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ORIGINAL COMMUNICATION

Rapid carbohydrate digestion rate produced lesser short-term satiety in obese preschool children

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Objective: To examine whether high carbohydrate meals with different carbohydrate digestion rates have an effect on the short-term satiety in normal and obese preschool children.
Subjects and setting: In total, 48 children of both gender, 24 normal and 24 obese, according to body mass index, aged between 3 and 6 y, were selected from children who were attending to a day-care center where they consumed three meals in the day.
Interventions: Rapid (potato-based meal) and *lente* (spaghetti-based meal) carbohydrate digestion rate meal were given at lunch, matching energy intake, carbohydrate, protein and fat levels, and then the preschool children's energy intake at the subsequent mealtime was observed. In this last mealtime, the children received varied types of high-acceptability foods in higher quantities than the normal serving.
Results: At lunch, a significant higher energy intake, lesser satiation, was observed in both groups, normal-weight and obese children, when they consumed the potato-based meal. In the subsequent mealtime, a significant effect of carbohydrate digestion rate was demonstrated, but only in obese preschool children, being higher in the meal with rapid digestion rate carbohydrates.
Conclusions: Rapid carbohydrate digestion rate meal produced a significative lesser satiation in normal-weight and obese children. However, only in obese children a significant lesser satiety was observed after consumption of the rapid carbohydrate digestion rate meal, indicating a decreased capacity of energy regulation in obese children. The finding of the present work could provide dietary strategies required for decreasing prevalence in overweight and obesity in preschool children.
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Introduction

Obesity is one of the very important nutritional problems of the population of developed as well as developing countries (Albala & Vio, 1995, Odgen *et al*, 2002), beginning at early ages as demonstrated by the obesity prevalence observed in preschool children (Onis & Blössner, 2000). The etiology of this illness is complex, but the interaction of genetic and environmental factors is considered of the key situation, in explaining the development of obesity. As the genetic dot is considered constant in a population, the environmental factors are those that may be changed and are considered in interventions directed to lower the obesity risk. Food intake is one of the variables that defines better the relationship between life-style and human obesity, influencing the energy balance of the individuals. It is conditioned by cultural, social, economic and dietary factors in complex interactions that occur during the life cycle.

Short-term satiety has been proposed as an appropriate variable to study the effect of dietary factors on energy regulation (Hill *et al*, 1995), and it is defined as the energy intake in a subsequent meal after the consumption of a test meal (Van Itallie & Vander Weele, 1981). Human short-term satiety is modulated by several dietary factors such as energy intake, macronutrient composition, energy density, physicochemical food properties and the physical state of the

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meals (Björck *et al*, 1994; Blundell *et al*, 1994; Rolls, 1995; Bell *et al*, 1998; Santangelo *et al*, 1998).

The traditional meals of Chilean population have a high carbohydrate content, with a high proportion of starch and a moderately low fat content (Araya *et al*, 1989; Vera *et al*, 1991). These types of meals are consumed frequently by preschool children attending day-care center where they receive foods given by governmental food programs. In this age group, the prevalence of obesity and overweight is close to 35% (Atalah *et al*, 2000) and, consequently, the programs have to adapt its daily menus to this situation, per example, incrementing the consumption of meals which induce greater satiety in preschool children.

Preschool children is the age group in which food intake is more sensible to food manipulation in the previous meal. However, few studies have investigated the effect of dietary variables on satiety in preschool children, essentially those from Birch (Birch *et al*, 1991, 1993a, b; Birch & Fisher, 1997) and those from our laboratory (Araya *et al*, 1989, 1999, 2000; Alviña *et al*, 1990, 2000; Vera *et al*, 1991) have related the effect of dietary variables on energy regulation in one mealtime. However, Birch *et al* (1991) had demonstrated that preschool children's food consumption is highly variable from meal time to mealtime but their daily energy intakes were relatively constant.

A dietary factor that may be influencing energy intake is the type of carbohydrate consumed. Several authors have shown that food carbohydrates differ in their *in vitro* digestion rates (Björck & Siljestrom, 1987, Englyst & Hudson, 1996; Englyst *et al*, 1996). Furthermore, some biological biomarkers such as glycemic and insulinemic levels are dependent on the sensibility of food carbohydrates to enzymatic digestion in the intestinal tract (Bornet *et al*, 1989; Englyst *et al*, 1999; Araya *et al* 2002) and a relationship between the *in vitro* and biological essays has been reported. Some works have demonstrated in adults and obese adolescents an inverse relationship between glycemic index and satiety (Ludwig *et al*, 1999; Ludwig 2000; Augustin *et al*, 2002), but in other's investigations the results showed the inverse tendency (Holt *et al*, 1996; Raben *et al*, 1996). Furthermore, there are no published information relating the effect of nutritional status and carbohydrate digestion rate on short-term satiety in preschool children.

To assess whether different carbohydrate digestion rates in meals have an effect on the short-term satiety in normal and obese preschool children, we planned a study to examine the effect of common meals differing in their carbohydrate digestion rates that were consumed in one mealtime with matched energy and carbohydrate levels on the energy intake in preschool children at the subsequent mealtime. To obtain these dietary conditions, normal foods were used in order that the results can be interpreted in the real setting of the children.

Methods

Subjects

In total, 48 children, 24 normal weight and 24 obese according to body mass index (BMI), aged 3–6 y old, were selected from children attending to a day-care center where they consumed three meals per day. Gender, age and height (Table 1) paired the subjects. The same observers took anthropometric measurements according to standard conditions. All children's parents signed a letter of informed consent. The protocol was approved by the ethics Committee of Faculty of Medicine, University of Chile.

Diets

Two meals based on foods considered as good carbohydrate sources, but with different carbohydrate digestion rates (Table 2), were tested at lunchtime. The carbohydrate digestion rates were determined using the enzymatic method proposed by Englyst *et al* (1992), modified by extending the hydrolysis time to 180 min (very slowly digestible starch fraction) (Araya *et al*, 2002). The meal ingredients and the carbohydrate percentage of each of them are shown in Table 3. The test meals were prepared in the laboratory, following the common culinary procedure used by the Chilean families. The spaghetti was cooked for 15 min in boiling water, with a spaghetti:water ratio of 1:2.5 and then was transferred to a strainer in order to drain of the water, and was mixed with tomato sauce and ground meat. The potatoes without peel were cooked for 25 min in boiling water, with a potatoes:water ratio of 1:2, and then were grounded and mixed with milk to obtain a puree. Finally, the

Table 1 Anthropometric characteristics of preschool children (mean values ± standard deviations)

	Boys			*Girls*		
Measure	*Normal (n 12)*	*Obese (n 12)*	*t-test*	*Normal (n 12)*	*Obese (n 12)*	*t-test*
Age (m)	53.25 ± 9.18	53.17 ± 9.23	N.S	58.28 ± 10.71	58.78 ± 8.24	N.S
Weight (kg)	18.43 ± 2.08	22.75 ± 3.29	0.001	18.84 ± 2.16	21.06 ± 1.94	0.001
Height (cm)	105.6 ± 4.3	106.3 ± 5.3	N.S	106.9 ± 5.5	106.3 ± 4.7	N.S
BMI (kg/m^2)	16.69 ± 0.48	19.79 ± 0.92	0.001	16.42 ± 0.45	18.63 ± 0.39	0.001

tomato sauce and grounded meat were added. Meals were put in thermos bottles at 40°C, transported to the day-care center and then immediately offered to the children. Chemical composition, serving sizes and energy contents of the test meals are shown in Table 4. The meals were isoenergetic and had the same amount of carbohydrate, but differed in the offered volumes.

Table 2 *In vitro* carbohydrate digestion rate (%) of the tested meals

Meals	*RDS*	*SDS*	*VSDS*	*RS*
Spaghetti with tomato sauce and orange	35.3	38.2	21.9	4.6
Mashed potatoes with meat and orange and nectar juice	60.6	39.5	0	0

RDS=Rapidly digestible starch (20 min).
SDS=Slowly digestible starch (120 min).
VSDS=Very slowly digestible starch (150–180 min).
RS=Resistant starch.

Table 3 Recipes of the offered meals in the lunchtime

Meals	*Foods*	*Carbohydrates (%)*
Spaghetti with tomato sauce and orange	Spaghetti	80.3
	Tomato sauce	5.4
	Onion	3.1
	Carrot	1.0
	Grounded meat	1.9
	Vegetable oil	0
	Orange	8.3
Mashed potatoes with meat and orange and nectar juice	Potato	56.1
	Milk	2.6
	Tomato sauce	2.1
	Onion	1.8
	Carrot	1.4
	Grounded meat	2.8
	Vegetable oil	0
	Orange	8.1
	Nectar juice	25.1

Procedure

Lunch was served at 1200 h in amounts that met the children's energy requirements for this mealtime (approximately 30% of the daily energy intake according to FAO/WHO/UNU (1985) for children aged 3–6 y. Meals were essayed on nonconsecutive days at random order and all children consumed both test meals, rapid and *lente* carbohydrate digestion rate meals.

The energy regulation was studied using the food and energy intakes observed during teatime (afternoon snack), served at 15:30 h. During this mealtime, a variety of highly accepted foods were offered in quantities greater than the normal serving, except milk, which was served in the usual amount. The type and quantity of each food offered to children are shown in Table 5. Children were encouraged but not forced to eat the meal served. No foods were consumed between lunch and teatime.

The amount of foods consumed by children during both mealtimes were determined by weighing the amount of foods served and left over during lunch and teatime by each child. The chemical composition of the foods was determined by proximal analysis according to AOAC (1980). The energy intake was calculated using the amount of meal consumed by each child and multiplying the macronutrient composition obtained from the chemical analyses by the corresponding Atwater's factors (4 kcal/g for protein, 4 kcal/g for carbohydrate and 9 kcal/g for lipid).

Statistical analysis

Results are presented as means ± s.d. The statistical analysis was performed with the SPSS statistical package. For anthro-

Table 4 Nutrient composition and energy value of the essayed meals

Meals	*Serving sizes (g)*	*Proteins (g)*	*Lipids (g)*	*Carbohydrates (g)*	*Energy (kcal)*
Spaghetti with tomato sauce and orange	373	18.5	10.5	69.0	445
Mashed potatoes with meat and orange and nectar juice	592	17.9	11.1	70.1	452

Table 5 Nutrient composition and energy value of the food offered in teatime

Foods	*Amount (g)*	*Proteins (g)*	*Lipids (g)*	*Carbohydrates (g)*	*Energy (kcal)*
Milk with sugar	200	6.4	5.2	26.0	176
Bread with marmalade	20	1.2	0.1	11.7	54
Cheese	30	7.5	7.6	1.5	104
Ham	30	7.6	5.7	0.1	82
Cookies	20	1.0	2.8	14.4	87
Total	300	23.7	21.4	53.7	503

pometric results, *t*-test was used. The statistical significance for the subsequent energy intake means across the two treatment groups (rapid *vs lente* carbohydrate digestion rate meal) and differences between the groups (obese *vs* normal-weight children) were tested with two-factor repeated measures ANOVA and Bonferroni's test of significance was performed to evaluate differences between conditions. The effect of the order of dietary treatments (rapid and *lente* carbohydrate digestion rate meals) was tested with two-factor repeated measures ANOVA.

Results

Energy intakes during lunch, teatime and in both mealtimes are illustrated in Figures 1 and 2 and Table 6, respectively. Effects of type carbohydrate meal and nutritional status of the children were observed at lunch (Figure 1). The potato-based meal showed a significantly higher energy intake in both children groups. Furthermore, the obese children consumed a higher energy intake than the normal children in both essayed meals.

During teatime, a significant effect of the type of carbohydrate was demonstrated, but only in obese preschool children, energy being intake higher when the meal with rapid digestion rate carbohydrates was essayed (Figure 2).

When both mealtimes were considered (lunch and teatime), an effect of types of carbohydrate as well as the nutritional status of children was observed (Table 6). The energy increment was 50 kcal for normal children and 140 kcal for obese children when potato meal was compared with the spaghetti meal.

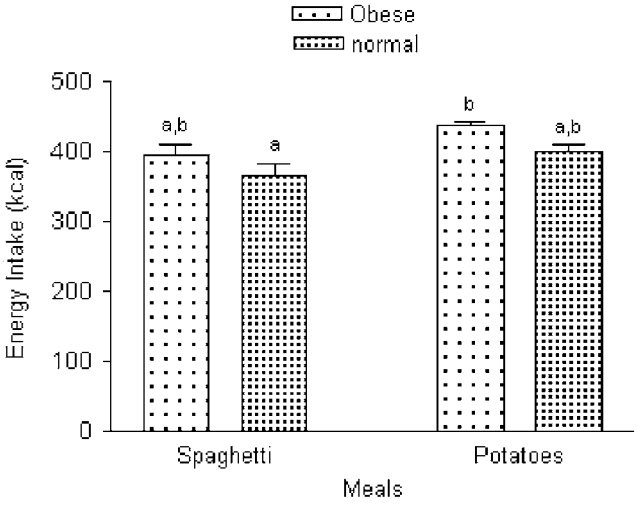

Figure 1 Energy intake at lunchtime. Two-way repeated measures ANOVA: effect of carbohydrate deigestion rate $P<0.002$, $F=11.21$; effect of nutritional status $P<0.02$, $F=5.80$; effect of interaction NS; Different letters indicate significant differences between conditions ($P<0.05$ Bonferroni's Test).

The statistical analysis demonstrated that the order of dietary treatments had no effect on the children's energy intakes.

Discussion

The results of the present study demonstrate that satiation at lunch was influenced by carbohydrate digestion rates of meals and the nutritional status of children. Children showed a greater satiation when meal with *lente* digestion rate carbohydrates was consumed, although this meal was offered in a lower volume than the meal with rapid digestion rate carbohydrates. Therefore, since preschool children have a lesser gastric capacity, the finding that dietary volume has no direct influence on satiation was unexpected. Other dietary factor that may be contributing to the greater satiation observed in the low digestion rate carbohydrate meal is the solid physical state of this meal (Santangelo *et al*, 1998). On the contrary, potato-based meal was in semiliquid

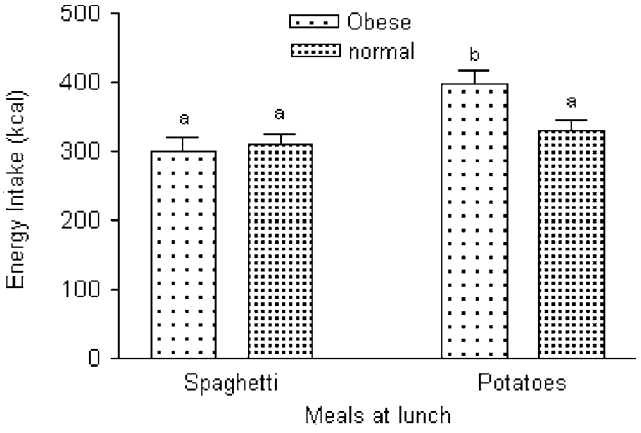

Figure 2 Subsequent energy intake at teatime. Two-way repeated measures ANOVA: effect of carbohydrate deigestion rate $P<0.001$, $F=18.91$; effect of nutritional status NS; effect of interaction $P<0.07$, $F=7.97$. Different letters indicate significant difference between conditions ($P<0.05$ Bonferroni's Test).

Table 6 Energy intake in both meals (lunch plus teatime)

	Energy intake (kcal)	
Meals at lunch	*Obese*	*Normal*
Spaghetti with tomato sauce and orange	691.7 ± 149.2^a	671.4 ± 116.8^a
Mashed potatoes with meat and orange and nectar juice	835.1 ± 84.1^b	728.7 ± 80.6^a

Two-way repeated measures ANOVA; effect of carbohydrate digestion rate $P<0.001$, $F=28.15$; effect of nutritional status $P<0.02$, $F=5.96$; effect of interaction $P<0.03$, $F=5.18$. Different letters indicate significant differences between conditions ($P<0.05$ Bonferroni's test).

state, which may induce a higher consumption in children. The obese children were able to consume in this mealtime significantly higher energy intakes than normal children, independent of carbohydrate digestion rates of meals, suggesting that these children have a lower capacity to regulate their energy intakes.

In the present study, short-term satiety was studied at the subsequent meal, offering a variety of foods, including different textures, flavors, and macronutrient contents since it was demonstrated that the availability of a variety of foods offered during a mealtime enhances the food intake (Rolls *et al*, 1981). In this design condition, a lesser short-term satiety was observed when the obese preschool children consumed the potato meal during lunch. Several authors have indicated that short-term satiety may be influenced directly by the weight of foods previously consumed (Hunt & Stubbs, 1975; Porrini *et al*, 1997). In the present study, the potato-based meal was given in the highest volume to the children, explained by its semiliquid physical state and the apricot juice offered. However, this meal produced a lower satiety, compared with the spaghetti-based meal. Some studies had demonstrated that obese subjects have a higher gastric emptying rate than normal subjects do, and, consequently, they are able to have a higher energy intake in the next meal (Read *et al*, 1994). Moreover, the solid physical state of the spaghetti meal may delay gastric emptying and thus contribute to its higher satiety.

Although both tested meals had the same carbohydrate content, the potato meal had higher amount of rapid digestion rate starch and a greater amount of simple carbohydrate. A physiological mechanism that has been proposed to explain the relationship between the type of food carbohydrate and the short-term satiety is based on the glycemic responses. High glycemic index meals induced a lesser satiety (Holt & Miller, 1994; Liljeberg *et al*, 1999), because rapid digestion carbohydrates give rise to a marked increase of glycemia and insulinemia and is followed by a rapid fall to the basal levels (Wolever & Bolognesi, 1996a, b). Furthermore, a large increase in the insulinemic response has been observed when potatoes were consumed (Hermansen *et al*, 1986; Soh & Miller, 1999). These metabolic responses have been raised by several authors as causal factors of higher energy intake observed at the subsequent meal when high glycemic foods were consumed in the test meal (Holt & Miller, 1995; Ludwig, 2000). In the present work, these metabolic effects on short-term satiety may be overexpressed in obese children and cause lesser satiety observed when these children consumed meal with greater amounts of rapid digestion rate carbohydrates. These results support the finding of Ludwig *et al* (1999) who demonstrated that low glycemic index breakfast meals produced a lower energy intake (81%) during the following 5 h in obese teenage boys. Furthermore, some authors (Odeleye *et al*, 1997; Sigal *et al*, 1997) have demonstrated that children who had higher basal insulin levels were able to gain more weight than children with normal basal insulin levels. These findings suggest that meals with high glycemic index are inducing higher energy intakes and higher fat depots.

In conclusion, we demonstrated that obese children consume a higher energy intake when they were consuming the high carbohydrate meal with the rapid carbohydrate digestion rate. The finding of the present work could provide dietary strategies required for decreasing overweight and obesity prevalence in preschool children. However, additional research is needed to examine whether manipulating the carbohydrate digestion rate during a longer period of time produces similar effects on energy intake of preschool children of different nutritional status.

References

Albala C & Vio F (1995): Epidemiological transition in Latin America: the case of Chile. *Public Health* **109**, 431–442.

Alviña M, Vera G, Pak N & Araya H (1990): Effect of the addition of malt flour to extruded pea-rice preparations on food and energy intake by preschool children. *Ecol. Food Nutr.* **24**, 189–193.

Alviña M, Araya H, Vera G & Pak N (2000): Effect of starch intake on satiation and satiety in preschool children. *Nutr. Res.* **20**, 479–489.

Araya H, Alviña M, Vera G, Araya J & Pak N (1989): Consumo de preparaciones con diferentes atributos nutricionales y texturales por preescolares de 2 a 3 años. *Rev. Chil. Nutr.* **17**, 182–189.

Araya H, Vera G & Alviña M (1999): Effect of the energy density and volume of high carbohydrate meals on short term satiety in preschool children. *Eur. J. Clin. Nutr.* **53**, 273–276.

Araya H, Hills J, Alviña M & Vera G (2000): Short term satiety in preschool children: a comparison between high protein meal and high complex carbohydrate meal. *Int. J. Food Sci. Nutr.* **51**, 119–124.

Araya H, Contreras P, Alviña M, Vera G & Pak N (2002): A comparison between an *in vitro* method to determine carbohydrate digestion rate and the glycemic response in young men. *Eur. J. Clin. Nutr.* **56**, 735–739.

Atalah E, Bustos P & Burgueño M (2000): Obesidad infantil. In: *Pediatría pediátrica en diálogos*, eds J Meneghello, N Fanta, A Grau & O Blanco pp 229–236. Edit Médica Panamericana. Buenos Aires, Bogotá, Caraeas, Madrid, México, São Paulo.

Association of Official Analytical Chemists (1980): *Official Methods of Analysis 13 Th*, Washington, DC: AOAC.

Augustin LS, Franceschi S, Jenkins DJ, Kendall CW & La Vechia C. (2002): Glycemic index in chronic desease: a review. *Eur. J. Clin. Nutr.* **56**, 1049–1071.

Bell EA, Castellanos VH, Pelkman C, Thorwart ML & Rolls BJ (1998): Energy density of food affects energy intake in normal weight women. *Am. J. Clin. Nutr.* **67**, 412–420.

Birch LL, Johnson SL, Anderson G, Peters JC & Schulte MC (1991): The variability of the young children's energy intake. *N. Engl. J. Med.* **324**, 232–235.

Birch LL, McPhee LS, Bryant JL & Johnson SL (1993a): Children's lunch intake: effects of midmorning intake snacks varying in energy density and fat content. *Appetite* **20**, 83–94.

Birch LL, Johnson SL, Jones MP & Peters JC (1993b): Effects of a nonenergy fat substitute on children's energy and macronutrient intake. *Am. J. Clin. Nutr.* **58**, 326–333.

Birch LL & Fisher JO (1997): Food intake regulation in children. *Fat and sugar substitutes and intake. Ann. NY. Acad. Sci.* **819**, 194–220.

Björck I & Siljestrom M (1987): *In vivo* and *in vitro* digestibility of starch in autoclaved pea and potato in the small intestine of man. *Am. J. Clin. Nutr.* **45**, 425–431.

Björck I, Grandfeldt Y, Liljeberg H, Tovar J & Asp N-G (1994): Food properties affecting the digestion and absorption of carbohydrates. *Am. J. Clin. Nutr.* **59**, 699S–705S.

Blundell JE, Green S & Burley V (1994): Carbohydrates and human appetite. *Am. J.Clin. Nutr.* **59**, 728S–734S.

Bornet FRJ, Fontvieille AM, Rizkalla S, Colonna P & Blayo A (1989): Insulin and glycemic responses in healthy humans to native starches processed in different ways: correlation with *in vitro* alfa-amylase hydrolysis. *Am. J. Clin. Nutr.* **50**, 315–323.

Englyst HN & Hudson GJ (1996): The classification and measurement of dietary carbohydrates. *Food Chem.* **57**, 15–21.

Englyst HN, Kigman SM & Cummings JH (1992): Classification and measurement of nutritionally important starch fractions. *Eur. J. Clin. Nutr.* **46**, 33S–50S.

Englyst HN, Veenstra J & Hudson GJ (1996): Measurement of rapidly available glucose (RAG) in plant foods as *in vitro* predictor of glycemic response. *Br. J. Nutr.* **73**, 327–337.

Englyst KN, Englyst HN, Hudson GJ, Cole TJ & Cummings JH (1999): Rapidly available glucose in foods: an *in vitro* measurement that reflects the glycemic response. *Am. J. Clin. Nutr.* **69**, 448–454.

FAO/WHO/UNU (1985): *Energy and protein requirements*, WHO Technical Report Series No. 724. Geneva: World Health Organization.

Hermansen K, Rasmussen O, Arnfred J, Winter E & Schmitz O (1986): Differential glycaemic effects of potato, rice and spaghetti in type I (insulin dependent) diabetic patients at constant insulinaemia. *Diabetologia* **29**, 358–361.

Hill AJ, Rogers PJ & Blundell JE (1995): Techniques for the experimental measurement of human eating behaviour and food intake: a practical guide. *Int. J. Obes. Relat. Metab. Disord.* **19**, 361–375.

Holt SHA & Miller BJ (1994): Particle size, satiety and the glycemic response. *Eur. J. Clin. Nutr.* **48**, 496–502.

Holt SH & Miller JB (1995): Increased insulin responses to ingested foods are asssociated with lessened satiety. *Appetite* **24**, 43–54.

Holt SHA, Brand Miller JC & Petocz P (1996): Interrelationships among postprandial satiety, glucose and insulin responses and changes in subsequent food intake. *Eur. J. Clin. Nutr.* **50**, 788–797.

Hunt JN & Stubbs DF (1975): The volume and energy content of meals as determinants of gastric emptying. *J. Physiol.* **245**, 209–225.

Liljeberg HG, Akerberg AK & Bjorck IM. (1999): Effect of the glycemic index and content of indigestible carbohydrates of cereal-based breakfast meals on glucose tolerance at lunch in healthy subjects. *Am. J. Clin. Nutr.* **69**, 647–655.

Ludwig DS. (2000): Dietary glicemic index and obesity. *J. Nutr.* **130**, 280S–283S.

Ludwig DS, Majzoub JA, Al-Zahrani A, Dallal GE, Blanco I & Roberts SB. (1999): High glycemic index foods, overeating, and obesity. *Pediatrics* **103**, E261–E266.

Odeleye OE, de Courten M, Pettitt DJ & Ravussin E. (1997): Fasting hiperinsulinemia is a predictor of increased body weight gain and obesity in Pima indian children. *Diabetes* **46**, 1341–1345.

Odgen CL, Flegal KM, Carroll MD & Johnson CL. (2002): Prevalence and trends in overweight among US children and adolescents, 1999-2000. *JAMA* **288**, 1728–1732.

Onis M & Blössner M (2000): Prevalence and trend of overweight among preschool children in developing countries. *Am. J. Clin. Nutr.* **72**, 1032–1039.

Porrini M, Santangelo A, Crovetti R, Riso P, Testolin G & Blundell JE (1997): Weight, protein, fat, and timing of preloads affect food intake. *Physiol. Behav.* **62**, 563–570.

Raben A, Holst JJ, Christensen NJ & Astrup A. (1996): Determinants of postprandial appetite sensations: macronutrient intake and glucose metabolism. *Int. J. Obes. Relat. Metab. Disord.* **20**, 161–169.

Read N, French S & Cunnighan K (1994): The rol of the gut in regulating food intake in man. *Nutr. Rev.* **52**, 1–10.

Rolls BJ (1995): Carbohydrates, fat and satiety. *Am. J. Clin. Nutr.* **61**, 960S–967S.

Rolls BJ, Rowe EA, Rolls ET, Kingston B, Megson A & Gunary R (1981): Variety in a meal enhances food intake in man. *Physiol. Behav.* **26**, 215–221.

Santangelo A, Peralchi D, Conte M, Franquelli M & Porrini M (1998): Physical state of meal affects gastric emptying cholecystokinin release and satiety. *Br. J. Nutr.* **80**, 521–527.

Sigal RJ, El-Hashimy M, Matin BC, Soeldner JS, Krolwski AS & Warram JH. (1997): Acute postchallenge hyperinsulinemia predicts weight gain: a prospective study. *Diabetes* **46**, 1025–1029.

Soh NL & Brand Miller J (1999): The glycemic index of potatoes: the effect of variety, cooking method and maturity. *Eur. J. Clin. Nutr.* **53**, 249–254.

Van itallie TB & Vander Weele DA (1981): The phenomenon of satiety. In *Recent Advances in Obesity Research III*, eds Bjorntorp P, Cairella M, Howard AN, pp 278–289. London: John Libbey.

Vera G, Alviña M, Rojas J, Delgadillo A, Durán R, Fajardín N, Muñoz C, Pino A, Silva X, Vasquez E, Pak N, Araya J & Araya H (1991): Estructura Alimentaria. Valor nutritivo y aceptabilidad de preparaciones incluidas en la alimentación institucional del preescolar. *Rev. Chil. Nutr.* **19**, 39–56.

Wolever TMS & Bolognesi C (1996a): Source and amount of carbohydrate affect postprandial glucose and insuline normal subjects. *J. Nutr.* **126**, 2798–2806.

Wolever TMS & Bolognesi C (1996b): Prediction of glucose and insuline responses of normal subjects after consuming mixed meals varying in energy, protein, fat, carbohydrate, and glycemic index. *J. Nutr.* **126**, 2807–2812.