Motor behavior according to Body Mass Index in boys and girls aged 6 to 10 years from Viña del Mar, Chile

Conducta motriz según índice de masa corporal en niños y niñas de 6 a 10 años de la comuna de Viña del Mar, Chile

Jacqueline Páez Herrera[1,2], Norman MacMillan Kuthe[1], Juan Hurtado Almonacid[1,2], Rodrigo Yáñez Sepúlveda[3], Francisco Olate Gómez[2]

1 Escuela de Educación Física. Pontificia Universidad Católica de Valparaíso. Chile.
2 Grupo de estudios Efidac. Pontificia Universidad Católica de Valparaíso. Chile.
3 Escuela de Educación. Pedagogía en Educación Física. Universidad Viña del Mar, Chile.

CORRESPONDENCIA:

Jacqueline del Carmen Páez Herrera
jacqueline.paez@pucv.cl

Recepción: septiembre de 2018 • Aceptación: marzo de 2019

CÓMO CITAR EL ARTÍCULO:

Páez, J., MacMillan, N., Hurtado, J., Yáñez, R., & Olate, F. (2020). Motor behavior according to Body Mass Index in boys and girls aged 6 to 10 years from Viña del Mar, Chile. *Cultura, Ciencia y Deporte, 15*(45), 313-319.

Abstract

The objective of the study was to compare and relate motor behavior in relation to body mass index (BMI) and sex in children aged 6 to 10 years in Viña del Mar, Chile. 221 students participated (girls, n=102; boys, n=119) with an average age of 7.55 ± 1.31 years. Motor behavior was determined and classified with the Test of Gross Motor Development (TGMD-2). The body mass index (BMI) was calculated based on the ratio between weight and height (expressed in W/H^2). The nutritional status was determined using the indicators of the Ministry of Health of Chile, which are based on international standards for nutritional evaluation of children and adolescents from 5 to 19 years of age. For result analyses, the sample was divided into two groups (low-normal-weight and overweight-obese) with a confidence interval of 95% ($p < 0.05$) for comparison between the groups. It was shown that low and normal body mass index boys had better locomotion ($p = 0.026$) and object control ($p = 0.045$) in relation to overweight and obese boys. The female sex presented no differences between groups. Amongst boys, BMI is negatively related to motor quotient ($p = 0.001$), while in girls, no relationship was observed. In terms of gross motor development, low-weight and normal-weight boys are more likely to have a better gross motor development than overweight and obese boys, though not the case in girls. It is concluded that overweight and obese boys have a lower motor skill than normal and low boys.

Key words: Motor skill, nutritional status, students.

Resumen

El objetivo del estudio fue comparar y relacionar la conducta motriz según estado nutricional y sexo en niños y niñas de 6 a 10 años de la comuna de Viña del Mar, Chile. Participaron 221 estudiantes (niñas, n= 102 y niños, n=119) con edad promedio de 7,55 ± 1,31 años. La conducta motriz se determinó y clasificó con el Test of Gross Motor Development (TGMD-2), el índice de masa corporal (IMC) se calculó de acuerdo a la relación entre el peso y la talla, expresados en kg/m^2. El estado nutricional se clasificó a partir de las indicaciones internacionales y del Ministerio de Salud de Chile según las normas para la evaluación nutricional de niños y niñas y adolescentes de 5 a 19 años de edad. Para el análisis de los resultados la muestra se dividió en dos grupos (bajopeso-normopeso y sobrepeso-obeso) considerando un intervalo de confianza del 95% ($p < 0.05$) para la comparación entre los grupos. Se evidenció que los niños bajopeso y normopeso presentaron una mejor locomoción ($p = 0.026$) y manipulación ($p = 0.045$) en relación a los niños con sobrepeso y obesidad. El sexo femenino no presentó diferencias entre los grupos. Entre los niños, el IMC está relacionado negativamente con el cociente motor ($p = 0.001$), mientras que en las niñas no se observó relación. En términos de desarrollo motor grueso, los niños con bajo peso y peso normal tienen más probabilidades de tener un mejor desarrollo motor grueso que los niños con sobrepeso y obesidad, aunque no es el caso en las niñas. Se concluye que los niños con sobrepeso y obesidad presentan una conducta motriz más descendida que los niños normopeso y bajo peso.

Palabras clave: Desarrollo motriz, estado nutricional, estudiantes.

Introduction

The first years of life are a source of several significant and enduring processes over time. This development process is indicated by Campo (2010), as a continuous process through which the child gradually acquires complex abilities that allow him/her to interact with people, objects, and situations of his/her environment in different ways. Therefore, processes such as growth, maturation, adaptation, and learning make the development of human beings possible, configuring his/her identity in bio-psycho-social aspects. Furthermore, it is at this stage, according to Haywood and Getchell (2001), that we see a progressive advance from reflex movements to basic motor skills. These are the essential building blocks that enable children to participate in motor activities, which in turn enable them to progress towards the development of specific motor skills. Rocha, Gheno, Carneiro and Dal Farra (2017), showed that the first childhood stage is a critical phase for motor development and Brien, Belton and Issartel (2015), point out that the fundamental movement skills are basic observable patterns of behavior present from childhodd to adulthood. Meanwhile, Cano, Leyton and Duran (2015), refer to basic motor skills as the foundation that leads to more complex sequences of movements. To this, Lopez (2013), indicates that this privileged period is precisely the stage for consolidating and influencing mastery of basic motor skills.

However, it is evident that such evolution is not the result of chance, but rather a series of both external and internal factors that influence motor evolution, such as by different structural characteristics and (strongly) by anthropometric characteristics (Mendez, Estay, Calzadilla, Duran & Dias, 2015). Bucco and Zubiaur (2013); Vidal (2016); González, Pelegrín and Carballo (2017), insist on this idea, indicating that the changes shown during childhood are the product of individual limitations, life experiences, and the possibilities and/or restrictions of context, among others. Evidence indicates that poor motor skills, social status, and adiposity levels are some of the factors influencing quality of movement ability Cenizo, Ravelo, Morilla and Fernández (2017); Rudisill (2011); Oliveira, Pires, Santos and Oliveira (2011); Almeida, Lima Pellegrini, Higassiaraguti and Yukiko, (2012); Bardid et al. (2013), Mathisen (2016); Bustamante et al. (2008); Willian et al. (2008). Meanwhile, Méndez et al. (2015), point out that being overweight/obesity negatively influences development of motor skills in preschoolers. Bucco and Zubiaur (2013), also point out that obese and overweight children perform worse and have lower motor skills than expected for their age in balancing, running, side-step running, galloping, and jumping; and receiving, throwing, bouncing, kicking, and hitting a ball. At the same time, Lepes, Halasi, Mndaric and Tanovic (2014) point out that the human body is complex, composed of many tissues that change as the body develops, matures, and ages.

A high body mass index is a factor that influences the development of motor skills in a negative way in preschool children, where children with overweight or obesity perform and have a motor competence lower than expected for their age in locomotion, handling and balance Mendez et al. (2015); Bucco and Zubiaur (2013); Cigarroa, Sarqui and Zapata-Lamana (2016). Rocha et al. (2016), indicates that physical activity and motor development are strongly related. They evidenced the importance of physical activity in motor development by analyzing the important changes that happen in general motor coordination between the ages of 5 to 10.

According to Ruiz, Mata and Moreno (2007), children with the least motivation for physical activity and sport are those with the least motor skills. This is supported by Martínez, Lara, Chacón and Rodríguez (2009), who indicate that decreased physical activity in children and young people is one of the main causes of body weight gain.

In Chile, the current situation is beyond concerning: it has one of the highest overweight indexes in Latin America (Malo-Serrano & Castillo, 2017). Unfortunately, this figure involves children to a large extent. In fact, the National Board of School Aid and Scholarships (JUNAEB, *Junta Nacional de Auxilio Escolar y Becas*), in its 2016 nutritional study, indicated that there are currently 660.000 children at obese and overweight levels. Of those, 26.4% of children (between 5 and 7 years of age) in preschool, kindergarten, and first grade are overweight, and 23.9% are obese. Meanwhile, the Agency for the Quality of Education, 2016, (ACE, *Agencia de Calidad de la Educación*) indicates that these poor healthy living habits have influenced the high overweight and childhood obesity indicators.

This is a cross-cutting situation, where normal weights at all levels of education in our country have been affected. That same organization cites evidence of this worrying situation, with overnutrition rates at greater than 26.5%.

For all the above reasons, the objective of this study was to compare motor skills as correlates with BMI in boys and girls from 6 to 10 years in Viña del Mar, Chile.

Materials and methods

Participants

The non-probabilistic, convenience sampling included 221 students (102 girls and 119 boys) from Viña del Mar, Chile. The sample ages ranged from 6 to 10 years of age, with an average of 7.55 ± 1.31 years. Protocols from the ethical principles for human research proposed by the Declaration of Helsinki were applied (World Medical Association, 2013), and the procedural and documentation suggestions of the Directorate of Research of the Pontificia Universidad Católica de Valparaíso were followed. Additionally, permission from school authorities, and informed consent from parents and/or guardians, was requested. These parties were informed of the objectives and scope of the study in order to authorize children participation.

Instruments and procedures

The tests were carried out in educational establishments, the weight and height were evaluated, after that the tes was evaluated Test of Gross Motor Development Tool - Second Edition (TGMD-2) (Ulrich, 2010), in the evaluation of TGMD 2 the students were 24 hours without exercise and were not fasting. First, the BMI evaluation was carried out, where boys and girls were weighed and measured with bare feet, with shorts and a t-shirt for the development of the Physical Education class. Subsequently, the evaluation of motor behaviors was carried out by means of the TGMD -2 instrument. This evaluation was carried out in a flat space, without slopes and free of obstacles. Boys and girls performed the test with sportswear, after breakfast time. Boys and girls were evaluated individually, both in locomotion and manipulation tests. The evaluations were initiated with the six locomotion tests, applying them in the following order: run, gallop, jump on one foot, jump on an object, horizontal jump and lateral displacement. The evaluation of the six object control tests was then carried out, which were applied as follows: hitting a stationary ball, stationary ball dribbling, catching a ball, kicking a ball, throwing a ball Ball over your shoulder and roll a ball.The body mass index was calculated with the formula weight (kg) / height (m) 2. Then, to obtain each of the categories associated with nutritional status, the z scores were used, which indicates the amount of standard deviations (SD) existing between the BMI measurement, with respect to the 50th percentile. In this way the BMI of the participants was obtained: low weight ≤ - 1 to - 1.9; normal weight + 0.9 to - 0.9; overweight ≥ + 1 to + 1.9 and obese ≥ + 2 to + 2.9, a portable altimeter (Bodymeter 206 Seca) and a digital scale (Scale plus Body Fat Monitor UM-028, TANITA) were used. The ratio between weight and height, expressed in kg/m^2, was calculated, and body composition was identified on the basis of Chilean Ministry of Health guidelines, with the standards for nutritional evaluation of children and adolescents from 5 to 19 years of age (MINSAL, 2016).

The TGMD-2 was used to identify motor behaviors. This instrument identifies motor development in children between the ages of 3 and 10, based on seven categories: very poor, poor, below average, average, above average, superior, and far superior. The subjects were classified by this test in their respective category and then sorted by sex and age (measured in months), considering motor evolutive development. Gross motor skills were evaluated in two ways: locomotion skills (sprint, gallop, jumping on one foot, two feet horizontal jump, obstacle sprinting, lateral movement) and manipulation skills (reception, bouncing, rolling, kicking, hitting with a bat, throwing). All this to generate three results: one for locomotion skill, one for manipulation skill and a last one for general gross motor skill. Each evaluated gross motor skill included three to four behavioral components, that were used as criteria to evaluate the execution. A score of 1 was recorded if a task was done correctly, and 0 if not. There were two attempts at each subtest, and the scores obtained were converted with a table of values that is sorted by age in months. The final result was the Standard Score, which describes the Gross Motor Quotient (GMQ). The GMQ is understood as a range of the seven categories, where far superior > 130; superior, 121-130; above-average, 111-112; average, 90-110; below average, 80-89; poor, 70-79; and very poor, < 70.

Statistic Analysis

The results are shown in comparative analysis, first by sex, then by BMI (low and normal weight groups vs overweight and obesity groups). Mean and standard deviation statistics are used to describe the variables. The Kolgomorov-Smirnov test (n>30) for data normality determined that variables did not present normal distribution. As such, the Mann-Whitney *U*-test (non-parametric) was used to compare the variables between groups. For results analyses, Excel® 2013 software from Windows (Redmond, Washington, USA) and Graphpad Prism® 7.0, Windows version (La Joya California, USA) were used. A confidence level of 95% ($p<0.05$) was considered to calculate statistical significance.

Results

When comparing skills by sex (Table 1), there were no differences in locomotion score between boys and girls. Boys got a score of 7.89 ± 3.25, while girls scored 7.56 ± 2.79. The same happened with the object control score, where boys got a score of 6.11 ± 2.99 and girls scored 5.98 ± 2.96, resulting in a not significant difference in the $p<0.05$ value.

In regard to the BMI of girls which were classified according to motor development, 51.7% of the ones under the low/normal weight category were classified as "poor" or "very poor" in motor development. The same happened in 52.3% of the girls under the overweight/obesity category (Table 2). In relation to boys (Table 3), 58.3% of the ones under the low/normal weight category were classified as "below average" in motor development, whilst 80.9% of the ones under the overweight/obesity category were classified as "below average", "poor" or "very poor".

Table 4 describes the basic variables and motor skills by weight group (low-normal vs. overweight-obese), shows that girls in the low/normal group had a body mass index of 15.76 ± 1.29(W/H^2) and overweight/obese girls have an index of body mass of 20.01 ± 2.51(W/H^2) with differences between the groups ($p = 0.000$), in the locomotion score was 5.93 ± 3.05 in girls low/normal and 6.05 ± 2.89 in girls overweight/obese ($p = 0.620$), the object control score of the low/normal group of girls was 7.79 ± 2.94, while in the overweight/obese group it was 7.27 ± 2.60 ($p = 0.480$), in the variables total score and motor quotient there were no differences between the group of girls low/normal and overweight/obese ($p > 0.05$). In the group of children, the low/normal group had a body mass index of 15.84 ± 1.34 and overweight/obese children had a body mass index of 19.90 ± 3.08 ($p = 0.000$), the locomotion score was 8.46 ± 3.33 in children low/normal and 7.02 ± 2.97 in children overweight/obese ($p = 0.026$), the object control score of the group of children low/normal was 6.58 ± 2.99, while in the group overweight/obese was of 5.40 ± 2.90 ($p = 0.045$), in the total score variables the children low/normal (15.04 ± 5.27) presented a better total score than the children overweight/obese (12.43 ± 4.87) ($p = 0.008$), in the quotient motor there were differences between the group of children low/normal (85.13 ± 15.80) and overweight/obese (77.28 ± 14.61) ($p = 0.008$)

Table 1. Average, standard deviation, and p values for basic variables and motor skills, by sex.

Variable	Girls (n=102)	Boys (n=119)	*P value*
Age (years)	7.65 ± 1.25	7.46 ± 1.35	*0.103*
Weight (kg)	28.71 ± 7.27	27.61 ± 7.33	*0.184*
Height (m)	1.27 ± 0.11	1.25 ± 0.11	*0.248*
BMI (W/H^2)	17.59 ± 2.84	17.44 ± 2.95	*0.717*
Locomotion Score	7.56 ± 2.79	7.89 ± 3.25	*0.522*
Object Control Score	5.98 ± 2.96	6.11 ± 2.99	*0.553*
Score total	13.55 ± 4.78	14.00 ± 5.25	*0.379*
Motor Quotient	80.52 ± 14.30	82.02 ± 15.75	*0.337*

Table 2. Gross motor development in girls by nutritional status.

Motor development category	Low-Normal (n=58)			Overweight-Obesity (n=44)		
	N°	%	Weighted %	N°	%	Weighted %
Very poor	16	27.6	27.6	9	20.5	20.5
Poor	14	24.1	51.7	14	31.8	52.3
Below average	12	20.7	72.4	8	18.2	70.5
Average	14	24.1	96.5	12	27.3	97.8
Above Average	2	3.5	100	1	2.2	100

Table 3. Gross motor development in boys by nutritional status.

Motor development category	Low-Normal (n=72)			Overweight-Obesity (n=47)		
	N°	%	Weighted %	N°	%	Weighted %
Very poor	14	19.4	19.4	13	27.7	27.7
Poor	12	16.7	36.1	11	23.4	51.1
Below average	16	22.2	58.3	14	29.8	80.9
Average	27	37.5	95.8	9	19.1	100
Above Average	2	2.8	98.6	0	0	0
Far Superior	1	1.4	100	0	0	0

Table 4. Average, standard deviation, and p values for basic variables and motor skills, by weight group (low-normal vs. overweight-obese).

Variable	Girls (n=102)			Boys (n=119)		
	Low-Normal (n=58)	Over-Obese (n=44)	P value	Low-Normal (n=72)	Over-Obese (n=47)	*P value*
Weight (kg)	25.94 ± 5.75	32.38 ± 7.50	*0.000*	25.17 ± 5.19	31.37 ± 8.54	*0.000*
Height (m)	1.28 ± 0.12	1.27 ± 0.11	*0.813*	1.26 ± 0.13	1.25 ± 0.09	*0.989*
BMI (W/H²)	15.76 ± 1.29	20.01 ± 2.51	*0.000*	15.84 ± 1.34	19.90 ± 3.08	*0.000*
Locomotion Score	5.93 ± 3.05	6.05 ± 2.89	*0.620*	8.46 ± 3.33	7.02 ± 2.97	*0.026*
Object Control Score	7.79 ± 2.94	7.27 ± 2.60	*0.478*	6.58 ± 2.99	5.40 ± 2.90	*0.045*
Score total	13.72 ± 5.07	13.32 ± 4.44	*0.842*	15.04 ± 5.27	12.43 ± 4.87	*0.008*
Motor Quotient	80.97 ± 15.11	79.95 ± 13.33	*0.908*	85.13 ± 15.80	77.28 ± 14.61	*0.008*

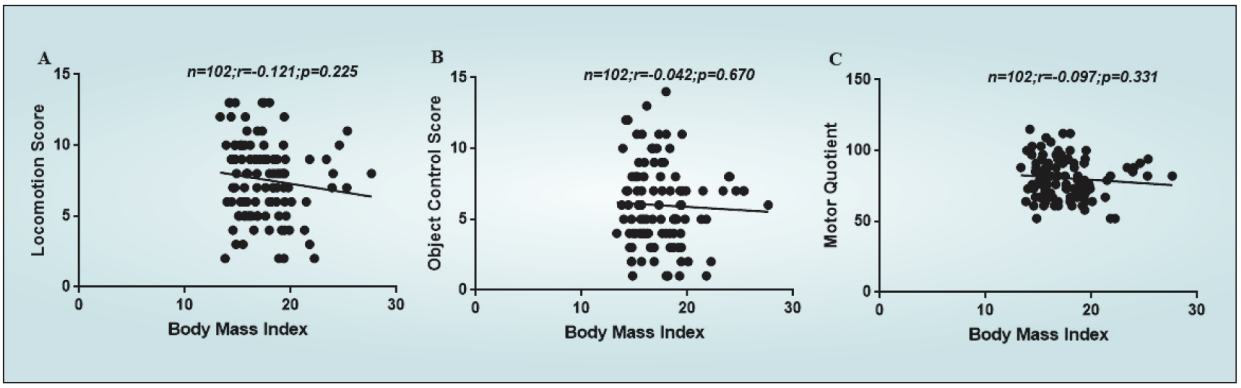

Figure 1. Level of correlation between body mass index, locomotion score, object control score and motor quotient in the group of girls.

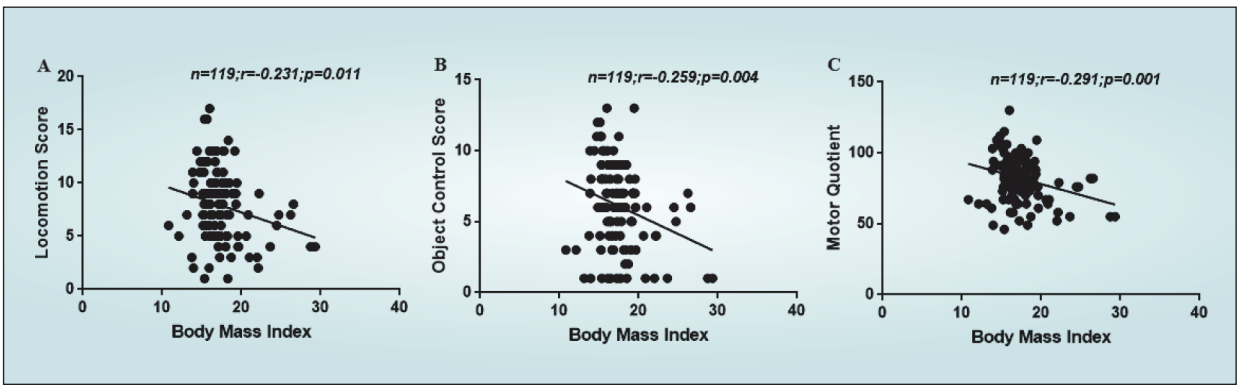

Figure 2. Level of correlation between body mass index, locomotion score, object control score and motor quotient in the group of boys.

When BMI's correlation to locomotion score, object control score and motor quotient on the girls group (figure 1) was analyzed, no significant correlations were found when correlated to locomotion score (p = 0.225), aswell as to object control score (p = 0.670) and motor quotient (p = 0.331), using Pearson's bivariate correlation test. As for the boys group (figure 2), significant correlations between BMI and locomotion score (p = 0.011), object control score (p = 0.004) and motor quotient (p = 0.001) were found, using the same correlation test.

Discussion

Of the overall sample of 221 students evaluated (102 girls and 119 boys), results showed no significant differences between sex for locomotion and object control variables. This matches with a study carried out by Ruiz and Graupera (2003), where they studied the differences according to sex in motor coordination with a sample of 903 schoolchildren between the ages of 4 and 14 (subdivided into sections of 4 to 6 years; 7 to 8 years; 9 to 10 years; and 11 to 12 years) using the ABC

Movement Battery, which measures manual dexterity, skill with ball, static balance, and dynamic balance. Results of that study showed no significant differences between sex in the first age group (4 to 6 years old).

The results of our study do not show statistically significant differences with respect to the motor development and BMI of the girls. This can be explained because according to Bucco and Zubiaur (2013), girls explore space much less and their activities are mostly focused on conversation spaces, or by being spectators of the activities carried out by boys.

In the male sex, regarding the BMI and motor development, our findings showed significant differences between both the normal weight and overweight/obese categories. The normal weight group presented better locomotion and object control.

This can be explained, since according to Pinel et al. (2017) the boys devote more weekly time to sedentary activities, such as the use of video games, while girls, although they do less activities, have less sedentary time, since they spend their free time in shopping. Likewise Trejo et al. (2012) point out that there is a tendency for obese boys to devote more time to these activities. This could explain the statistically significant differences in males, but not in females.

These results match the ones found by Bucco and Zubiaur (2013), where they evaluated 284 healthy children the ages 6 and 10. They found that normal weight girls were significantly better at gross motor skills than girls with overweight/obesity. Similar results were found by Cano, Oyarzun, Leyton and Sepulveda (2014), after evaluating 23 preschoolers (12 girls and 10 boys) aged 5 years, they concluded that children with overweight/obese present a low level of psychomotor development. Marramarco et al. (2012), in their study, on the nutritional status and children's motor performance examining 287 boys (150 boys and 137 girls), aged between 5 and 10. Children with severe obesity, obesity and mild malnutrition presented lower levels of motor development than expected for their age, leaving them inside the" poor" and "very poor" categories.

Méndez et al. (2015), in their study, compared psychomotor development (PMD) over three nutritional states: normal, overweight, and obese. The "TEPSI" PMD assay was applied to a total sample of 150 children age 4-5 years, from Integra foundation. The results showed that 100% of the preschoolers at normal weight presented normal motor development, 88,88% of the ones with overweight obtained also normal results and 11.12% were at risk of delayed development.

Saraiva and Rodrigues (2010), in their investigation they analyzed the studies made by Graf et al. (2004), Wrontniak, Epstein; Dorn, Jones and Kondilis (2006) and Cantell et al. (2008), Portugal, Flores, Riberiroe and Santos (2006), Houwen, Hartman and Visscher (2008), and concluded that overweight in children affect negatively in their motor behavior. They also saw that high BMI was related to poor motor development.

Likewise, Catuzzo et al. (2016), did a systematic review from studies made between the years 1990 and 2013, in this review using different criteria, 84 studies were selected, of which 45 were selected for qualitative analysis. They evidenced that there's an inverse relation between motor development and BMI. The analysis shows that 27 of the 33 studies reviewed concluded that increased BMI is related to an inefficient motor behavior.

Faced with these scenarios, the essential role of Physical Education becomes apparent. Levels of physical activity, sedentary behavior, and nutritional status during early life stages condition motor development in childhood (Mattocks et al., 2008) and during adulthood (Øglund, Hildebrand, & Ekelund, 2015). Early intervention is especially necessary, given that children today are not physically active often enough for healthy development. A study of Canadian children found that only 9% of children met the recommended levels of physical activity (Colley et al., 2012). As such, school playgrounds must primarily be a place to promote physical activity and to practice motor skills (Lim, Donovan, Harper & Naylor, 2017), where Physical Education can play a fundamental role in boosting motor development and modifying the current scenario. Thus, we propose early-life motor skill intervention based on improving gross motor skills in infants and children – indeed, these groups may be the most appropriate target for promoting general levels of physical activity in order to improve motor skills during later stages (Sanchez, Williams & Aggio, 2017) – through the development of public policies that increase compulsory PE class time for kindergartens in the Chilean education system.

Conclusion

It is concluded that there are no sex differences in motor development. Boys and girls showed low levels of motor development. It was also identified that an increase of BMI is related to poor motor development in children with overweight, because of their precarious locomotion skills, control of objects and motor quotient. On the other hand, an increase of BMI in girls, does not affect and is not negatively related to motor development. Based on these results, it becomes necessary to perform more investigations to support or reject these findings done in Chilean population.

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