Original Research Article

Nutritional Status in Parasitized and Nonparasitized Children from Two Districts of Buenos Aires, Argentina

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ABSTRACT: The Program for the Control of Intestinal Parasites and Nutrition was designed to intervene in small communities to prevent and control the effects of parasitic infections on children's health. Objectives: To analyze the association between nutritional status and parasitic infection in suburban and rural children from Buenos Aires, Argentina. Methods: Nutritional status was assessed by anthropometric (weight, height, BMI, skinfolds, upper arm circumference, muscle, and fat upper arm areas) and biochemical (Hb, Ca, Mg, Zn, and Cu) indicators. Parasitological analysis were made on both serial stool and perianal swab samples. A total of 708 children aged 3–11 were measured. The biochemical analysis included 217 blood samples and the parasitological study included 284 samples. Results: Anthropometric status was similar in both settings with low rates of underweight and stunting (<6%), and high rates of overweight (~17%) and obesity (~12%). Ca deficiency was significantly higher in suburban children where 80% of them were hypocalcemic. Around 70% of fecal samples contained parasites. Among infected children, the most prevalent species were *Blastocystis hominis* and *Enterobius vermicularis* (~43%) followed by *Giardia lamblia* (~17%). Differences in parasitological status between districts were not significant. In the suburban district parasitized children were lighter, shorter, and had a lower upper arm circumference than their non-infected peers. No differences in anthropometric status were seen among infected and uninfected rural children. Conclusions: The results suggest an association between intestinal parasites and physical growth in suburban children. Rural children seem to be protected against the effects of parasitic infection. Am. J. Hum. Biol. 26:73–79, 2014.

INTRODUCTION

Enteric parasitic infections constitute a great proportion of the burden of disease among the many health problems observed in economically disadvantaged populations around the world (Brooker et al., 2006; Bundy, 1994). In Latin America and the Caribbean, they occur in almost 42% of population, with 18% of them being trichuriasis, 15% ascariasis, and 9% ancylostomiasis. These values increase to 47, 39, and 24%, respectively, in infected poor people (de Silva et al., 2003; Hotez et al., 2008). The asymptomatic process and low morbidity levels of enteric parasitic infections have lead them to be accepted as normal and inevitable and referred to as neglected tropical diseases (Hotez et al., 2008; Tanner et al., 2009).

The most intense worm infections and related illnesses occur at preschool and school age. It has been estimated that between 25 and 35% of the children are infected with one or more worms of the major species (de Silva et al., 2003), and that among girls and boys aged 5–14 in low-income countries, intestinal parasitism accounts for 12 and 11% of the total disease burden in that age group, respectively (Drake and Bundy, 2001). Thus, schoolchildren are a natural target of intervention studies (Brooker et al., 2006), but they are, paradoxically, a group often overlooked in public health research (Best et al., 2010).

Intestinal parasites may affect the intake of food, its subsequent digestion and absorption, metabolism, and the maintenance of nutrient pools (Hesham et al., 2004). The iron status and copper and zinc deficiencies are the most commonly studied in relation to parasitic infection. However, inadequate intake of food, both in quality and quantity, and high requirements due to growth combined with a high burden of infectious diseases often result in multiple micronutrient deficiencies among vulnerable groups, especially children (Thurlow et al., 2006). In addition to nutritional stress, induced by malabsorption and its impact on physical growth and cognitive development (Crompton and Nesheim, 2002; Stephenson et al., 2000; Watkins and Pollitt, 1997); chronic helminthiasis may produce chronic immune activation, which may affect child's health by subtracting the energy intake from growth and development (McDade et al., 2008). Most studies have investigated the hypothesis, which assumes an association between poor nutritional status and parasite infection. However, the effects of intestinal parasitic infections on growth and nutritional status of children are diverse. Since intestinal parasites do not always cause anthropometric deficits, we explore whether they can produce micronutrient deficits. Ours is one of the few studies to investigate the impact of parasitic infection on specific

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nutritional deficiencies, body composition, and biochemical parameters.

This study reports the baseline data of the Program for the Control of Intestinal Parasites and Nutrition of the University of La Plata (PROCOPIN, UNLP), designed to intervene in small communities preventing and controlling the effects of parasitic infections on the health of schoolchildren. The aim of the study was to analyze the association between nutritional status (measured by anthropometric and biochemical indicators) and intestinal parasitic infection in children from two districts (suburban and rural) of the province of Buenos Aires, Argentina.

SUBJECTS AND METHODS

The PROCOPIN is a university program of community intervention developed in three stages. The first one is the baseline data collection, whose results are reported in this study. The second stage involves the intervention itself through two main actions: on one hand to carry out preventive actions using educative resources (theater play, thematic games, puppets, brochures, among others); however, a drug treatment is administered by pediatricians at the community health centers, based on the individual reports that PROCOPIN gives to the parent's child. In a third stage, the program measures the impact of those interventions. Among the previous published research from the project, Molina et al. (2011) found the presence of intestinal parasites in suburban schoolchildren was associated only with house flooding. A multivariate analysis identified *G. intestinalis* was correlated with use of latrine. Genomic amplification revealed zoonotic Giardia genotypes AII and B. In 2010–2011, Pezzani et al. (2012) compared environmental conditions and risk behaviors associated to intestinal parasites in suburban and rural children and adolescents. They found that risk factors among infected urban children were probably located at the school or other places outside homes, while the parasite transmission in rural children occurred primarily inside and surrounding the homes.

The activities were carried out in the districts of Berisso (suburban) and Magdalena (rural), in the Northeast of the province of Buenos Aires, near La Plata, the capital city of the province. The climate in the region is warm and humid due to its proximity to the estuary of the Rio de la Plata. Berisso (34° 52′ S, 57° 53′ W) is inhabited by around 88,400 people (593 inhabitants/km^2). Most of the surveyed families lived in small houses very close to one another, without sewer system or solid waste collection; drinking water was obtained through illegal connections. Family income was mainly based on temporary jobs and social support from the government. Magdalena is a rural district (34° 04′ S 57° 31′ W) which comprises around 19,000 inhabitants (9 inhabitants/km^2). Located in wide plots of land, homes are far apart from one another, usually with only one family living in them. They are made of brick masonry, are supplied drinking water and dispose of human waste in individual cesspools. The main activities in Magdalena are linked directly or indirectly to agriculture and dairy farming. Economic activity is based on agribusiness through food processing, meat and dairy industries, marking the importance of the food industry. In contrast, economic profile in Berisso is dominated by the industrial sector and can be essentially characterized by SMEs (Small and Medium Enterprises) with a strong influence on the provision of supplies and services for the Petrochemical Pole of Ensenada and the La Plata Port.

In both districts children spend four (preschool) and five (schoolchildren) hours at school, where they receive breakfast and lunch. Although each school has its own diet schedule, they are similar in terms of food and nutritional facts. Mostly, foods are rich in carbohydrates and poor in proteins. Pasta and rice are frequent, whereas fruits and vegetables are barely consumed. For breakfast, many children prefer *mate cocido* (an infusion prepared with strained yerba mate) rather than milk, and eat bread with jam.

People were invited to participate through the educational institutions, following the World Health Organization's guidelines that recommend the development of population studies by reaching the communities through schools (WHO, 1987). The schools were selected because their population of children represented adequately the living conditions of the suburbs and the rural settings. Finally, three suburban schools (Berisso) and three rural schools (Magdalena) were included. School authorities and official consents from the county councils were also obtained. School authorities informed parents about the aim of the program and invited them to take part in it. Each parent or guardian signed an informed consent form after an informative interview held at the school. Research protocols were approved by the committees of the institutions that funded the program. All personal information collected in the research protocol was protected, pursuant to the Declaration of Helsinki (1964), the Nuremberg Code (1947), and the National Law 25,326.

Data collection

Baseline data reported here were collected from April to June, between 2009 and 2011. A total of 356 boys and 352 girls (Berisso = 498 and Magadalena = 210) were measured once according to standard procedures (Lohman et al., 1988). Weight (kg) was recorded using a digital scale (Tanita BF350), and height (cm) was measured with a portable stadiometer (SECA S-213). Body mass index (BMI) was calculated as weight (kg)/height (m^2). Upper arm circumference (UAC) was measured in cm with a flexible steel tape, and tricipital and subscapular skinfolds (TS and SS, respectively) were measured in mm with a Lange caliper. The upper arm muscle and fat areas (UAMA and UAFA, respectively) were calculated according to Frisancho (1990) where: UAMA (cm^2) = $[((TS \times UAC)/2) - (\pi \times TS^2)]/4$ and UAFA (cm^2) = $(UAC - TS \times \pi)^2/4\ \pi$. In both cases, a constant bone size is assumed.

Blood samples were taken from 217 children, which amounted to 31% of the measured children (Berisso = 154 and Magdalena = 63). Approximately 5 ml of peripheral venous blood was collected from each child. Each sample was divided in two: in one tube EDTAK$_3$ (ethylenediaminetetraacetic acid, tripotassium salt) was added, and in the other no anticoagulant was used. Whole blood samples were stored at 4°C and analyzed within 24 h. The serum was separated 2 h after the sample was collected and stored at −20°C until processed. Hemoglobin (Hb) concentration was determined in a hematological cell counter (SYSMEX K21N, Japan) by the LSS-methemoglobin method. Serum calcium (Ca), magnesium (Mg), zinc (Zn), and copper (Cu) were analyzed by atomic absorption spectrometry (GBC 902, with air-acetylene flame, and

TABLE 1. Nutritional status in schoolchildren from Berisso and Magdalena (Province of Buenos Aires)

Nutritional status	Variable/Indicator	Berisso		Magdalena				
		Boys= 259	Girls= 239	Boys= 97	Girls= 113	Berisso	Magdalena	*P*-value
Anthropometric status	Weight (z score)	0.1 ±1.2	0.2 ±1.4	0.5 ±1.1	0.0 ±1.1	0.2 ±1.3	0.2 ±1.1	0.802
	Height (z score)	−0.4 ±1.0	−0.4 ±1.1	−0.2 ±1.0	−0.4 ±0.9	−0.4 ±1.1	−0.3 ±1.0	0.338
	BMI (z- score)	0.5 ±1.1	0.5 ±1.3	0.8 ±1.2	0.3 ±1.1	0.5 ±1.2	0.5 ±1.2	0.923
	UAC (z score)	0.1 ±1.2	0.2 ±1.3	0.4 ±1.0	0.2 ±1.4	0.2 ±1.2	0.3 ±1.3	0.247
	TS (z score)	0.9 ±1.2	0.9 ±1.4	1.3 ±1.3	1.0 ±1.4	0.9 ±1.3	1.1 ±1.3	0.018
	SS (z score)	0.9 ±1.8	1.2 ±2.1	0.8 ±1.6	0.8 ±1.7	1.0 ±2.0	0.8 ±1.6	0.180
	UAMA (z score)	−0.5 ±1.0	−0.4 ±1.3	−0.4 ±0.7	−0.6 ±0.9	−0.4 ±1.2	−0.5 ±0.8	0.472
	UAFA (z score)	0.6 ±1.2	0.7 ±1.6	0.9 ±1.3	0.7 ±1.4	0.7 ±1.4	0.8 ±1.4	0.384
	Underweight (%)	2.9	3.6	1.2	2.2	3.3	1.7	0.284
	Stunting (%)	6.6	5.4	3.5	3.5	6.0	3.3	0.142
	Overweight (%)	16.6	16.7	25.8	15.9	16.7	20.5	0.226
	Obesity (%)	11.2	14.6	11.3	9.7	12.9	10.5	0.377
Biochemical status [a]	Hb (g/dL)	12.4 ±0.9	12.5 ±0.9	12.1 ±0.9	12.3 ±0.7	12.4 ±0.9	12.2 ±0.8	0.082
	Ca (mg/dL)	7.9 ±1.1	7.9 ±1.1	8.6 ±1.4	9.0 ±1.7	7.9 ±1.1	8.8 ±1.5	0.002
	Mg (mg/dL)	1.9 ±0.3	1.9 ±0.3	1.9 ±0.3	1.9 ±0.2	1.9 ±0.3	1.9 ±0.2	0.780
	Zn (mg/dL)	105.4 ±6.3	106.7 ±9.5	107.2 ±8.5	107.2 ±8.1	105.9 ±12.7	107.2 ±8.2	0.522
	Cu (mg/dL)	107.9 ±15.1	110.6 ±16.0	109.8 ±18.1	111.6 ±14.7	108.9 ±15.4	110.5 ±11.5	0.566
	Anemia (%)	9.7	13.1	10.8	7.7	11.0	9.5	0.742
	Hypocalcemia (%)	83.6	91.4	57.7	52.9	86.5	55.8	0.000
	Hypomagnesemia (%)	9.8	20.0	7.7	5.9	13.5	7.0	0.405
	Zn deficiency (%)	0.0	0.0	0.0	0.0	0.0	0.0	-
	Cu deficiency (%)	0.0	0.0	0.0	0.0	0.0	0.0	-

Quantitative variables are expressed by means ± standard deviations and qualitative variables are expressed by prevalences (%)
[a]Blood sampling included 154 schoolchildren from Berisso and 63 from Magdalena

324.7 nm oxidative type), using the technique described by Piper and Higgins (1967).

For the screening of intestinal parasites, parents received instructions (oral and written) at the moment of the interview on how to collect the samples. Children's fecal samples were collected for 5 consecutive days in one wide-mouthed jar with screw cap containing formalin 10%. Stools were processed with the modified Telemann technique and the pellets were observed under light microscope after staining with lugol. The perianal zone was brushed with sterile swabs for 5 mornings, immediately after getting up, to detect eggs of *Enterobius vermicularis*. Swabs were stored in containers of formalin 10%. The containers were vigorously shaken and the liquid centrifuged at 1,000*g* for 5 min; the sediment was observed under light microscope (see Pezzani et al., 2009, for technical details). Only complete samples were processed ($N = 284$, Berisso = 179, and Magdalena = 107), which amounted to 40% of the measured children. Parasitological and blood sub-samples did not show systematic differences (i.e., bias) in relation to the anthropometric sample in terms of age and sex.

Data analysis

Anthropometric measurements were standardized to z scores relative to WHO references using Anthro and AnthroPlus (http://www.who.int/childgrowth). *Z* scores for body composition were calculated relative to NHANES references (Frisancho, 1990). The deficit in anthropometric status was defined by *z* scores less than 2 standard deviations relative to WHO 50th centile. Overweight and obesity were defined by BMI z scores above 1 and 2 standard deviations, respectively (de Onis et al., 2007).

The cutoffs for anemia were Hb < 11.0 g/dL in children under 5 years and Hb < 11.5 g/dL in older children (WHO, 2001). The reference values for the other biochemical elements were Ca: 9−11 mg/dL, Mg: 1.6−3 mg/dL, Zn: 64−118 mg/dL, and Cu: 27−153 mg/dL (Henry, 2005).

Prevalence rates by district and sex were compared using the Chi-square and Fisher tests. The association between nutritional status and parasitic infection was tested by Student and Mann-Whitney tests. The statistical analysis was performed by SPSS 18.0 (SPSS, Chicago, IL). Level of significance was set at 0.05.

RESULTS

Table 1 summarizes the mean and standard deviations for anthropometric and biochemical variables, and the mean prevalences for anthropometric and biochemical indicators of nutritional status by sex and district. Except height and UAMA, all *z* scores were ≥ 0 in boys and girls of both districts. Anthropometric indicators of nutritional status showed low rates of underweight (1.2–3.6%) and stunting (3.5–6.6%), but high rates of overweight (15.9–25.8%) and obesity (9.7–14.6%). Statistical differences between sexes (not shown) and districts were not significant.

Biochemical status indicated that the prevalence of anemia ranged from 7.7 to 13.1% and there was no deficiency in Zn and Cu blood levels. In contrast, there were deficiencies in serum Ca (52.9–91.4%), and Mg (5.9–20.0%). Although biochemical status was similar in boys and girls, Berisso showed significant lower Ca levels and higher hypocalcemia than Magdalena.

The overall frequency of intestinal parasitism was 70% (49% polyparasitic and 51% monoparasitic). Twenty-five percent of children were parasitized by protozoa, 20% by helminthes, and 25% presented mixed infection. Among infected children (Table 2), the most prevalent species were *Enterobius vermicularis* (34.5–52.9%) and *Blastocystis hominis* (38.0–46.1%), followed by *Giardia lamblia* (12.0–22.4%). Prevalences of the remainder species were <6.9%. Statistical differences in the prevalences of parasites between sexes of each district or between districts were not significant.

TABLE 2. *Prevalences of intestinal parasites found in schoolchildren from Berisso and Magdalena*

Parasitological status	Berisso		Magdalena		Berisso	Magdalena	*P*-value
	Boys	Girls	Boys	Girls	*N* = 179	*N* = 107	
Global prevalence	73.8	68.0	67.2	69.4	71.3	68.2	0.577
Polyparasitosis	53.2	52.9	53.8	35.3	53.1	45.2	0.280
Monoparasitosis	45.5	47.1	46.2	64.7	46.1	54.8	0.235
Protozoa	53.9	48.0	46.6	44.0	51.4	45.4	0.322
Helminthes	53.9	41.3	36.2	38.0	48.6	37.0	0.057
Enterobius vermicularis	52.9	37.8	34.5	38.0	46.9	36.1	0.074
Blastocystis hominis	46.1	44.0	39.7	38.0	45.2	38.9	0.296
Giardia lamblia	17.6	16.0	22.4	12.0	16.9	17.6	0.889
Hymenolepis nana	6.9	0.0	1.7	0.0	4.0	0.9	0.258
Ascaris lumbricoides	2.9	2.7	0.0	2.0	2.8	0.9	0.511
Trichuris trichiura	0.0	1.3	0.0	0.0	0.6	0.0	1.000

TABLE 3. *Differences in nutritional status between parasitized and non-parasitized children from Berisso and Magdalena*

Nutritional status	Variable/Indicator	Berisso			Magdalena		
		Non parasitized	Parasitized	*P*-value	Non parasitized	Parasitized	*P*-value
Anthropometric status	Weight (z score)	0.4 ± 1.2	0.0 ± 1.2	0.043	0.3 ± 1.1	0.5 ± 1.2	0.563
	Height (z score)	0.0 ± 1.2	?0.5 ± 1.1	0.018	?0.2 ± 1.9	?0.3 ± 1.1	0.667
	BMI (z- score)	0.6 ± 1.2	0.3 ± 1.1	0.138	0.8 ± 1.2	0.8 ± 1.2	0.969
	UAC (z score)	0.4 ± 1.4	0.0 ± 1.1	0.030	0.5 ± 1.1	0.4 ± 1.0	0.581
	TS (z score)	1.1 ± 1.3	0.7 ± 1.1	0.054	1.4 ± 1.3	1.4 ± 1.3	0.832
	SS (z score)	1.3 ± 1.7	0.8 ± 1.8	0.109	1.0 ± 1.8	1.0 ± 1.7	0.860
	UAMA (z score)	?0.2 ± 1.6	?0.6 ± 1.1	0.138	?0.5 ± 1.1	?0.5 ± 1.7	0.890
	UAFA (z score)	0.9 ± 1.3	0.5 ± 1.1	0.054	0.9 ± 1.6	0.9 ± 1.2	0.902
	Underweight (%)	0.0	4.7	0.334	3.4	1.7	1.000
	Stunting (%)	2.0	6.3	0.414	2.9	4.1	1.000
	Overweight (%)	17.6	16.5	0.858	32.4	27.4	0.599
	Obesity (%)	15.7	6.3	0.048	14.7	13.7	0.889
Biochemical status	Hb (g/dL)	12.5 ± 1.0	12.4 ± 0.8	0.481	12.4 ± 0.9	12.1 ± 0.8	0.199
	Ca (mg/dL)	7.6 ± 0.5	8.0 ± 1.2	0.137	8.5 ± 1.7	8.9 ± 1.5	0.496
	Mg (mg/dL)	1.8 ± 0.2	1.9 ± 0.3	0.227	1.9 ± 0.2	1.9 ± 0.3	0.682
	Zn (mg/dL)	0.0	0.0	–	0.0	0.0	–
	Cu (mg/dL)	0.0	0.0	–	0.0	0.0	–
	Anemia (%)	12.2	10.6	0.783	6.3	10.6	0.981
	Hypocalcemia (%)	100.0	82.9	0.105	60.0	54.5	1.000
	Hypomagnesemia (%)	5.0	15.8	0.210	0.0	9.1	0.779

We investigated protozoa and helminth infections as a group, since there were not significant differences between the effects of these parasites, that is, specific nutritional consequences. On average, parasitized children (children who were infected by helminths, protozoa, or a combination of both parasites) had lower *z* scores than their nonparasitized peers; but there were differences according to district (Table 3). In Berisso, weight, height, UAC, and obesity rates were significantly lower in infected children than in noninfected peers. In contrast, anthropometric status in children from Magdalena did not show differences related to parasitological status. Statistical differences in biochemical status (Hb, Ca, Mg, Zn, and Cu), anemia and micronutrient deficiencies in parasitized versus nonparasitized children were not significant both in Berisso and Magdalena.

DISCUSSION

In Argentina, a movement of the rural population toward several urban centers has been taking place since 1950. Most of these "domestic immigrants" are concentrated in the suburbs of booming cities. A movement of people from bordering countries into the urban and rural areas has added to the picture in the last decade. These settlements became more concentrated, which had a negative impact on the living conditions of these populations (Pezzani et al., 2012). That is the case of many villages and towns near La Plata, where significant proportions of the population are internal migrants settled on flooded, government-owned land and many lack basic public services such as sewers or drinking water. Most of people settled in those lands receive food assistance and children have lunch at school. Such is the case of our population, especially in Berisso. Settings with limited access to adequate sanitation and nutrition impose a double burden to children's health: intestinal parasites related to poor sanitation and obesity due to hypercaloric diets. In this regard, we found low rates of stunting and underweight along with high prevalences of overweight and obesity, exposing 3 out of 10 children to risk of adult obesity. These figures are consistent with those found in the literature on overweight status in Latin American schoolchildren (Best et al., 2010; Carrasco et al., 2011; IGBE, 2009;

Olaiz-Fernández et al., 2006; Orden et al., 2005). At the same time, these children showed an anthropometric profile defined by greater adiposity and less muscle mass than the reference population, as has been previously described in low-income children from Buenos Aires (Oyhenart et al., 2007).

It is well known that besides the lack of necessary macronutrients for healthy growth, many children in developing countries suffer from micronutrient deficiencies. This could be the case with the children under study. In fact, the dietary pattern of these populations has been characterized by a higher energy intake, with inadequacy in several micronutrients (Varea et al., 2011). We did not record the school diet but a nutrition survey in children 2–6 years old from Berisso during 2010 and 2011 (unpublished data) may be useful to understand a common eating pattern in these children. The survey reported that in terms of calories 42% of children exceeded those recommended by the Dietary Reference Intakes (Food and Nutrition Board, 2002). It also determined that 68, 41, and 60% of children ate <90% of the recommended amounts of Fe, Zn, and Ca. Furthermore, the diet intake was low in vitamins A, B9, and C. Such deficits are very common in low income Argentinian populations and may elapse under subclinical forms sometimes referred as hidden malnutrition. Besides that, the population under study had low rates of hemoglobin and magnesium deficiencies and no zinc and cooper deficiencies. By contrast, serum calcium was significantly higher in Magdalena and the hypocalcemia affected more than 80% of children from Berisso. This difference cannot be explained by global socioeconomic and health indicators (poverty, parental education, fecundity, child mortality, etc.), which in fact are similar in both districts according to census data. On a lesser scale Pezzani et al. (2012) found the greatest differences between both communities were related to house materials, waste disposal, and flooding, with worse environmental conditions in suburban populations than in rural ones. These characteristics can hardly be related to calcium serum levels between children of both communities. We believe this difference appears to be rather linked to nutritional factors. Magdalena is an area where the household economy, strongly linked to the countryside resources (especially milk and meat products), which would compensate the limited access to food that may occur in suburban areas, ensuring greater health and wellbeing to children.

According to WHO estimates, ~10% of the Argentinian population under 14 years old (around 950,000 children) requires preventive chemotherapy for soil transmitted helminthiasis (WHO, 2011). Our results, like those of other field studies in the region, indicate that geohelminthiasis is less frequent and less important in relation to other parasitic species. The parasites detected more frequently in both populations were *E. vermicularis*, *B. hominis*, and G. *lamblia*, matching other authors' findings in Argentina (Bracciaforte et al., 2010; Milano et al., 2007; Soriano et al., 2005; Zonta et al., 2007). They also confirm *B. hominis* as the protozoan with the highest prevalence in different regions of the country (Gamboa et al., 2009; Menghi et al., 2007; Soriano et al., 2005).The literature published in the last decade found the prevalence of parasitic infections in suburban and rural settlements in the province of Buenos Aires to be between 23 and 86% (Gamboa et al., 2009, 2011; Minvielle et al., 2004; Molina et al., 2011; Pezzani et al., 2004, 2009, 2012).

In many populations, intestinal parasites are a source of nutritional and energetic stress affecting child growth, but the evidence is not conclusive, perhaps because the parasitic burden is not enough to result in low anthropometric values to classify the subjects as undernourished. For instance, Wilson et al. (1999) found an association between intestinal parasitic infection, including infection by *Giardia* spp. and *E. vermicularis*, and lower Hb levels, weight, height, and weight-for-height; but they also noticed how difficult it was to explain why the infected children had significantly higher subscapular fat and sum of skinfolds. Carvalho-Costa et al. (2007) found an interaction between *G. lamblia* infection and weight, height, and UAC, suggesting that this species affected the nutritional status in Brazilian children. In contrast, other studies found no effects of giardiasis on child growth (Campbell et al., 2004; Hollm-Delgado et al., 2008), whereas Muniz-Junqueira and Queiroz (2002) found protein-energy malnutrition was associated with *G. lamblia* but not with geohelminths such as *A. lumbricoides* or *H. nana*. Similar results have been reported by Tanner et al. (2009) in the Tsimané, an indigenous group from the Bolivian Amazon. They found no associations between the most common parasitic infection, hookworm, and either long-term markers of growth (height-for-age) or short-term indicators of energetic reserves of nutritional stress (TS, SS or UAMA). We found that, on average, parasitized children had a higher prevalence of underweight and a lower prevalence of overweight than nonparasitized children, but—except obesity—such differences had no statistical significance, so that anthropometric indicators of nutritional status were not associated with parasitic infection. However, the analysis of single anthropometric variables showed that suburban parasitized children were lighter, shorter, and had lower UAC than their nonparasitized peers. We found no significant differences in body composition between them. Since fat and muscle arm areas—calculated using UAC—did not differ between infected and uninfected children, we assume that the arm bone mass could have been affected, although more complex studies would be needed to confirm that. However, we did not detect an association between intestinal parasites and anthropometric status in rural children, so we speculate that rural conditions might favor the access to food, which in turn may protect children against the harmful effects of parasitic infections.

Some studies have also considered changes in serum zinc, copper, iron, and other micronutrient levels as part of the complex host response to infection (Carvalho-Costa et al., 2007; Ertan et al., 2002), but again results are not consistent. We found no effects of intestinal parasitism on the biochemical status in these children. It has been proposed that chronic exposure to infection may compromise child growth as it imposes an energetic cost to the growing child (McDade et al., 2008; Tanner et al., 2009). Our results suggest that although the parasites did not affect the blood micronutrients status, they imposed a growth cost in suburban children. However, we do not know to what extent the growth deficit was an indirect result of intestinal parasitism or an outcome of inadequate nutrition. Calcium is involved in many vital processes such as muscle contraction, homeostasis, and bone mineralization. When calcium intake is adequate it is stored primarily at the end of long bones and mobilized to meet different needs such as growth, pregnancy and lactation.

A poor calcium intake may reduce serum calcium and bone structure because Ca must be subtracted from the bone stock (Gómez Alonso et al., 2004). Our own field observations led us to think that this hypocalcemia may have resulted from an inadequate consumption of dietary calcium, rather than a disorder in its absorption and/or utilization. In fact, the absence of these effects in rural children exposed to the same parasites suggests some nutritional factors may be involved, such as the access to calcium rich foods.

Some evidence about the effects of parasitism on bone growth has been observed in experimental conditions. Studies in lambs artificially infected with nematodes revealed that changes in hormonal balance may result in reduced bone growth and osteoporosis (Sykes et al., 1975). Also, growing lambs naturally infected with nematodes, showed significant reductions of serum calcium, bone mineral density, bone size, as well as thinning of the trabecular structure and reduced bone formation, probably associated with reduced osteoblastic activity. These effects were more pronounced in those animals exposed to lower levels of nutrition (Thamsborg and Hauge, 2001). These studies suggest that malnutrition interacts with parasitic infection affecting bone formation and perhaps levels of blood micronutrients.

The intestinal parasitism is one of the most common infections in school aged children. Since these infections are frequently asymptomatic, there is not a real concern to change household and environmental conditions in the affected communities. This study points out the need of carrying out field surveys that could underscore the substantial gap existing in hospital statistics, which record only acute problems in both districts, overlooking chronic diseases such as intestinal parasitism in populations with limited access to health care services. Although our conclusions are based on non probabilistic samples, children under study are quite representative of middle-low and low-income children living in several settings of the metropolitan area of Buenos Aires and the surrounding areas of the biggest cities of the country. There, living conditions adds complexity to the observational studies, because the difficulty to isolate confounding factors. Individual behaviors and some cultural practices are factors that probably buffer the relationship between infection and nutritional status, but its analysis would require other approaches such as the qualitative methods. Another limitation of our study was not to measure the parasitic burdens, which could affect more or less severely nutritional status. Nevertheless, we believe the results may contribute to public health by directing primary, secondary, and tertiary preventive actions based on the baseline diagnosis. Beyond these practical issues, we hope the present results generate new research about the mechanisms involved in the relationship among parasitic infection, nutritional status, and bone growth.

CONCLUSIONS

These results suggest that although parasitic infection did not affect the blood micronutrients status, it imposed a growth cost in suburban children. However, we do not know to what extent the growth deficit was an indirect result of intestinal parasitism or/and an outcome of inadequate nutrition. Rural children seem to be protected against the effects of parasitic infection.

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