



Original/*Obesidad*

## Critical periods in the variation in body composition in school children

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### Abstract

**Objective:** To identify critical periods in the variation in body composition during a school year and determine possible causes.

**Methods:** A total of 363 boys and girls aged between 10 and 14 years participated in the study. Before and after the Winter Holidays (WIH) and National Holidays (NAH) (July and September, respectively), measurements were taken of body weight, body fat percentage, waist perimeter, time spent on physical activity and hours of sleep in order to determine the variations. The normality of the data was confirmed and the means were compared with an alpha significance level of  $p < 0.05$ .

**Results:** The school children increased in weight by 600 g and 510 g in the NAH and WIH, respectively ( $p < 0.0001$ ), and their body fat percentage was significantly increased during both periods (0.51%); however, the waist perimeter measurement saw no significant changes. It can also be seen that in NAH physical activity dropped by an important amount (-41 min,  $p < 0.0001$ ), though this did not occur in WIH. A significant increase in hours of sleep was also seen during the two holiday periods (~1 to 2 hours/day).

**Conclusion:** It is concluded that both NAH and WIH can be considered critical periods due to the sharp increase in body weight and body fat percentage in the school children, where a possible cause is the reduction in time spent on physical activity.

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Key words: *Obesity, body weight, fat percentage, critical periods, physical activity.*

### PERIODOS CRÍTICOS EN LA VARIACIÓN DE LA COMPOSICIÓN CORPORAL EN NIÑOS EN EDAD ESCOLAR

### Resumen

**Objetivo:** Identificar periodos críticos en la variación de la composición corporal durante un año escolar y determinar causas posibles.

**Métodos:** Un total de 363 niños y niñas entre 10 y 14 años participaron en el estudio. Antes y después de las Vacaciones de invierno (VI) y Vacaciones nacionales (VN) (julio y septiembre, respectivamente), se tomaron mediciones de peso corporal, porcentaje de grasa corporal, perímetro en la cintura, tiempo dedicado a actividad física y horas de sueño para determinar las variaciones. La normalidad de los datos fue confirmada y las medias fueron comparadas con un nivel de significancia alfa de  $p < 0.05$ .

**Resultados:** Los niños en edad escolar aumentaron su peso en 600 g y 510 g en las VN y VI, respectivamente ( $p < 0.0001$ ), y su porcentaje de masa corporal aumentó significativamente en ambos periodos (0.51%); sin embargo, la medición del perímetro de la cintura no reveló cambios significativos. También se observó que en las VN la actividad física descendió notablemente (-41 min,  $p < 0.0001$ ), aunque esto no fue el caso en las VI. Se pudo constatar un importante aumento de horas de sueño durante los dos periodos de vacaciones (~1 a 2 horas/día).

**Conclusión:** Se constata que las VN y las VI pueden ser consideradas periodos críticos debido al marcado aumento del peso corporal y porcentaje de masa corporal en los niños en edad escolar, donde una causa posible es la reducción del tiempo dedicado a la actividad física.

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Palabras clave: *Obesidad, peso corporal, porcentaje de grasa, periodos críticos, actividad física.*

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## Introduction

Obesity is characterised by the over-accumulation of body fat and can be conceptualised as the physical manifestation of a chronic excess of energy<sup>1</sup>. It is a disorder that affects the entire world, and has seen an explosive increase in number of cases in the last 20 years. It is particularly worrying when it occurs in children and adolescents<sup>2</sup>.

In the case of Chile, the latest report from the Organisation for Economic Cooperation and Development places Chile in sixth place on the list of countries with highest prevalence of obesity and overweight in children from 6 to 17 years of age<sup>3</sup>. In addition to this there is the high level of sedentary lifestyle in the Chilean population (82.7%)<sup>4</sup>, a social context that considerably increases the risk of children becoming obese as adults<sup>5</sup>.

Certain critical periods have been observed during the year, leading to significant increases in body weight or body fat percentage over a short time. Summer holidays, thanksgiving, and national holidays are sensitive periods in adults and children as they tend to lead to modified eating habits and reduced levels of physical activity<sup>6-10</sup>.

It has been shown that only a few weeks of bad eating habits and decreased physical activity can generate negative effects, such as higher total cholesterol, LDL-cholesterol, triglycerides, slight increases in insulin during fasted periods, all of which can last several months or even a year<sup>11</sup>. As well as an increase in body weight, there may also be higher adiposity, decreased fat-free mass<sup>12</sup>, increased blood pressure<sup>13</sup>, etc. These effects can be even more pronounced in subjects with overweight or obesity, due to a greater tendency to increase body weight over short periods of time<sup>10,14</sup>.

It has also been shown that when school children are away from school their body weight increases significantly, implying that educational establishments play a very important therapeutic role<sup>15</sup>. Programs applied within schools have proven effective in controlling weight increases in children, even in low to medium income countries, where the problem is seen on a greater scale<sup>16</sup>. Therefore, school and prevention programs are fundamental to helping decrease the prevalence of obesity, and also to help promote healthy eating habits and physical activity<sup>17,18</sup>.

However, the critical periods during the school year are not well established, since each country has its own festivals and holiday periods, which can occur in different seasons (climate factor), for different durations (time factor) and can focus on the consumption of certain foods or the practise of traditional games (dietary and exercise factor).

Therefore, the main objective of this study was to identify the changes occurring in school children with regard to different body composition variables during the National Holidays (NAH) and the Winter Holidays (WIH) and to investigate their possible causes.

## Materials and Methods

The study was carried out in the city of Valparaiso in Chile and was conducted in accordance with the international standards of the Helsinki declaration for research involving human beings and the deontological standards of the Universidad Católica de Valparaiso, Chile. In a meeting with the parents and guardians of the school children, they were informed of the objectives of the research, were given the option of receiving information on the results, were made aware of the confidentiality of the data and were asked to voluntarily sign a participation consent form for their children.

The first part of the study was carried out during the WIH (16 days in the month of July) and in which 147 school children participated (86 boys and 61 girls). The second part was carried out during the NAH (9 days in the month of September), in which 216 school children participated (87 boys and 129 girls). All the children were aged between 10 and 14 years ( $11.8 \pm 1.2$  years). Their socioeconomic level was identified as "medium" following the Adimark, 2000, application manual.

The children were evaluated during the two days (Thursday and Friday) prior to each holiday period and the two days (Monday and Tuesday) after. Their height was measured with a stadiometer (model 216, Seca®, Germany) and body weight with a scale calibrated to a precision of 0.1 kg (model TBF-300A, Tanita®, Japan). All the children were measured early in the morning wearing shorts, a t-shirt and without footwear. The boys were evaluated by a man and the girls by a woman from the study team. Waist perimeter and body fat percentage were calculated in accordance with the body composition evaluation protocol proposed by GREC, 2009<sup>19</sup>. For calculations of fat mass, a fold of tissue was measured on the leg and the triceps using the formula from Slaughter et al., 1988<sup>20</sup>. Any child presenting stomach problems or any other disorder that may interfere with the objectives of the data collection was excluded from the study.

All the children were given a questionnaire on their physical activity habits which was validated for Chilean children<sup>21</sup>. They were asked about the amount of time they spend on different activities, such as: time lying down, sleep at night, time seated, in classes, doing homework, reading, drawing, eating, in a car or other means of transport, playing videogames, watching television, number of streets they walk, cycling, playing, running, etc. In this study, each item was given a value in minutes/day in order to identify the weekly mean of time spent on physical activity.

## Statistical analysis

The statistics software GraphPad Prism, version 5.00, was used to calculate mean and standard deviation (mean  $\pm$  SD) of all the groups in the study. A nor-

mality test (Kolmogorov-Smirnov) was applied, and the means pre and post-holiday periods were compared using a student t-test for parametric data and a Wilcoxon test for non-parametric. The alpha significance value was set at  $p < 0.05$  for statistical significance.

## Results

Before beginning the study, a small pilot test was conducted to identify the variation in body weight during a normal school week. A total of 216 boys and girls (10-14 years of age) were selected at random and the results are shown in the following (table I).

It can be seen that after the NAH and WIH body weight has increased significantly both in boys and

girls. The mean increase in the children is  $\sim 1.2\%$  over NAH and  $\sim 1.0\%$  over WIH. It should be noted that over the WIH the girls tend to gain 280 g more than the boys; this difference is not seen over the NAH (tables II, III and IV).

A significant increase in body fat percentage is also seen in the children. In both holiday periods there was an increase of  $0.51\%$ , which is equivalent to  $\sim 254$  g of fat, considering the mean weight of the children before the holidays (tables 2, 3 and 4).

Regarding waist perimeter, which is an indicator of fat accumulation, no important changes are seen over the two holiday periods, there is only a significant increase of  $0.65$  cm in girls after the WIH (table 4).

In addition, a significant decrease in physical activity is seen in the children during the NAH ( $\sim 41$  minu-

**Table I**  
Variation in body weight over a normal school week (boys and girls)  $n=216$

	PRE	POST	$\Delta$	Value p
Boys	50.77 $\pm$ 09.51	50.79 $\pm$ 09.46	+0.02	0.6674
Girls	50.23 $\pm$ 10.26	50.29 $\pm$ 10.32	+0.06	0.1119
Boys + Girls	50.45 $\pm$ 09.94	50.49 $\pm$ 09.96	+0.04	0.1251

Mean  $\pm$  SD;  $\Delta$ : variation;  $P < 0.05$ .

**Table II**  
Variation in study variables in boys over NAH and WIH

	NAH (boys) $n=87$				WIH (boys) $n=86$			
	PRE	POST	$\Delta$	Value p	PRE	POST	$\Delta$	Value p
Weight (kg)	50.8 $\pm$ 9.4	51.4 $\pm$ 9.7*	+0.600	<0.0001	49.2 $\pm$ 12.2	49.6 $\pm$ 12.2*	+0.380	<0.0001
Fat (%)	24.5 $\pm$ 8.2	25.1 $\pm$ 8.4*	+0.56	0.0493	23.8 $\pm$ 7.9	24.3 $\pm$ 8.1*	+0.48	0.0055
WP (cm)	68.2 $\pm$ 6.6	68.1 $\pm$ 6.8	+0.01	0.6567	68.7 $\pm$ 7.9	69.1 $\pm$ 8.3	+0.39	0.0597
PA (min)	72.27 $\pm$ 36.6	30.49 $\pm$ 25.3*	-41.7	<0.0001	41.1 $\pm$ 19.8	45.1 $\pm$ 29.7	+4.48	0.3263
Sleep (h,min)	9.06 $\pm$ 1.32	10.25 $\pm$ 1.45*	+1.19	<0.0001	9.07 $\pm$ 1.1	10.32 $\pm$ 2.1*	+1,25	<0.0001

WP: Waist perimeter; PA: physical activity;  $\Delta$ : variation; \*: statistically significant.

**Table III**  
Variation in study variables in girls over NAH and WIH

	NAH (girls) $n=129$				WIH (girls) $n=61$			
	PRE	POST	$\Delta$	Value p	PRE	POST	$\Delta$	Value p
Weight (kg)	50.3 $\pm$ 10.3	50.9 $\pm$ 10.4*	+0.590	<0.0001	49.1 $\pm$ 11.9	49.7 $\pm$ 11.9*	+0.660	<0.0001
Fat (%)	26.6 $\pm$ 6.1	27.0 $\pm$ 6.4*	+0.47	0.0097	28.5 $\pm$ 5.7	29.1 $\pm$ 5.6*	+0.56	0.0028
WP (cm)	65.5 $\pm$ 6.8	65.76 $\pm$ 7.0	+0.26	0.1181	65.4 $\pm$ 9.8	66.4 $\pm$ 9.7*	+1.0	<0.0001
PA (min)	53.39 $\pm$ 35.9	13.3 $\pm$ 16.5*	-40.0	<0.0001	25.0 $\pm$ 14.6	23.3 $\pm$ 27.7	-2.12	0.1561
Sleep (h,min)	9.04 $\pm$ 1.39	10.24 $\pm$ 1.87*	+1.20	<0.0001	9.02 $\pm$ 1.2	11.11 $\pm$ 1.8*	+2.09	<0.0001

WL: Waist perimeter; PA: physical activity;  $\Delta$ : variation; \*: statistically significant.

**Table IV**  
Variation in study variables in boys and girls over NAH and WIH

	NAH (boys and girls) n=216				WIH (boys and girls) n=147			
	PRE	POST	Δ	Value p	PRE	POST	Δ	Value p
Weight (kg)	50.5±9.9	51.1±10.1*	+0.600	<0.0001	49.3±12.0	49.8±12.1*	+0.510	<0.0001
Fat (%)	25.7±7.1	26.2±7.3*	+0.51	0.0013	25.8±7.4	26.3±7.6*	+0.51	<0.0001
WP (cm)	66.6±6.8	66.7±7.04	+0.15	0.3325	67.3±8.9	68.0±9.0*	+0.65	<0.0001
PA (min)	61.4±37.3	20.4±22.2*	-41.0	<0.0001	34.2±19.4	36.1±30.7	+2.30	0.9245
Sleep (h,min)	9.12±1.37	10.24±1.71*	+1.12	<0.0001	9.04±1.2	11.02±2.0*	+1,58	<0.0001

WL: Waist perimeter; PA: physical activity; Δ: variation; \*  $p < 0.05$ .

tes). This is equivalent to a reduction of 66.7%. During the WIH, no significant change can be seen.

Lastly, there is a significant increase in the time the children spend sleeping during their holidays. During WIH girls tend to sleep more than boys (~44min), while during NAH, the increase is similar for both groups (~1h and 20min/day) (tables 2, 3 and 4).

## Discussion

This study corroborates the NAH as a critical period of weight increase in school children, obtaining very similar results to another research study that showed an increase of ~600g during the same time period<sup>9</sup>. It is the first study to investigate the variation in body fat percentage and waist perimeter measurement during NAH and WIH in Chilean school children.

After analysing the data, it appears to indicate that the WIH may also be considered a critical period, since the values seen (for weight and body fat percentage) are very similar to those observed during NAH. Similarly, it was shown that the waist perimeter measurement of the children tends to increase, and can be a predictor of cardiometabolic risk in this sample<sup>22</sup>.

The importance of the data is due to the fact that the literature shows that lower levels of physical activity and increased calorie consumption over short periods can produce negative effects (increased body fat percentage, cholesterol, triglycerides, etc.) which can last several months<sup>11</sup>. Subsequent to this sharp weight increase, the person can require several months to lose the weight gained, and may also tend to continue accumulating fat mass (mainly in the central area of the body), while the lean body mass does not increase<sup>6,11,12</sup>.

Therefore, identifying the periods of the year during which the most notable gains in weight, body fat percentage or waist perimeter occur can be necessary for generating strategies aiming to prevent such increases, mainly in children with overweight and obesity who are more prone to unfavourable changes in their body composition and physical condition over short periods<sup>9,15,23</sup>.

In this context, school plays a fundamental role, since fewer sharp increases in weight are observed during the school period, while the opposite is seen when the children are out of school<sup>15,17</sup>. Despite this, it should be noted that there are other factors that influence weight fluctuations in children, such as their social context<sup>24</sup>.

Several programs have been developed in schools to promote healthy eating habits and physical exercise, showing some very good results<sup>25,26</sup>, both long-term interventions<sup>16</sup> and short-term<sup>9</sup>. It is important to consider this point when generating tools and policies with regard to these issues<sup>27</sup>.

The data in the present study agrees with the article by Carson et al., 2010, which shows that there appears to be less physical activity during winter than during spring<sup>28</sup>. This factor may explain why there is no significant decrease seen in the amount of time spent on physical activity during WIH, since the values prior to the winter break would already be low.

Interestingly, this study demonstrated that as well as decreasing their level of physical activity, the children significantly increase the amount of time they spend sleeping. During NAH, the children sleep 1h 12min more and in WIH 1h 58min, which would significantly decrease the time available for expending energy through physical activity. It should be noted that several studies have shown the association between hours of sleep and weight gain<sup>29</sup>. The results of the present study are contrary to research that has analysed habitual sleep behaviour in children, and therefore this factor must also be considered in future studies.

Finally, it is important to note some observations regarding this study that may be considered in future research in this area. It would be relevant to use more objective methods to quantify the time and intensity of physical activity, to determine the number of steps taken per day, time inactive, etc. and relate this with variations in body composition of school children during holidays.

It is also important to study the variations in energy intake (quantity, density, frequency) during these critical periods, in order to identify the degree of association and responsibility of eating habits in the weight gain. It is also necessary to conduct longitudinal stu-

dies in order to identify the critical periods during the year for variations in body composition, eating habits and physical activity, and subsequently generate preventative programs for the community.

It is concluded that both NAH and WIH can be considered critical periods for weight gain and increased body fat in Chilean school children, where a decrease in time spent on physical activity is a factor that influences this phenomenon.

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