p < 0.048$, ANOVA) (Figure 3A), and the weight-for-height Z-score were lower than that of non-infected children or those exclusively infected with *Ascaris lumbricoides* or *Hymenolepis nana* ($p = 0.03$, ANOVA) (Figure 3B). Children coinfected with *Ascaris lumbricoides* and *Giardia lamblia* were in an intermediate situation (Figure 3A and 3B). Parasitic infections caused no change of height-for-age Z- score ($p > 0.05$, ANOVA) (Figure 3C).

Only 36.9% (45/122) of the children showed normal serum retinol concentration (>20µg/100 ml), while 60.6% (74/122) presented levels between 10-20µg/100ml, and 2.45% (3/122) below 10µg/100ml. There was no statistical difference in retinol concentration in serum in the different age-groups (Table 1). Sixty five out of 88 children (74%) showed retinol equivalent intake below 80% of daily recommended intake.

Sixty out of 122 children (49.2%) were suffering some mild infectious disease when evaluated, including skin infections, diarrhea, acute otitis or upper respiratory tract infections. Only three out of 124 children presented axillary temperature higher than 37.5°C. The retinol concentration in children with infections (18.3µg/100ml)

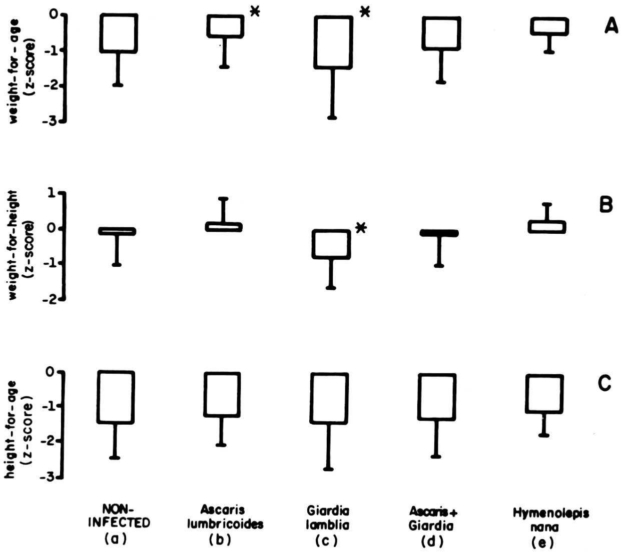

Figure 3 - Influence of intestinal parasitic infection on anthropometrical indices for < 6 year-old-children, living in Varjão, Brasilia, Brazil. The children were distributed in the following groups: a) non-infected (n=27); b) infected exclusively by Ascaris lumbricoides (n=23); c) infected exclusively by Giardia lamblia (n=12); d) coinfected by Ascaris lumbricoides and Giardia lamblia (n=12); e) infected exclusively by Hymenolepis nana (n=8). The values are expressed as mean±SD Z-score. The 50th percentile of the growth charts of NCHS was used as the normal standard. ***In A:*** *Weight-for-age. Group* ***b*** *is statistically different from Group* ***c*** *(p=0.04, ANOVA and Student-Newman-Keuls method for multiple comparisons).* ***In B:*** *Weight-for-height. Group* ***c*** *is statistically different from Groups* ***a***, ***b*** *and* ***e*** *(p=0.03, ANOVA and Student-Newman-Keuls method for multiple comparisons).* ***In C:*** *Height-for-age. No statistical difference was observed between the Groups (p>0.05, ANOVA).*

were similar to that without infections (18.2µg/100ml) (p>0.05, Mann-Whitney test). Again, no difference in the serum retinol concentrations was detected among those infected with (17.5µg/100 ml) or without (18.5µg/100ml) concomitant malnutrition, and also between well-nourished children with (19.9µg/100ml) or without (17.4µg/100ml) infection (p>0.05, Kruskal-Wallis test).

Although the wasted children (weight-for-age Z-score < - 2 SD) had lesser retinol in serum (median = 14.9µg/100ml) than the better nourished children (> -2SD) (median = 17.1µg/100ml; 19.5µg/100ml; 18.3µg/100ml) these differences were not statistically significant (p>0.05, Kruskal Wallis test) (Figure 4A). A higher percentage of wasted children (75%; 9/12) showed retinol in serum below 20µg/100ml than the better nourished children (59%, 65/110), although also without statistical significance (Figure 4B).

Children exclusively infected by *Hymenolepis nana* showed serum retinol levels higher than those infected with other parasites (p=0.02, Kruskal-Wallis test) (Figure 5A). No one child infected with *Hymenolepis nana* had weight-for-age below -2 SD Z-score (Figure 5B).

Both *Ascaris lumbricoides*-infected or non-infected wasted children (<-2 SD Z-score) showed low serum

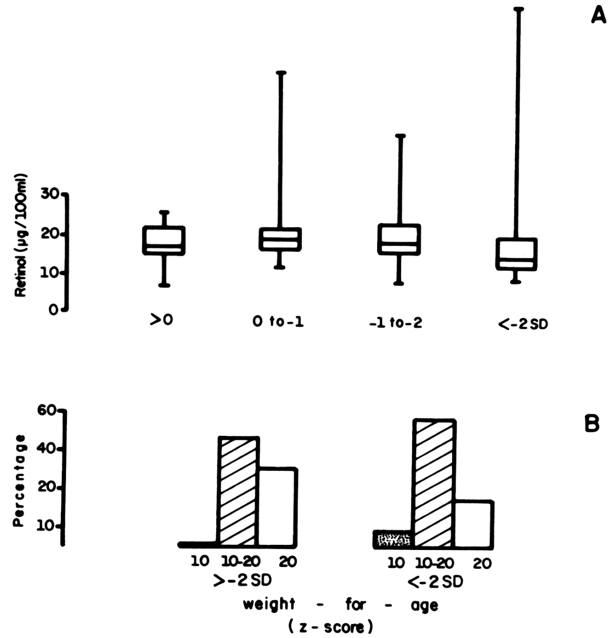

Figure 4 - Relationship between serum levels of vitamin A and weight-for-age Z-score. ***In A:*** *serum retinol concentration (µg/100ml) for children with median of weight-for-age Z-score > 0, 0 to -1, -1 to -2, < -2 SD (50th percentile of the growth charts of NCHS was used as normal standard). The values are expressed as median, quartiles and extremes. (p > 0.05, Kruskal-Wallis test).* ***In B:*** *percentage of children with the weight-for-age Z-score ≥ -2 SD or lesser than < -2 SD showing serum retinol concentration ≤10 µg/100ml, 10 - 20 and > 20µg/100ml. There was no difference statistically significant between the groups (p > 0.05, Chi-square test).*

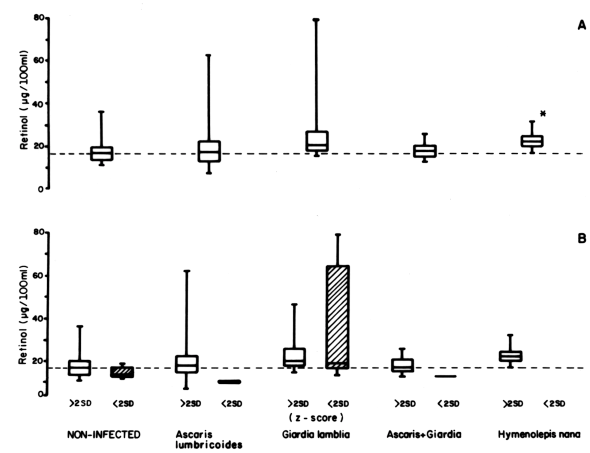

Figure 5 - Relationship between serum levels of vitamin A, parasitic infections and weight-for-age. ***In A:*** *serum retinol concentration (µg/100ml) in children: a) non-infected (n=25), b) infected exclusively by* Ascaris lumbricoides *(n=22), c) infected exclusively by* Giardia lamblia *(n=11), d) coinfected by* Ascaris lumbricoides *and* Giardia lamblia *(n=12), e) infected exclusively by Hymenolepis nana (n=8) (p=0.028, Kruskal-Wallis test). The values are expressed as median, quartiles and extremes.* ***In B:*** *serum retinol concentration (µg/100ml) in children: a) non-infected and distributed for > -2 or < -2 weight-for-age Z-score, b) infected exclusively with* Ascaris lumbricoides *and distributed for > -2 or < -2 weight-for-age Z-score, c) infected exclusively by* Giardia lamblia *and distributed for > -2 or < -2 weight-for-age Z-score, d) coinfected by* Ascaris lumbricoides *and* Giardia lamblia *and distributed for >-2 or < -2 weight-for-age Z-score, e) infected exclusively by* Hymenolepis nana *and distributed for > -2 or < -2 weight-for-age Z-score. The 50th percentile of the growth charts of NCHS, USA, was used as the normal standard.*

retinol concentrations (Figure 5B). However, the wasted children (<-2 SD Z-score) infected with *Ascaris lumbricoides* had the lowest value of serum retinol concentration (Figure 5B).

DISCUSSION

The group of children studied showed a high prevalence of protein-energy malnutrition, hypovitaminosis A and intestinal parasitic infections. The head circumference and the height-for-age were the most altered anthropometric indices. However, these children showed a normal weight-for-height, suggesting an adaptation to the chronic nutritional deficit. Children under one year of age showed a higher deficit in weight-for-age and height-for-age than older children, with 20% and 40%, respectively, below - 2 SD Z-score.

Two major consequences may result from protein-energy malnutrition: deficient physical growth and intellectual performance. Wachs[40] suggested that chronic, mild postnatal malnutrition might be associated with a variety of cognitive and behavioral deficits across the life span. However, malnutrition appears to be a necessary but not a sufficient condition for causing behavioral deficits[40]. Waterlow[42] considers that the consequences for intellectual development of the non-severe lower physical growth and the lower head circumference, related to the international growth charts of NCHS, as observed in our Brazilian children, are not yet clarified[42]. However, it has been recognized that the risk of a child dying is increased when infection is associated to malnutrition, even a mild one[33 36].

Anemia detected by laboratory test was present in 17% of the children and was possibly due to the low iron intake. This occurred mainly in the age group between 6 months and 2.5 years old. This is when the predominance of cow's milk intake (poor in iron) in diet may led to low iron intake[3]. In fact, we detected a low iron intake in 91% of these anemic children. In 78% of the whole group, iron intake was deficient. The possibility that the iron stores of these children were depleted cannot be excluded.

Parasites were present in 75.5% of the children, and 29.4% of them were infected by multiple parasites. *Ascaris lumbricoides* and *Giardia lamblia* were the two most prevalent parasites observed in our study population. Eggs of *Ancilostomidae* were not observed and anemia was not a major problem in these children. However, it is possible that these parasites were not found because we studied only children under 6 years old, and *Ancylostomidae* are mostly prevalent in adult workers[6]. Eggs of *Ascaris lumbricoides* and *Hymenolepis nana* were present in children as young as 9 months suggesting a low degree of sanitation and education in this population.

The pathologic consequences of multiple parasitic infections for the host and its metabolic cost are unknown. It has been suggested that the interactions between parasites in the host may have either antagonistic or synergistic effects, and can result in worsening of inflammatory reactions and clinical manifestations to the parasites[26]. In our study, only *Giardia lamblia* infection was related to deleterious consequences to protein-energy nutritional status. *Giardia lamblia*-infected children had significantly decreased weight-for-age and weight-for-height, while these anthropometric indices were not negatively affected in children infected with *Ascaris lumbricoides* and *Hymenolepis nana*. Children coinfected by *Ascaris lumbricoides* and *Giardia lamblia* were in an intermediate situation between the children infected exclusively by *Giardia lamblia* or *Ascaris lumbricoides*, in relation to protein-energy nutrition. This finding suggests an antagonistic effect between these two parasites. Whether the infection by *Giardia lamblia* was acute or chronic may also have influenced the end result.

Ascaris lumbricoides- or *Hymenolepis nana*-infected children presented weight-for-age and height-for-weight higher than the non-infected. It is recognized that the level of adult helminth infection in an individual host is determined by the balance between establishment of the parasites (input) and their death (output)[6]. The input depends mainly on public health sanitation and educational level, while output depends on the factors associated to the parasite and/or host. For the worm intestinal expulsion to occur, an environment must be created that is too hostile for juvenile and adult worms to continue to develop, or maintain their position[8]. Thus, it is a possibility that, in well-nourished children the abundance of food and the favorable microenvironment around the parasite in the intestinal environment facilitates maintenance of the established parasite for a longer time. Another possibility is that some specific nutrient may be necessary for parasite survival.

The children under study showed predominantly mild or moderate protein-energy malnutrition, and only 14.5% of them presented a heavy load of *Ascaris lumbricoides*. Malnutrition was not a problem in helminth-infected children; on the contrary, these children were better nourished. This fact may suggest a minor influence of infection by intestinal helminthes on the nutrition and growth of the children when they have a low burden of parasite and mild malnutrition. It is possible to conclude that light or moderate parasitism with *Ascaris lumbricoides* did not cause a major detrimental effect on the nutritional status of the children, but it is possible that a heavy burden of the parasite in children also with a deficit in food supply can do so. Furthermore, it is not possible to determine whether these better nourished children would have been heavier and taller if they had grown without parasitic infections. Neither helminth nor *Giardia lamblia* infection influenced the height-for-age. This fact suggests that parasites had only a short and temporary influence on the children's growth.

The group younger than 1 year old presented a low frequency of parasite infection but showed a higher percentage of protein-energy malnutrition. The reasons why these non parasite-infected children had low antrophometric indices and vitamin A serum levels were not clarified. It is possible that in the first year of the life the children may be more susceptible to other negative outside influences independent of parasite infections.

The concomitant infections by viruses and bacteria in the group investigated need to be analyzed. Most infections, including those responsible for mild diarrhea and respiratory diseases, provoke an acute-phase reaction which reduces the synthesis of retinol-binding protein in the liver, and so depresses circulating retinol. This fact does not imply reduced overall vitamin A stores, but may result in a temporary impairment of transport of vitamin A to functional locations[4]. Infectious diseases apparently were not the main cause of the lower values of retinol observed in these children. However, we cannot rule out the possibility that the level of retinol in such infected-children would be higher if they were non-infected.

Hypovitaminosis A was a major nutritional deficiency in this population under investigation. The main sources of vitamin A are milk, meat, liver, fish, eggs, green vegetables and some orange colored fruits and vegetables[29], besides, it is fat-soluble and depends on lipids for intestinal absorption[24], and these kinds of food are not cheap. Considering the low vitamin A intake, the absence of relation from retinol with parasitoses, and the absence of relationship between retinol and infectious diseases, it appears that the low food intake was the main cause of this deficiency. Besides, children below -2 SD weight-for-age Z-score also showed the lowest level of serum retinol. It is possible that in these children the low supply, and poor variety of food, with predominance of rice and beans, had affected both protein-energy nutritional status and vitamin A status. It is not clear why children infected by *Hymenolepis nana* showed values of retinol higher than the other groups.

Our data indicate that malnutrition is more importantly affected by socio- economical and cultural factors, capable of impairing food supply and intake, than by metabolic cost of parasitism and the impairment in digestion and absorption by intestinal parasitic infections, except for *Giardia lamblia*. This latter parasite apparently facilitated the development of protein-energy malnutrition. However, it is likely that helminth infection is not detrimental to nutritional state, provided that food intake is adequate. The association of both low food intake and parasite infections was detrimental.

Our data support the hypothesis that early treatment of *Giardia lamblia* infection will improve the growth of infected children. We need to treat helminth diseases to decrease the morbidity and mortality of related illnesses. However, treatment of helminthes alone would not be efficient as a measure to improve growth of children since these children were no more malnourished than non-parasitized children before treatment. Strategies to increase the supply and intake of food would probably be more effective in poor populations.

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