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Effect of *Giardia* Infection on Nutritional Status in Primary Schoolchildren, in Northwest Iran

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Abstract: In order to determine the association between *Giardia* infection and nutritional status, a cross- sectional study was performed on twenty randomly selected primary schools from two regions of Ardabil province in 2005. Anthropometric factors including height, weight and midarm muscle circumference (MAC) were measured for 813 children (413 males, 400 females). The food intake was estimated for energy and other nutrients by 24 h recall method for three days in week. Determination of *Giardia* infection was done by using direct wet mount and formalin-ether sedimentation concentration.10.9% of boys and 17.2% of girls were infected with *Giardia* infection. Weight and MAC in none infected girls and boys (only 7 and 11 years old) were higher than in infected groups. The average values for weight, height and MAC for both genders were lower than those of NCHS values. Vitamin E and phosphorous intake in non infected boys (in 7-10 years old) were less than infected boys. Calorie, protein, vitamins (B3, B5, B6, E and folacin) and minerals (copper, magnesium, phosphorous, potassium and selenium) intake of infected girls were less than non infected girls in 11-12 years old category. Based on the results found in this study, we conclude that *Giardia* infection may affect on some of anthropometric factors as well as the calorie and other nutrients intake in some of age groups.

Key words: *Giardia*, height, weight, students, Ardabil

INTRODUCTION

Growth and nutrition with respect to all of the macronutrients and virtually all of the micronutrients have been documented to be adversely affected by gastrointestinal pathogens (Solomons, 1993). *Giardia intestinalis* is one of the most common intestinal parasites in the world, with an estimated number of 2.8×10^6 infections per year in humans (Ali and Hill, 2003). Intestinal parasitic infections are a public health problem in developing countries (Quihui *et al*., 2006). Geographical conditions and poor nutritional and socioeconomic status contribute to making the Islamic Republic of Iran favorable area for parasitic infections. The prevalence of intestinal parasitic infections has been found to vary in different parts of Iran, with 47.2% in Kerman (Nasser and Jafar, 2009), 18.4% in Tehran (Nematian *et al*., 2004) and 3.85% in Karaj (Nasiri *et al*., 2009). Giardiasis may present a broad clinical spectrum that ranges from the asymptomatic carrier state to a chronic infection characterized by abdominal pain, diarrhea, flatulence, steatorrhea, malabsorption syndrome, poor growth and weight loss in infants and children (Wolfe, 1992; Thompson *et al*., 1993). There is a general acceptance that *Giardia* infection is likely to result in failure to thrive and poor growth in infants and children (Islam, 1990; Wolfe, 1992). However, other studies showed that children with symptomatic infections had significantly lower weight-for-age and lower height-for-age than asymptomatic children (Simsek *et al*., 2004; Newman *et al*., 2001). There has also been a strong association between giardial infection and undernutrition, wasting and stunting in the children (Loewenson *et al*., 1986). Giardiasis can produce steatorrhea, maldigestion and malabsorption of carbohydrates and of vitamins A and B12 (Solomons, 1995). Therefore, it may be an important factor contributing to the low nutritional status of many primary schoolchildren (Loewenson *et al*., 1986). The main aim of this study was to determine any association between giardiasis and nutritional status in primary schoolchildren.

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MATERIALS AND METHODS

In a cross-sectional study, twenty primary schools from two regions of Ardabil province in Iran were randomly selected in 2005. They had different numbers of students with different socioeconomic conditions comprising 813 (413 males, 400 females) school children in the range of 7-12 years old. The food intake was estimated for energy and other nutrients by 24 h recall method for three days in week. Determination of *Giardia* infection was done by using direct wet mount and formalin-ether sedimentation concentration. Anthropometric factors including height, weight and midarm muscle circumference (MAC) were measured for all subjects included in the study. Height and weight were obtained using a portable digital scale and portable digital Stadiometer following a standard technique. Height and weight were measured without shoes and in light summer school uniform in a private. The subjects were asked to stand, without shoes against the wall with heels, buttocks and shoulders touching the wall. The head was kept in the plane and measurement was noted in the nearest 0.5 cm. Weight was measured to the nearest 0.1 kg using portable soenle digital scales with a range of 0-200 kg. BMI was calculated from the students' height and weight. The food intake was estimated for energy and other nutrients by the 24 h recall for three days. Mean daily dietary intake and food composition were estimated using Iranian food composition tables (Mafiei *et al*., 2002). The 50th percentile of the growth charts of the National Center for Health Statistic (NCHS), USA, was used as normal standard (Hamill *et al*., 1979). Statistical analyses were performed using SPSS version 13 for windows. Results are expressed as Mean±SD. Statistical comparison of means among groups was performed with independent samples t-test. Differences were considered statistically significant at $p<0.05$.

RESULTS AND DISCUSSION

In this study, 10.9% of boys and 17.2% of girls were infected with *Giardia*. The statistical comparisons of weight, height and MAC between infected and non infected children for both sexes are shown in Table 1. On overall, in non infected students, weight, height and MAC were higher than those in infected children. However, these differences are statistically significant only in some age and sex groups (boys at 7 and 11 years old). Height (Fig. 1), weight (Fig. 2) and MAC (Fig. 3) of both infected sexes were lower than NCHS standards. Vitamin E and phosphorous intake in non infected boys

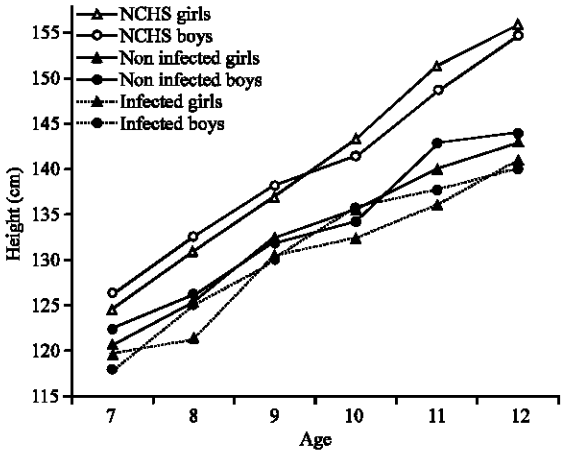

Fig. 1: Comparison of height in schoolchildren infected and none infected by *Giardia* with NCHS

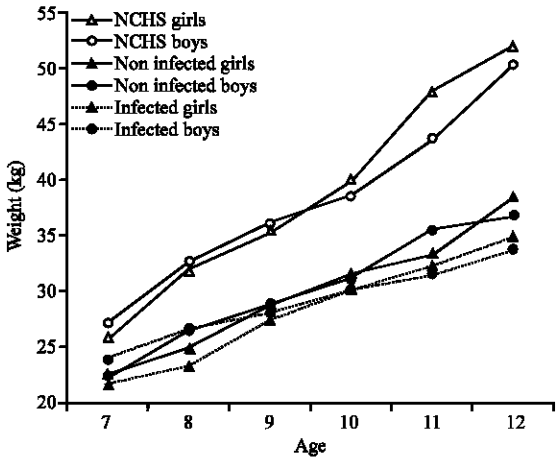

Fig. 2: Comparison of weight in schoolchildren infected and none infected by *Giardia* with NCHS

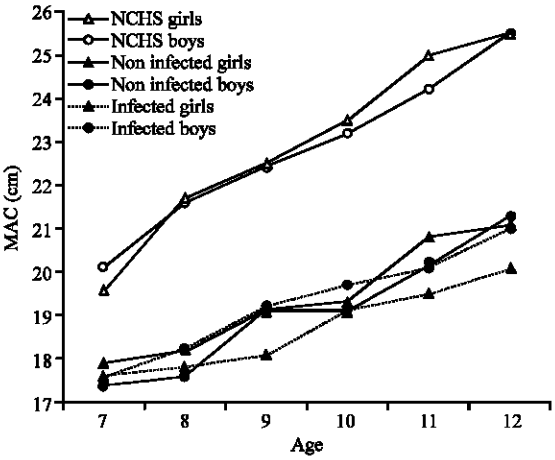

Fig. 3: Comparison of MAC in schoolchildren infected and none infected by *Giardia* with NCHS

Table 1: Comparison of height, weight and MAC between schoolchildren infected and none infected by *Giardia*

		Boys					Girls				
Variables	Age (years)	Non infected	N	Infected	N	p-value	Non infected	N	Infected	N	p-value
Height (cm)	7	122.3±5.5	54	117.8±4.2	7	0.04	120.6±5.5	61	119.5±6.3	12	0.58
	8	126.1±4.7	75	125.0±7.1	9	0.55	125.4±6.3	61	121.3±5.6	7	0.10
	9	131.7±5.7	86	130.2±7.7	8	0.49	132.4±7.4	58	130.5±6.5	15	0.36
	10	134.1±6.7	64	135.7±6.7	7	0.55	135.4±8.4	73	132.3±5.7	11	0.24
	11	142.8±6.5	47	137.6±4.8	8	0.03*	139.9±7	60	136.0±5.7	12	0.07
	12	143.2±5.9	31	140.0±3.5	5	0.26	142.9±8.6	23	141	1	0.83
Weight (kg)	7	23.9±3.5	54	22.4±4.2	7	0.29	22.6±3.6	61	21.7±2.2	12	0.42
	8	25.6±3.7	75	27.5±6.1	9	0.8	24.9±4.1	61	23.3±3.7	7	0.34
	9	28.9±6.4	86	28.0±4.1	8	0.66	28.9±7.1	58	27.4±3.7	15	0.43
	10	31.1±5.6	64	30.1±5.8	7	0.67	31.6±7.9	73	30.2±6.8	11	0.62
	11	35.5±7.5	47	31.5±3.5	8	0.14	33.4±6.4	60	32.3±4.7	12	0.54
	12	36.8±8.5	31	33.8±6.6	5	0.45	38.5±8.1	23	35	1	0.67
MAC (cm)	7	17.9±1.7	54	17.6±2.5	7	0.65	17.5±1.6	61	17.4±1.4	12	0.82
	8	18.2±1.7	75	17.8±2.9	9	0.62	18.2±1.6	61	17.6±1.1	7	0.36
	9	19.1±2.3	86	18.1±1.8	8	0.3	19.2±2.6	58	19.1±1.7	15	0.87
	10	19.3±2.4	64	19.1±1.3	7	0.79	19.7±2.6	73	19.1±2.1	11	0.50
	11	20.8±2.7	47	19.5±1.1	8	0.16	20.1±2.7	60	20.2±1.4	12	0.89
	12	21.1±2.6	31	20.1±2.9	5	0.47	21.3±2.9	23	21	1	0.92

Values are Mean±SD. *Significant p<0.05

Table 2: Comparison mean intake of calorie and other nutrients in boys infected and none infected by *Giardia*

	Boys					
	7-10 years			11-12 years		
Variables	Non infected (N = 278)	Infected (N = 31)	p-value	Non infected (N = 27)	Infected (N = 13)	p-value
Calorie (Kcal)	1790.3±461	1817.00±512	0.76	1961.4±627.3	1952.4±559.2	0.96
Protein (g)	66±25	61.80±22.4	0.39	69.2±28.6	71.7±27.4	0.77
CHO (g)	252.9±69.1	261.70±77.7	0.51	292.9±102.3	272.2±79.1	0.48
Fiber (g)	10.2±6.4	9.80±4.8	0.75	13±7.4	12.6±7.5	0.79
Total fat (g)	58.1±24.7	59.50±28.9	0.78	60.8±21.1	65.0±29.9	0.53
Vitamin B1 (mg)	1.2±0.4	1.30±0.4	0.18	1.5±0.58	1.3±0.47	0.30
Vitamin B2 (mg)	1.1±0.5	0.98±0.5	0.49	1.2±0.5	1.1±0.4	0.81
Vitamin B3 (mg)	19.4±10.4	18.30±7.1	0.57	20.8±10.6	21.7±10.5	0.78
Vitamin B6 (mg)	1±0.6	1.00±0.7	0.47	0. 9±0.5	1.1±0.4	0.09
Folacin (µg)	*102.1±89.1	*90.90±73.7	0.50	*109.3±77.8	*92.6±48.5	0.45
Vitamin B5 (mg)	3.4±1.4	2.50±1.6	0.26	2.7±1.5	2.6±0. 8	0.79
Vitamin C (mg)	45.3±35.4	45.00±34.5	0.67	49.3±30.5	47.9±31.4	0.86
Vitamin E (mg)	3.2±2.3	2.10±1.3	0.009	3.1±1.9	3.3±1.8	0.61
Ca (mg)	493.3±292.9*	*427.60±223.7	0.23	477.5±260.7*	*476.3±235	0.98
Cu (mg)	0.69±0.5	0.60±0.3	0.35	0.7±0.5	0.7±0.4	0.89
Fe (mg)	16.3±6.3	18.30±5.7	0.08	20.2±9.1	17.8±7.2	0.37
Mg (mg)	116.3±65.4	107.90±68.4	0.50	117.5±56.5	127.9±5	0.53
P (mg)	678.9±314.9	516.40±247.4	0.006	659.6±305.5	723.7±232.2	0.47
K (mg)	1565.6±893	1367.20±883	0.24	1562.1±735.3	1754.6±822.2	0.39
Se (µg)	35.8±21.3	31.10±20.1	0.23	39.2±19.9	41.4±18.8	0.70
Na (mg)	2135.9±1108	2019.30±1349	0.58	2419.9±1375	2729.3±1522.8	0.46
ZN (mg)	5.1±3.1	5.10±2.7	0.88	*5.4±2.4	5.4±3.3*	0.93

Values are Mean±SD. CHO: Carbohydrate, Ca: Calcium, Cu: Copper, Fe: Iron, Mg: Magnesium, P: Phosphorus, K: Potassium, S: Selenium, Na: Sodium, Zn: Zinc. *Different is significant at the 0.05 compared with dietary reference intakes

were less than infected boys for 7-10 years of age ($p<0.05$). We observed no statistically significant differences between calorie and other nutrients intakes in infected and non infected boys for other age groups (Table 2). Calorie, protein, vitamins (B3, B5, B6, E and folacin) and minerals (copper, magnesium, phosphorous, potassium and selenium) intake in infected girls was higher than those of non infected girls for 11-12 years age groups ($p<0.05$). The differences in intake of other nutrients were not statistically significant between two age groups (Table 3). Calorie and other nutrients intake of both genders were also compared with WHO Recommended Dietary Allowance (RDA) values. Although, folacin, calcium and zinc intake of girls were lower, the intakes of other nutrients were relatively similar to those of RDA values. Similarly, folacin and calcium intake in all boys as well as the zinc and calorie in 11-12 years old were lower than RDA of WHO, but other nutrients intake were in the range of acceptable values.

Table 3: Comparison mean intake of calorie and other nutrients in girls infected and none infected by *Giardia*

	Girls					
	7-10 years			11-12 years		
Variables	Non infected (N = 252)	Infected (N = 45)	p-value	Non infected (N = 83)	Infected (N = 13)	p-value
Calorie (Kcal)	1695.1±480.1	1735.10±448.8	0.60	1753.5±488.5	2042.20±321.4	0.04
Protein (g)	61.8±27.7	60.30±24.4	0.73	61.9±24.9	88.50±29.4	0.001
CHO (g)	242.7±76.2	247.20±79.4	0.71	257.4±75.8	283.70±89.9	0.26
Fiber (g)	10.6±7.6	11.60±6.4	0.39	10.7±5.8	13.20±7.5	0.16
Total fat (g)	55.8±22.7	52.40±21.3	0.67	54.8±24.1	61.70±29.6	0.35
Vitamin B1 (mg)	1.2±0.4	1.20±0.4	0.94	1.3±0.4	1.40±0.5	0.32
Vitamin B2 (mg)	1.02±.06	1.01±0.5	0.71	0.96±0.4	1.20±0.7	0.06
Vitamin B3 (mg)	17.9±10.1	17.10±8.6	0.62	17.5±5.7	27.80±12.3	0.00
Vitamin B6 (mg)	0.9±0.5	0.90±0.5	0.68	0.67±0.5	1.60±0.7	0.00
Folacin (μg)	92.5±71.4*	92.90±60.4*	0.97	81.8±57.3*	151.50±97.3*	0.00
Vitamin B5 (mg)	2.7±1.5	2.70±1.3	0.84	2.6±1.6	3.90±1.7	0.008
Vitamin C (mg)	49.1±45.3	50.90±37.9	0.79	42.3±31.6	51.70±33.9	0.32
Vitamin E (mg)	2.9±2.2	2.90±1.5	0.96	2.9±2.6	5.50±6. 6	0.01
Ca (mg)	496.2±291.5*	492.70±311.2*	0.94	464.5±247.7*	493.10±276.2*	0.70
Cu (mg)	0.6±0.4	0.60±0.3	0.98	0.6±0.4	1.10±0.7	0.002
Fe (mg)	16.1±8.3	15.20±5.1	0.53	16.4±6.3	18.80±6.6	0.20
Mg (mg)	116.6±67.9	111.40±54.8	0.62	107.9±53.9	158.10±68.4	0.003
P (mg)	656.7±315.5	628.80±291.8	0.58	607.7±316.8	932.50±377.5	0.001
K (mg)	1546.6±855.6	1680.90±816.3	0.33	1480.8±847.2	2035.40±944.8	0.03
Se (μg)	36.5±22.2	35.20±20.1	0.71	38.8±23.6	68.60±37.2	0.00
Na (mg)	2044.4±1163.7	2114.60±1045.2	0.70	1968.1±1207.7	2351.50±1135.5	0.28
ZN (mg)	4.6±2.4*	4.60±2.5*	0.81	4.9±2.7*	6.36±2.4*	0.06

Values are Mean±SD. CHO: Carbohydrate, Ca: Calcium, Cu: Copper, Fe: Iron, Mg: Magnesium, P: Phosphorus, K: Potassium, S: Selenium, Na: Sodium, Zn: Zinc. *Different is significant at the 0.05 compared with dietary reference intakes

This study highlights the effects of *Giardia* infection on anthropometric factors including height, weight and MAC in schoolchildren. Comparing infected and none infected children revealed that the weights, heights and MAC are lower in children infected with *Giardia*. This infection has affected on height of girls in all age groups and boys only 7 and 11 years of age. This might be due to the fact that girls have shorter growth spurts than boys and that the infection may effect on growth of all age groups. Several data suggest that parasitic infections can affect the nutritional status of infected people, by modifying the key stages of food intake, digestion and absorption (Rosenberg and Bowman, 1984; Muniz-Junqueira and Oliveira-Queiróz, 2002). The findings of the present study on children with both symptomatic and asymptomatic giardiasis demonstrated low weight-for-age and low height-for-age, whereas in the previous reports, children with symptomatic giardiasis had significantly lower weight-for-age and lower height-for-age than the asymptomatic children (Simsek *et al*., 2004; Newman *et al*., 2001). *Giardia intestinalis* is one of the most common intestinal parasites in the world and it contributes to diarrhea and nutritional deficiencies in children in developing regions. It seems that in this study also *Giardia* may have an associational role in the nutritional status of the schoolchildren. Our study revealed that the weights and heights are lower in children with giardiasis than the children without infection, which supports the study of Celiksoz *et al*. (2005). *Giardia intestinalis* infection was related to deleterious consequences to protein-energy nutritional status. Children infected by *G. intestinalis* showed significantly decreased weight-for-age and weight-for-height, which is consistent with the study of Muniz-Junqueira and Oliveira-Queiróz (2002). Previous studies have produced conflicting evidence about the association between *Giardia* infection and malnutrition, but have focused primarily on nutritional comparisons between children infected and none infected by *Giardia*. However, some studies suggested that *Giardia* may be associated with a poorer nutritional status (e.g., decreased height and weight velocities) (Farthing *et al*., 1986; Gupta *et al*., 1990). Chandrasena *et al*. (2004) in a study in rural areas of Sri Lanka showed that a greater proportion of boys than girls were underweight and stunted in both communities and that is inconsistent of this present study. Baseline data revealed stunting and underweight in children in specific years of old and widespread inadequate intakes and/or biochemical evidence of micronutrient deficiencies. Specifically, protein, vitamins (B3, B5, B6, E and folacin) and minerals (copper, magnesium, phosphorous, potassium and selenium) intake of infected girls were less than non infected girls in 11-12 years age. This may show increased requirement of girls infected with *Giardia* in this stage, as well as the capability of *Giardia* in inducing malabsorption leading to nutritional deficiencies (Cheek *et al*., 1989). The duration of *Giardia* episodes and their association with

diarrhea appeared to be the most important factors associated with growth disturbance. Although, simultaneous infection with other enteropathogens might occur in some children, the previous report suggests that *Giardia* infection may have independent deleterious effects on children growth (Farthing *et al*., 1986). *Giardia*-negative children tended to achieve higher weight and height for age than *Giardia*-positive children, which is inconsistent with the study of Ish-Horowicz *et al.* (1989). Similar to the study of Walker *et al.* (1980), children infected with *Giardia* were significantly smaller than those with negative stool examinations. Similar to our study Pobocik and Richer (2002) showed that median intake of calcium of children was less than 50% of the Recommended Dietary Allowance (RDA). Childhood and adolescence are the period of most rapid skeletal growth in an individual's lifetime. A greater peak bone mass achieved in the first 2-3 decades of life may protect against the risk of osteoporotic fracture in later life (Gibbons *et al*., 2004). Calcium under nutrition can adversely affect the bone mineral metabolism (Harinarayan *et al*., 2004). Based on the results found in this study, we conclude that *Giardia* infection may affect on some of anthropometric factors as well as the calorie and other nutrients intake in some of age groups.

REFERENCES

Ali, S.A. and D.R. Hill, 2003. Giardia intestinalis. Curr. Opin. Infect. Dis., 16: 453-460.

Celiksoz, A., M. Acioz, S. Degerli, Z. Cinar, N. Elaldi and M. Erandac, 2005. Effects of giardiasis on school success, weight and height indices of primary school children in Turkey. Pediatr. Int., 47: 567-571.

Chandrasena, T.G., A.C. de Alwis, L.D. de Silva, R.P. Morel and N.R. de Silva, 2004. Intestinal parasitoses and the nutritional status of Veddah children in Sri Lanka. Southeast Asian J. Trop. Med. Public Health, 35: 255-259.

Cheek, D.B., G.H. McIntosh, V. O'Brien, D. Ness and R.C. Green, 1989. Malnutrition in aboriginal children at Yalata, South Australia. Eur. J. Clin. Nutr., 43: 161-168.

Farthing, M.J., L. Mata, J.J. Urrutia and R.A. Kronmal, 1986. Natural history of *Giardia* infection of infants and children in rural Guatemala and its impact on physical growth. Am. J. Clin. Nutr., 43: 395-405.

Gibbons, M.J., N.L. Gilchrist, C.H. Frampton, P. Maguire, P.H. Reilly, R.L. March and C.R. Wall, 2004. The effects of a high calcium dairy food on bone health in pre-pubertal children in New Zealand. Asia Pac. J. Clin. Nutr., 13: 341-347.

Gupta, M.C., M. Mehrotra, J.C. Samantray and S. Arora, 1990. Effect of *Giardia* infection on nutritional status of preschool children. Indian J. Med. Res., 92: 341-343.

Hamill, P.V., T.A. Drizd, C.L. Johnson, R.B. Reed, A.F. Roche and W.M. Moore, 1979. Physical growth: National center for health statistics percentiles. Am. J. Clin. Nutr., 32: 607-629.

Harinarayan, C.V., T. Ramalakshmi and U. Venkataprasad, 2004. High prevalence of low dietary calcium and low vitamin D status in healthy South Indians. Asia. Pac. J. Clin. Nutr., 13: 359-364.

Ish-Horowicz, M., S.H. Korman, M. Shapiro, U. Har-Even, I. Tamir, N. Strauss and R.J. Deckelbaum, 1989. Asymptomatic giardiasis in children. Pediatr. Infect. Dis. J., 8: 773-779.

Islam, A., 1990. Giardiasis in Developing Countries. In: Giardiasis Meyer, E.A. (Ed.). Elsevier, Amsterdam, pp: 235-266.

Loewenson, R., P.R. Mason and B.A. Patterson, 1986. Giardiasis and the nutritional status of Zimbabwean schoolchildren. Ann. Trop. Paediatr., 6: 73-78.

Mafiei, M., M. Bostam, A. Marandi, A. Jalali and R. Vakili, 2002. Iranian food consumption program. A unique nutritional software in Iran. Iranian J. Public Health, 31: 105-107.

Muniz-Junqueira, M.I. and E.F. Oliveira-Queiróz, 2002. Relationship between protein-energy malnutrition, vitamin A and parasitoses in children living in Brasília. Revista Sociedade Brasileira Medicina Trop., 35: 131-141.

Nasiri, V., K. Esmailian, G. Karim, M. Nasir and O. Akhavan, 2009. Intestinal parasitic infections among inhabitants of Karaj city, Tehran province, Iran in 2006-2008. Korean J. Parasitol., 47: 265-268.

Nasser, Z.A. and M. Jafar, 2009. Prevalence of intestinal parasites in the city of Kerman. Iran J. Parasitol., 11: 129-129.

Nematian, J., E. Nematian, A. Gholamrezanezhad and A.A. Asgari, 2004. Prevalence of intestinal parasitic infections and their relation with socio-economic factors and hygienic habits in Tehran primary school students. Acta Trop., 92: 179-186.

Newman, R.D., S.R. Moore, A.A. Lima, J.P. Nataro, R.L. Guerrant and C.L. Sears, 2001. A longitudinal study of *Giardia lamblia* infection in North-East Brazilian children. Trop. Med. Int. Health, 6: 624-634.

Pobocik, R.S. and J.H. Richer, 2002. Estimated intake and food sources of vitamin A, folate, vitamin C, vitamin E, calcium, iron and zinc for Guamanian children aged 9 to 12. Pac. Health Dialog., 9: 193-202.

Quihui, L., M.E. Valencia, D.W. Crompton, S. Phillips, P. Hagan, G. Morales and S.P. Diaz-Camacho, 2006. Role of the employment status and education of mothers in the prevalence of intestinal parasitic infections in Mexican rural schoolchildren. BMC Public Health, 6: 225-225.

Rosenberg, I.H. and B.B. Bowman, 1984. Impact of intestinal parasites on digestive function in humans. Federation Proc., 43: 246-250.

Simsek, Z., F.Y. Zeyrek and M.A. Kurcer, 2004. Effect of *Giardia* infection on growth and psychomotor development of children aged 0-5 years. J. Trop. Pediatr., 50: 90-93.

Solomons, N.W., 1993. Pathways to the impairment of human nutritional status by gastrointestinal pathogens. Parasitology, 107: 19-35.

Solomons, N.W., 1995. Giardiasis: Nutritional implications. Rev. Infect. Dis., 4: 859-869.

Thompson, R.C.A., J.A. Reynoldson and H.W. Mendis, 1993. *Giardia* and giardiasis. Adv. Parasitol., 32: 71-160.

Walker, R.B., J.C. Hough and J.W.A. Brough, 1980. Survey of intestinal parasites in rural children. J. Fam. Pract., 11: 559-561.

Wolfe, M.S., 1992. Giardiasis. Clin. Microbiol. Rev., 5: 93-100.