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Original / *Pediatría*

## Somatotype and intellectual ability (Raven progressive matrices test) in Chilean school-age children

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### Abstract

**Objectives:** The aim of this study was to determine the relationship between somatotype and intellectual ability (IA) in 11-12 and 15-16 year-old students (n = 1,015) in the Chile's Metropolitan Region from a representative sample of 33 educational establishments chosen at random.

**Methods:** The Heath-Carter somatotype and the IA assessed through the Raven Progressive Matrices Test were measured.

**Results:** The endomorph was observed in 59% of the students; 28% had a mesomorph and 13% ectomorph. The IA was distributed in: 11.2% Grade I, 26.8% Grade II, 41% Grade III, 17.6% Grade IV and 3.2% Grade V. A positive and significant correlation of IA with the endomorphic component ( $r = 0.074$ ,  $p = 0.02$ ) was found in the total sample and only in females ( $r = 0.109$ ,  $p = 0.02$ ); at the same time, a positive and significant correlation with the ectomorph component was also observed ( $r = 0.067$ ,  $p < 0.05$ ).

**Conclusions:** This suggests that other variables would influence more strongly the IA for which further research is needed to quantitate this multifactorial problem.

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Key words: *Intelligence. Somatotype. Endomorphism. Adolescent. Students.*

### SOMATOTIPO Y CAPACIDAD INTELECTUAL (PRUEBA DE MATRICES PROGRESIVAS DE RAVEN) EN ESCOLARES CHILENOS

#### Resumen

**Objetivos:** El objetivo de este estudio fue determinar la relación entre el somatotipo y la habilidad intelectual (HA) en estudiantes de 11-12 y 15-16 años de edad de la Región Metropolitana, Chile.

**Métodos:** Se registró una muestra representativa de 1.015 escolares de acuerdo a los resultados del sistema de medición de la calidad de la educación (SIMCE) 2009. Se evaluó el somatotipo de Heath-Carter y la HA de acuerdo al Test de Matrices Progresivas de Raven.

**Resultados:** Un 59% presentó un somatotipo endomórfico, 28% mesomórfico y 13% ectomorfo. La HA se distribuyó en: 11,2% Grado I, 26,8% Grado II, 41% Grado III, 17,6% Grado IV y 3,2% Grado V. Se presenta una correlación significativa positiva con el componente endomórfico ( $r = 0,074$   $p = 0,02$ ), y sólo en mujeres ( $r = 0,109$   $p = 0,02$ ), a la vez se observa una relación significativa positiva con el componente ectomorfo ( $r = 0,067$   $p < 0,05$ ).

**Conclusiones:** Esto sugiere que otras variables estarían influyendo más fuertemente en la HA, además de apoyar la no discriminación por biotipo en los establecimientos educacionales.

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Palabras clave: *Inteligencia. Somatotipo. Endomorfismo. Adolescentes. Escolares.*

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## Introduction

### *Somatotype*

The somatotype is a morphological characteristic of the body built, i.e. “a phenotypic entity capable of changes with growth, aging, exercise and nutrition”.<sup>1</sup> It is defined by three components: endomorphic, referred to relative adiposity; mesomorphic related to the muscle-skeletal magnitude and, finally, the ectomorphic based on physical thinness and or its linearity. It is important to recognize the somatotype describes the body in general, and does not answer more specific questions related to the specific dimensions of the body.<sup>1</sup>

The somatotype has several uses in sports to improve physical performance. Thus, to analyse the somatotype of athletes comparing it with the “ideal” or reference somatotype for a given sport, accepting that an athlete achieves a higher performance when its physical configuration is more similar to their sport model.<sup>2</sup> Several studies have been carried out to describe somatypes during childhood and adolescence.<sup>3-7</sup> Other investigations analysed somatypes in relation to disease conditions,<sup>8,9</sup> and the changes observed in somatotype along the lifetime.<sup>10</sup>

Adolescence is the period in which the somatotype exhibits significantly changes.<sup>3</sup> When men begin puberty, their somatotype increases in mesomorphy and ectomorphy but decreases in endomorphy, because the amount of subcutaneous fat tissue of the upper and lower limbs and the lower and dorsal region of the thorax is reduced, unlike women, who increase their endomorphy. Variables such as nutrition and physical activity are critical in modifying each somatotype component.<sup>3,6</sup>

Several studies of somatotype on students have been carried out In Chile, aiming to determine their biotype; studies in school populations in Temuco (Southern Chile, Araucania Region) indicate that the endomorphic component predominates in women.<sup>4,5</sup> Also in school-age women from the Mapuche ethnicity (also from Araucanía) their somatotype tends to endomorphy and men towards mesomorphy, with a second endomorphic component. These populations have experienced changes in their lifestyles induced by their migration from rural to urban areas.<sup>7</sup> This trend towards a higher fat component during adolescence has been observed by our group while comparing students evaluated from 1985 and 2011, where an increase in the endomorphic component for both genders is seen, although predominantly in women.<sup>10</sup>

### *Intellectual Ability (IA)*

IA is a standardized measure that considers a wide range of cognitive abilities, verbal or non-verbal, increasing or decreasing in adolescence and directly affecting the academic performance.<sup>11</sup>

In Chilean school-age children, their nutritional status has been positively and significantly correlated with socio-economic conditions, scholastic achievement (SA) and IA, especially with those indicators of past nutrition, such as weight, height and head circumference (HC). In this context, HC is the most relevant index associated with learning and intelligence.<sup>12,13</sup>

The nutritional background is very important for brain development, IA and SA. Malnutrition in early life affects brain growth and intellectual development; at the same time, a high percentage of the students with very low SA show a suboptimal HC and smaller brain volume.<sup>13,14</sup>

The general cognitive factor (G factor), suggested by Charles Spearman, is a fundamental skill involved in all mental operations; it represents mental energy and moves across all non-automated tasks. It is a reflection capability enabling the subject to observe his/her inner self, conceive the essential relationships between two or more ideas and the initial ideas implicit in a relationship.<sup>15</sup> The G factor is related to the complexity of the cognitive activity required by problems, i.e. it captures relationships between elements, abstract concepts, reasoning, analyzing, finding commonalities between different surface elements and infer conclusions from data;<sup>16</sup> therefore, the G factor is considered as the best measure of general IA, and it has been shown it is correlated with brain size and cortical thickness.<sup>11</sup> This factor can be measured using several tests; the most commonly used is the Raven Progressive Matrices, which predicts performance in a wide range of reasoning tasks, which include analytical reasoning, visuospatial reasoning or figures and perceptual-motor control.<sup>17</sup> Thus, the Raven Progressive Matrices Test results appropriate to firstly approach the IA.<sup>18</sup> It is simple to use and evaluate cheap, individual or collective form and is independent from the cultural factors.<sup>18</sup> The test is commonly used to measure IA and standardised norms for Chilean school populations were established for both special and general scales.<sup>18</sup>

This study aimed to determine the relationship between anthropometric somatotype and general IA for 11-12 and 15-16 year-old students from public, private and subsidized schools from the Metropolitan Region, Chile, in order to verify the hypothesis that IA is significantly associated with the anthropometric somatotype proposed by Carter.<sup>1</sup>

## Methods

### *Subjects*

The target population were 1,262 educational establishments from the Metropolitan Region, Chile which met the following criteria for inclusion: located in urban areas, participated in the SIMCE score 2009 and had at least 20 students per year, both in 4 and 8 grade of elementary school during 2009. The database was provided by the Ministry of Education of Chile in July

of 2010. Rural schools were discarded for their low representativity.

The sampling system was performed in two stages. In the first stage 33 educational establishments which represented 2.61% of the total population of urban schools ( $N = 1,262$ ) were randomly selected by proportional allocation according to their stratification by type of school and the levels of achievement in the SIMCE score 2009 established by the Ministry of Education, Chile (high, medium and low). In the second stage, all students who were enrolled in both grades who took the SIMCE 2009 in each one of the 33 schools were invited to participate in the study. A total of 1,015 subjects ( $n = 485$  female and  $n = 530$  male) and their parents agreed to participate in the study and signed the informed consent form. Their age ranged from 9.9 y to 18.2 y (mean age  $10.8 \pm 0.6$  y) in the fifth grade of elementary school and from 12.7 y to 17.6 y (mean age  $14.8 \pm 0.6$  y) in the first year of high school.

### *Ethical aspects*

This study was approved by the Committee on Ethics in Studies in Humans of the Institute of Nutrition and Food Technology (INTA), University of Chile and ratified by the Committee on Bioethics of the National Fund for Scientific and Technologic Development (FONDECYT), Chile. Subjects' consent was obtained according to the norms for Human Experimentation, Code of Ethics of the World Medical Association<sup>19</sup>. Each anthropometric assessment and tests required parent or guardian, school and student authorizations. The field study was carried out during 2011.

### *Anthropometry*

The physical assessment record considered: name, sex, date of birth, date of assessment, age in years, height, weight, four skinfolds (triceps, subscapular, supraspinal and medial calf), 2 diameters (humeral and femoral) and 2 perimeters (brachial in contraction and maximum calf) in standardized and described in points.<sup>1</sup>

Weight and height were assessed with the student standing, barefoot and minimal clothing. The instrument used is a scale (Seca model 769) with transportable stadiometer (Seca model 220), which was placed in a rigid wall, with an accuracy of 0.1 cm. A Slim Guide caliper was used for skinfolds. Diameters were assessed using the sliding Campbell 10 caliper and perimeters were recorded with a flexible inextensible tape (Lufkin).

### *IA*

IA was evaluated by means of the Raven Progressive Matrices Test in book form, with the general scale for

children over 11 years. The test was administered individually by the psychologist and the scores were established in a percentile scale according to age as follows: Grade I = Superior Intellectual Ability (score  $\geq p95$ ); Grade II = Above Average (score  $\geq p75$  and  $< p95$ ); Grade III = Average (score  $> p25$  and  $< p75$ ); Grade IV = Below Average (score  $> p5$  and  $\leq p25$ ) and Grade V = Intellectually Defective (score  $\leq p5$ ).<sup>18,20</sup>

### *Statistical analysis*

Average and standard deviation were determined for each variable. Associations between variables were determined using the Spearman Correlation Coefficient for at least one ordinal qualitative variable. The chi-square was determined for the independence of the variables and the analysis of variance (one-way ANOVA) to compare various groups in a quantitative variable, working with a significance of 0.05. Data were tabulated in an Excel spreadsheet and analysed in SPSS Statistics 20.0 for Windows 7.

## **Results**

### *Somatotype*

Somatotype distribution in the sample was 59% of subjects with predominance towards endomorphy, 28% for mesomorphy and 13% for ectomorphy.

Table I shows the somatotype classification by sex and age, including the average weight and size as well as the somatotype components with their respective standard deviations. Results show a predominance of endomorphic component for women, followed by a second mesomorphic component; men show the reverse situation at the age of 15 and 16 (first mesomorphic component followed by an endomorphic component). The mesomorphic and endomorphic components in men are equally present at the age of 11 and 12 (mesomorph-endomorph classification).<sup>1</sup>

### *IA and somatotype*

The following distribution was observed in the sample according to the IA range given by the Raven Progressive Matrices: 11.2% had a superior IA, 26.8% showed an above average IA, with predominance in the average grade (41%), 17.6% were below average and finally, 3.2% of schoolchildren had low IA.

Table II shows that somatotype components expressed as mean (SD) did not differ significantly according to IA grades.

Each component of the somatotype (endomorphy, mesomorphy and ectomorphy) was correlated with the Raven Progressive Matrices test. There is a positive and significant Spearman correlation between IA and endo-

**Table I**  
*Classification of average somatotype in students by sex and age*

Age (y)	Weight	Height	Endomorphy	Mesomorphy	Ectomorphy	X	Y
<i>Females</i>							
11 (n = 160)	48.0 (10.1)	148.9 (6.82)	5.4 (2.07)	4.1 (1.26)	1.8 (1.31)	-3.6 (3.18)	0.8 (2.78)
12 (n = 63)	50.5 (9.9)	151.2 (5.30)	5.2 (1.77)	3.9 (1.25)	1.8 (1.27)	-3.4 (2.93)	0.7 (2.43)
15 (n = 153)	59.8 (10.2)	158.0 (5.65)	6.0 (1.72)	4.0 (1.39)	1.5 (1.20)	-4.4 (2.75)	0.6 (2.88)
16 (n = 109)	58.8 (10.9)	158.4 (6.04)	5.7 (1.54)	4.0 (1.35)	1.6 (1.02)	-4.1 (2.36)	0.6 (2.83)
<i>Males</i>							
11 (n = 174)	47.2 (10.8)	147.7 (6.93)	5.0 (2.33)	4.8 (1.26)	1.8 (1.39)	-3.1 (3.55)	2.8 (2.64)
12 (n = 103)	49.9 (10.1)	152.1 (6.42)	4.7 (2.27)	4.7 (1.29)	2.1 (1.47)	-2.6 (3.60)	2.6 (2.70)
15 (n = 172)	64.6 (10.9)	169.2 (6.18)	3.8 (1.87)	4.2 (1.19)	2.5 (1.31)	-1.2 (2.98)	2.2 (2.79)
16 (n = 81)	65.6 (13.5)	169.8 (6.15)	3.6 (1.88)	4.3 (1.47)	2.6 (1.42)	-1.0 (3.15)	2.5 (3.05)

Note: Results are expressed as mean and numbers in parentheses are standard deviations.

**Table II**  
*Somatotype and intellectual ability grades*

Raven's test grades	Endomorphy	Mesomorphy	Ectomorphy
Grade I (n = 114)	4.8 (1.98)	4.4 (1.18)	2.1 (1.39)
Grade II (n = 272)	4.8 (2.14)	4.4 (1.31)	2.1 (1.36)
Grade III (n = 417)	5.0 (2.09)	4.3 (1.34)	2.0 (1.33)
Grade IV (n = 179)	5.2 (2.13)	4.3 (1.40)	1.8 (1.33)
Grade V (n = 33)	5.3 (2.67)	4.2 (1.54)	1.8 (1.47)
F	1.612 NS	0.230 NS	1.210 NS

Note: Results are expressed as mean and numbers in parentheses are standard deviations. F= variance; Grade I = superior; Grade II = above average; Grade III = average; Grade IV = below average; Grade V = intellectually defective.

morphy ( $r = 0.074$ ,  $p = 0.02$ ) and the ectomorphy ( $r = 0.067$ ,  $p < 0.05$ ). No significance was found for the mesomorphic somatotype.

By correlating each somatotype component with the Raven Progressive Matrices test by gender, a positive and significant Spearman correlation was found only in females in the endomorphic component ( $r = 0.109$ ,  $p = 0.02$ ); no significant correlation was found in the mesomorphy and ectomorphy both in females or males.

## Discussion

One of the research areas on body composition relates to the variations comprising changes in physiological and pathological conditions.<sup>21</sup> The anthropometric somatotype is one of the methods used for the assessment of human morphostructure;<sup>1</sup> it allows to evaluate the changes that occur during growth, biometrically assessing individuals according to their endomorphic, mesomorphic and ectomorphic components that represent the primary tissues of the body.<sup>1</sup> In this study the mesomorphy was more frequent in males (15 to 16 years old) while the endomorphy was predominant in females, which is consistent with results of

other studies in Chile.<sup>4,7,10</sup> These results are in agreement with those from the present study since males show reductions in the amounts of subcutaneous fat of the upper and lower limbs and the dorsal and lower region of the thorax. This was not the case for women, who increase their endomorphy as development progresses, and the scores of their mesomorphic component will depend on their physical activity and nutrition.<sup>6</sup>

However, values greater than 5.5 for endomorphy correspond to a high relative adiposity,<sup>1</sup> as shown by women and reported by our group.<sup>10</sup> This condition may lead to non-transmissible chronic diseases, which constitute a public health problem in Chile, explained mainly by the nutritional transition to high-calorie food and insufficient physical activity.<sup>22,23</sup>

In relation to the IA, in this group of students the average or normal level predominates (41%); this result is similar to that obtained by Ivanovic et al. (2000) and is consistent with those found in England by Raven and in Argentina, Uruguay and Spain.<sup>18,20</sup>

In the present study, the deficient IA reached 3.2% while 11.2% had above average IA, 26.8% was above average and 17.6% below average and 41% average IA. These results diverging from those found by



Ivanovic et al. (2000), where the superior and deficient IA are presented in the same proportion, (6.8% and 6.4%, respectively), the above average and below average IAs (20.9% and 21.4%, respectively), and 44.5 had average IA. In order to determine any relationships between the somatotype and the IA, each somatotype component was correlated, finding significant and positive correlations in the ectomorphy and endomorphy components and only in females with the endomorphy.

In this case, endomorphy correlates positively with IA, i.e. the higher the endomorphy, the higher the IA in females and in the total sample. Simultaneously, a positive correlation was observed for ectomorphy, i.e. the higher the ectomorphy the lower the IA. It may be inferred that the fat component may participate in the achievement of better overall IA results as measured by the Raven progressive matrices test. This result disagrees with those of the studies by Portillo et al. (2011), which shows that obese children who (tend towards endomorphy) show worse performance for memory, abstract reasoning and following of directions than children with normal weight, and perform worse than those malnourished in relation to memory and visual closure.

The results of Portillo show that obese children have lower neuropsychological performance than malnourished children.<sup>24</sup> The discrepancies between the results of Portillo et al. (2011) and this study are mainly probably consequences of the types of tests used to determine the cognition components, as Portillo used other neuropsychological tests for the evaluation, such as the Wechsler scale in 8 to 12 year old children, whereas our study was conducted with the Raven Progressive Matrices test. Another study established that low-weight girls have poorer memory performance than healthy, overweight or even obese children, with results similar to those in this study, since underweight girls have less fat tissue, decreasing their endomorphy.<sup>25</sup>

Genovese et al. (2012) studied the relationship between mesomorphy and the experiential cognitive style, who observed a positive relationship between the development of their musculature (mesomorphy) and a particular style of learning. Not difference from these results, Genovese observed significant correlations between mesomorphy and experiential cognitive style for men ( $r = 0.33$ ) and women ( $r = 0.25$ ) and significant correlations in endomorphy and ectomorphy but only in males ( $r = 0.39$  and  $r = -4.8$ , respectively).

There are some discrepancies between the results of Genovese et al., 2012 and this study. One of the reasons for these differences may be primarily the quality of the population sample and its size, since the study by Genovese only included 54 people between 20 to 48 years of age while our study involved 1,015 school-children of 11-12 and 15-16 years old, and calculations with 95% confidence interval while Genovese's study calculated its results with an 80% confidence interval.<sup>26</sup>

Another equally important reason is that the experiential cognitive style is an emotional-type, non-rational processing system, while the Raven Progressive Matrices test is a non-emotional and rational system, as it studies the G factor related to the complexity of the cognitive activity required by problems, i.e. it captures relationships between elements, abstract concepts, and analyzes and searches for commonalities between superficially different elements and infers conclusions from discrete data elements; thus, the Raven progressive Matrices test predicts performances in a wide range of reasoning activities, including analytical reasoning, visual-spatial reasoning or figures and perceptual-motor control.<sup>17</sup>

It may be then inferred the relationships between the somatotype and the IA is a strong variable, but a student will not necessarily be more or less intelligent by the mere fact of being thin or obese (low or high relative fatness). Such relationship depend on other variables, such as the head perimeter which is one of the most significant anthropometric variables of the relations between nutrition and intelligence.<sup>18</sup> The classification of schoolchildren within these stereotypes only increases the emergence of discrimination problems like bullying,<sup>27</sup> which in turn hinder the learning process in students.

Different studies have shown obese children and adolescents evidence a higher prevalence of psychological and psychiatric disorders than their normal-weight peers, and that this risk of psychopathology is higher in women and increases with age. In general, obese children have a poor self-image and express feelings of inferiority, rejection and low self-esteem. Discrimination by peers triggers behavioral disorders leading to isolation, depression and inactivity<sup>28</sup>. Therefore, the results of this study help support nondiscrimination in schools when it rejects stereotyping students according to their body type and focusing instead on their intelligence, promoting social inclusion and equity.

The findings of this study contribute to verify the hypothesis that IA is significantly associated to the anthropometric somatotype as suggested by Carter & Heath.<sup>1</sup> It is worth noting the IA represents a multi-factorial parameter determined by socio-economic, socio-cultural, family, nutrition, neurodevelopment and educational factors. Thus, the IA of parents and maternal stimulation, as well as early-age nutritional conditions represent some of the most relevant variables related to school-age children IA.<sup>13,14,29</sup>

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## References

1. Carter L, Heath B. Somatotyping development and applications. Cambridge: Cambridge University Press, 1990.
2. Carter L, Ackland TR, Kerr DA, Stapff AB. Somatotype and size of elite female basketball players. *J Sports Sci* 2005; 23 (10): 1057-63.
3. Carter L, Mirwald R, Heath-Roll B, Bailey D. Somatotypes of 7- to 16-Year-Old Boys in Saskatchewan, Canada. *Am J Hum Biol* 1997; 9 (2): 257-72.
4. Silva H, Collipal L, Martínez C, Torres I. Análisis del IMC, somatotipo en una muestra de adolescentes con sobrepeso y obesidad en Temuco-Chile. *Int J Morphol* 2008; 26 (3): 707-11.
5. Martínez C, Silva H, Collipal E, Carrasco V. Descripción del somatotipo e IMC en una muestra de Adolescentes de colegios municipalizados de la ciudad de Temuco-Chile. *Int J Morphol* 2008; 26 (3): 653-7.
6. Mladenova S, Nikolova M, Andreenko E, Boyadjev D. Somatotypological characterization of Bulgarian children and adolescents (Smolyan region), Bulgaria. *Coll Antropol* 2010; 34 (3): 963-71.
7. Martínez C, Rodríguez M, Silva H, Vargas R, Collipal E, Carrasco V, Gatica P, Silva T. Somatotipo y estado nutricional de 10 a 14 Años de edad en una muestra de mapuches de la IX Región, Temuco-Chile. *Int J Morphol* 2012; 30 (1): 241-6.
8. Buffa R, Floris G, Putzu PF, Carboni L, Marini E. Somatotype in elderly type 2 diabetes patients. *Coll Antropol* 2007; 31 (3): 733-7.
9. Baltadjiev AG, Baltadjiev GA, Kaleva NN. Somatotypological characteristics of children with type 1 diabetes mellitus. *Folia Med (Plovdiv)* 2009; 51 (4): 29-33.
10. Lizana P, Almagià A, Simpson C, Ivanovic D, Binvignat O, Berral F. Changes of somatotype in high school students, V region, Chile: 1985-2010. *Nutr Hosp* 2012; 27 (1): 270-5.
11. Ramsden S, Richardson F, Josse G, Thomas M, Ellis C, Shakeshaft C, Seghier M, Price C. Verbal and non-verbal intelligence changes in the teenage brain. *Nature* 2011; 479 (7371): 113-6.
12. Ivanovic D, Leiva B, Castro C, Olivares M, Jansana J, Castro V, Almagià A, Toro T, Urrutia M, Millera P, Bosch E, Larraín C, Pérez H. Brain development parameters and intelligence in Chilean high school graduates. *Intelligence* 2004; 32 (5): 461-79.
13. Ivanovic D, Leiva B, Pérez H, Olivares M, Díaz N, Urrutia M, Almagià A, Toro T, Miller P, Bosch E, Larraín C. Head size and intelligence, learning, nutritional status and brain development Head, IQ, learning, nutrition and brain. *Neuropsychologia* 2004; 42 (8): 1118-31.
14. Ivanovic D, Rodríguez M, Pérez H, Alvear J, Almagià A, Toro T, Urrutia M, Cruz A, Ivanovic R. Impact of nutritional status at the onset of elementary school on academic aptitude test achievement at the end of high school in a multicausal approach. *Br J Nut* 2009; 102 (1): 142-54.
15. Amador J, Forns M, & Kirchner T. Tests de factor G y factoriales. Departamento de personalidad, evaluación y tratamiento psicológico, facultad de psicología. España, Universidad de Barcelona, 2005.
16. Colom R, Flores C. Inteligencia y Memoria de Trabajo: La Relación Entre Factor G, Complejidad Cognitiva y Capacidad de Procesamiento. *Psicología: Teoría e Pesquisa* 2001; 17 (1): 37-47.
17. Ivanovic R, Forno S, Durán M, Hazbún J, Castro G, Ivanovic D. Estudio de la capacidad intelectual (Test de matrices progresivas de Raven) en escolares chilenos de 5 a 18 años. I. Antecedentes generales, normas y recomendaciones. *Revista de Psicología General y Aplicada* 2000; 53 (1): 5-30.
18. Prabhakaran V, Smith J, Desmond J, Glover G, Gabrieli J. Neural Substrates of Fluid Reasoning: An fMRI Study of Neocortical Activation during Performance of the Raven's Progressive Matrices Test. *Cogn Psychol* 1997; 33 (1): 43-63.
19. The World Medical Association. Declaration of Helsinki - Ethical Principles for Medical Research Involving Human Subjects (Declaration of Helsinki). 59<sup>th</sup> WMA General Assembly, Seoul, Korea, October, 2008.
20. Raven, J. Test de matrices progresivas. Escala general. Buenos Aires, Paidós, 2007.
21. Heymsfield, S. Timothy, G. Lohman, T. Wang, Z. Human Body Composition Human Body Composition: Methods and Finding. Champaign IL: Human Kinetics, Champagne, IL, 2005.
22. Albala C, Vio F, Kain J, Uauy R. Nutrition transition in Chile: determinants and consequences. *Public Health Nutr* 2002; 5 (1A): 123-8.
23. Vio F, Albala C, Kain J. Nutrition transition in Chile revisited: mid-term evaluation of obesity goals for the period 2000-2010. *Public Health Nutr* 2007; 11 (4): 405-12.
24. Portillo V, Puente A, Pérez M, Loya Y. Deterioro neuropsicológico en niños mexicanos con estados nutricionales alterados: desnutrición leve a moderada vs. obesidad. *Revista Neuropsicología, Neuropsiquiatría y Neurociencias* 2011; 11 (2): 133-46.
25. Gunstad J, Spitznagel M, Paul R, Cohen R, Kohn M, Luyster F. Body mass index and neuropsychological function in healthy children and adolescents. *Appetite* 2008; 50 (2-3): 246-51.
26. Genovese J, Little K. Mesomorphy correlates with experiential cognitive style. *J Genet Psychol* 2011; 172 (4): 433-9.
27. Janssen I, Craig WM, Boyce WF, Pickett W. Associations between overweight and obesity with bullying behaviors in school-aged children. *Pediatrics* 2004; 113 (5): 1187-94.
28. Urrejola P. ¿Por qué la obesidad es una enfermedad? *Rev Chil Pediatr* 2007; 78 (4): 421-3.
29. Benton D. Micronutrient status, cognition and behavioral problems in childhood. *Eur J Nutr* 2008; 47 (Suppl. 3): 38-50.