Analysis of motor coordination by Body Mass Index and sex in Chilean schoolchildren

Análisis de la coordinación motora por Índice de Masa Corporal y sexo en escolares de Chile

Análise da coordenação motora por Índice de Massa Corporal corporal e sexo em escolares chilenos

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ABSTRACT

The objective of this research was to analyze the relationship between motor coordination (MC) and Body Mass Index in Chilean schoolchildren between 7 and 9 years of age. The study was observational cross-sectional, correlational and descriptive study. 180 students of both sexes were evaluated (90 women aged 8.4 ± 0.9 years and 90 men aged 8.5 ± 0.9 years). Anthropometric weight and height variables were measured and the Body Mass Index (BMI) was calculated. The MC was evaluated using the battery of Körperkoordinationstest Für Kinder (KTK). The results showed that in the lateral transposition, the normal weight group outperforms the overweight and Obesity group ($p<0.05$) for women. For men, in monopedal jumps, the normal weight group also outperformed the obesity group ($p<0.05$). In addition, when analyzing the differences between the sexes, it was noted that women had a higher score than men in the rear balance ($p<0.05$). On the other hand, men had performed better in lateral jumps, lateral transposition and the total KTK score ($p<0.05$). In conclusion, the study found that there was a lower MC index in schoolchildren with a high BMI, and that there were significant differences between men and women in terms of balance, lateral jumps, lateral transposition, and the total score of the KTK test.

Key words: Motor coordination; Adiposity; Schoolchildren; Child Development.

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RESUMEN

La investigación tuvo como objetivo analizar la relación entre la Coordinación Motora (CM) con el Índice de Masa Corporal en escolares chilenos de entre 7 y 9 años. El estudio fue observacional de corte transversal, con características descriptivas y correlacionales. Se evaluaron a 180 escolares (90 mujeres de 8.4 ± 0.9 años y 90 hombres de 8.5± 0.9 años). Se midieron variables antropométricas de peso y talla. Se calculó el Índice de Masa Corporal (IMC). La coordinación motora (CM) se evaluó utilizando la batería de Körperkoordinationstest Für Kinder (KTK). Los resultados mostraron que en las mujeres el grupo Normopeso tenía un mejor desempeño en la transposición lateral que los grupos Sobrepeso y Obesidad (p<0.05). En los hombres, el grupo Normopeso superó al grupo Obesidad en los saltos monopedales (p<0.05). Además, al analizar las diferencias entre sexos, se determinó que las mujeres registraron mayor puntaje que los hombres en el equilibrio a la retaguardia (p<0.05), por su parte, los hombres registraron mejores rendimientos en saltos laterales, transposición lateral y el puntaje total del KTK (p<0.05). Se concluye que existe menor índice de CM en los escolares con elevado IMC, y que existen diferencias significativas entre hombres y mujeres en el equilibrio, saltos laterales, transposición lateral y el puntaje total del test KTK.

Palabras clave: Coordinación Motora; Adiposidad; Escolares; Desarrollo Infantil.

RESUMO

O objetivo da pesquisa foi analisar a relação entre a coordenação motora (CM) com o Índice de Massa Corporal corporal em escolares chilenos entre 7 e 9 anos de idade. O estudo foi observacional transversal, com características descritivas e correlacionais. Foram avaliados 180 escolares de ambos os sexos (90 mulheres com idade de 8,4 ± 0,9 anos e 90 homens com idade de 8,5 ± 0,9 anos). Variáveis antropométricas de peso e altura foram medidas. O Índice de Massa Corporal (IMC) foi calculado. Além disso, a coordenação motora (MC) foi avaliada por meio da bateria Körperkoordinationstest Für Kinder (KTK). Os resultados mostraram que, para mulheres em transposição lateral, o grupo Peso Normal supera o grupo Sobrepeso e Obeso (p<0,05). Para os homens, nos saltos monopedais o grupo Peso Normal supera o grupo Obesidade (p<0,05). Além disso, ao analisar as diferenças entre os sexos, percebe-se que as mulheres apresentam pontuação maiores que os homens no equilíbrio de retaguarda (p<0,05), enquanto os homens apresentam melhor desempenho nos saltos laterais, transposição lateral e pontuação total KTK (p< 0,05). Conclui-se que há menor índice de CM em alunos com IMC elevado, e que existem diferenças significativas entre homens e mulheres para equilíbrio, saltos laterais, transposição lateral e pontuação total do teste KTK.

Palavras chave: Coordenação motora; Adiposidade; Alunos; Desenvolvimento Infantil.

INTRODUCTION

Motor coordination (MC) is defined as the set of abilities that precisely organize and regulate all the partial and global processes of a movement based on a pre-established motor objective (Benjumea et al., 2017; Schilling & Kiphard, 1976). Thus, MC involves: an adequate measure of strength in the amplitude and speed of the movement; an appropriate choice of the muscles that influence the conduction and orientation of the movement; and an ability to quickly alternate muscle tension and relaxation (Schilling & Kiphard, 1976; Torralba et al., 2016).

According to the above, MC is characterized by a continuous modification in movement, which is based on the interaction between the process of neuromuscular maturation, which is probably genetically controlled, physical growth, residual effects between previous motor experiences and new motor experiences (Lopes, 1992; Malina, 2012). Based on this, it follows that MC depends on and/or is influenced by factors such as the teaching context, motivation, neurological development, physical growth, social and cultural conditions, along with past experiences (Lopes et al., 2011).

Currently, the increase in the use of technologies, the increase in economic income, urbanization, fat consumption and sedentary behavior have generated major problems at the sociodemographic level, which have impacted child development (Albala et al., 2002; Álvarez et al., 2020; Luna-Villouta et al., 2016). These factors have caused obesity to triple in Chile over the last 20 years, with more than half of children between 4 and 10 years of age being overweight or obese (Junta Nacional de Auxilio Escolar y Becas [JUNAEB], 2021), which is particularly related to physical inactivity and malnutrition due to excess, thus producing an imbalance between the high amount of energy consumed in relation to daily energy expenditure (Hurtado et al., 2023).

Along these lines, physical inactivity is one of the major causes of increased body weight and low motor competence in schoolchildren (Herlitz et al., 2021; Oliveira et al., 2010; Tishukaj et al., 2017). For its part, having low motor levels and being obese negatively impact health, relationships with other people, generate social isolation and impair behavior at school level. In addition, they increase anxiety and stress in the face of new situations (Bucco-dos Santos & Zubiaur-González, 2013; Luna-Villouta et al., 2016; Muriel et al., 2014). In fact, the developmental problems in MC exhibited during childhood persist beyond adolescence with implications for physical and mental health during adult life (Ruiz et al., 2007). In this same context, a high level of physical activity (PA) and a good MC contribute to children and young people having a greater repertoire of motor options that promote better healthy lifestyle habits throughout the life cycle (Fort-Vanmeerhaeghe et al., 2017). So much so that it has been reported that a high level of PA favors the development of movement and coordination in schoolchildren (Ruiz et al., 2008), additionally, it supports the acquisition of healthy lifestyle habits, influences having an adequate body weight and greater motor activity throughout life (Alberga et al., 2012; Díaz et al., 2015; Díaz & Vargas, 2009), in addition, it strengthens personality and mental well-being (Otero & Ruiz, 2015).

The background presented poses as a challenge, from the practical application of this subject, the creation of studies that allow to delve deeper into the association between the level of MC with health indicators in children in the school stage, since they are still limited, especially at the national level (Gomez-Campos et al., 2019; Herlitz et al., 2021; Oliveira et al., 2010). The above will allow to promote and implement pedagogical interventions especially aimed at the specifically detected needs, which articulated in a multifaceted way can lead, from an early age, to more effective and lasting results (Méndez-Giménez, 2020; Flores et al., 2021; Pradenas et al., 2017), as well as establishing itself as a possible alternative for the prevention of obesity (Fort-Vanmeerhaeghe et al., 2017; Herlitz et al., 2021; Luna et al., 2016).

In summary, and taking into account all the above-mentioned background information, it is hypothesized that MC is negatively related to increased BMI in schoolchildren. Thus, the objective of the study was to analyze the relationship between MC and BMI in Chilean school children between 7 and 9 years old.

METHODS

Participants

A cross-sectional study was conducted with descriptive and correlational characteristics. The

sample was selected in a non-probabilistic way for convenience. 180 schoolchildren (90 boys and 90 girls) from five private subsidized schools in the city of Concepción, Bío Bío region, Chile, participated voluntarily. The inclusion criteria were the following: 1) be between 7 and 9.9 years of age at the time of applying the evaluations; 2) be enrolled in a private subsidized school in the city of Concepción; 3) present informed consent, duly signed by his/her guardian or tutor. The exclusion criteria were: 1) not complete all the evaluations; 2) not present with appropriate clothing or sports shoes for the motor evaluations; 3) present some type of injury that would affect the result of the motor evaluations.

Procedures

Initially, formal authorization was requested from the school principals through an invitation letter containing detailed information about the objectives of the study and the procedures to be carried out. Once the schools confirmed their participation, informed consent was delivered and collected from the students' parents, thus accounting for the objective of the research and the evaluation procedures. After the approval and signature of the parent, the participation of the schoolchildren was confirmed by signing a written consent document, in accordance with the Declaration of Helsinki, updated at the World Medical Assembly in Fortaleza (2013) for research on humans (World Medical Association [WMA], 2013).

Data collection took place from Monday to Friday from 8:00 a.m. to 2:00 p.m., during the months of October and November 2021. The entire evaluation procedure was carried out in the schools' gyms or multi-purpose courts, during school hours, and was conducted by 4 Physical Education teachers. These evaluators had the necessary experience to collect the information and were also previously trained in three sessions to administer and apply the test protocols. In addition, a pilot application was carried out with boys and girls aged 11, in order to ensure equal criteria, avoid confusion, visualize the data analysis and detect potential errors in the administration of the evaluations.

Anthropometric measurements were performed in the morning before the MC tests, individually, in a private and specially equipped room, following the standard procedures of Marfell-Jones et al. (2012). Height (cm) was measured with the subject barefoot on the Frankfurt plane, using an aluminium stadiometer graduated in millimetres (Seca 220, Hamburg, Germany). Body weight was verified using a mechanical scale, with a precision of 50 grams and a range of 0 to 220 kg (Seca 700, Hamburg, Germany). Body Mass Index (BMI, expressed in kg/m2) was calculated according to the criteria established by the World Health Organization [WHO] (2000). BMI categories were determined according to the percentiles indicated by the Center for Disease Control and Prevention CDC-2000 (Kuczmarski et al, 2000). Three categories were established: normal weight (percentiles 15 to 85), overweight (percentiles 85 to 95) and obesity (equal to or greater than the 95th percentile). Finally, biological maturation was determined by levels of maximum acceleration of growth velocity (MAGV), using the equation of Moore et al. (2015) for Women MAGV = -7.709133 + [0.0042232 x (age x height)], and for Men MAGV = -7.999994 + [0.0036124 x (age x height)]. The values obtained are interpreted as -3MAGV, -2MAGV, -1MAGV, 0MAGV, 1MAGV, 2MAGV, 3MAGV. The negative is before the MAGV occurs, zero (“0”) for the exact moment of the MAGV and the positive, after the MAGV. The MC tests were carried out after the anthropometric measurements, in the gymnasiums or multi-purpose courts of each school. The participants had to wear sports clothing (sweatshirt or shorts,

T-shirt and sneakers). The students carried out each test only once, which was recorded on a laptop computer with a spreadsheet designed especially for the study. The test began with a 15-minute warm-up (general physical exercises and stretching). Then the MC test proposed by Kiphard & Schilling (1974) (Körperkoordinationstest Für Kinder) was applied, which consists of four motor tests to characterize total body coordination and body control in men and women between five and 14 years of age. The structure of the application was as follows: first, the Rear Balance test was evaluated, which measures dynamic balance by walking backwards, using three wooden beams or girders of three meters length and different widths (6 cm, 4.5 cm and 3 cm), making three passes per girder, recording the number of steps without falling or losing balance, up to a maximum of eight steps. Secondly, the Monopedal Jumps were performed, measuring the strength and coordination of the lower limbs. This test consists of jumping foam blocks (50 x 20 x 5 cm) with one leg, with three attempts being considered per height and leg. For each height, the passages were evaluated as follows: the first valid attempt is assigned 3 points; the second valid attempt is 2 points; and the third valid attempt is 1 point. The continuity of the test was determined by the ability to jump the blocks by height with each of the legs. Third, the Lateral Jumps were performed, which evaluate the speed in alternating jumps, where the person must jump at maximum speed with both feet together, for a time of 15 seconds, without leaving the rectangle (50 x 60 cm), or stepping on the central bar (2 cm high). The number of correctly performed jumps was recorded in two attempts of 15 seconds each. Finally, the Lateral Transposition test was performed, which evaluates the space-time structuring by means of moving on platforms (25 x 25 cm, with a height of 5 cm) that are arranged in parallel on the floor, where the performer must move at maximum speed for 20 seconds on the platforms, standing on them with both feet and passing them forward with both hands. The number of transpositions was recorded in two attempts of 20 seconds. The four tests were performed according to the protocol of Kiphard & Schilling (1974).

Statistical Analysis

Data analysis was performed using the statistical software SPSS IBM Corp. version 17.0 (IBM®, Somers, NY, United States). Descriptive statistics were applied for mean, standard deviation (SD), minimum and maximum. In addition, the Kolmogorov-Smirnov test established the normal distribution of the variables. Differences between men and women were determined using the t test for independent samples. The relationship between the variables was established using the Pearson correlation coefficient. In addition, one-way ANOVA and Tukey's test were used to compare the means obtained in the MC tests by sex according to three BMI categories (normal weight, overweight and obesity). For all cases, the significance level used was $p<0.05$.

RESULTS

Table 1 contains the description of the sample variables expressed as mean, standard deviation (SD), minimum (Min), maximum (Max), in women and men, respectively. When analyzing the differences between sexes, it is observed that

women show higher scores than men in the Rear Balance test ($p < 0.05$), while men show better performance in Lateral Jumps, Lateral Transposition and total KTK test ($p < 0.05$), there were no significant differences between both sexes in chronological age, body weight, Peak Acceleration of Growth Velocity (MAGV), BMI or Single-Pedal Jumps.

Table 1

Anthropometric and MC characterization of the sample.

Variables	Females (n=90)				Males (n=90)				
	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.	p
Age (years)	8.4	0.9	7.1	9.9	8.5	0.9	7.2	9.9	0.83
Body weight (kg)	34.9	8.8	24	70	35.8	8.9	17	70	0.47
Height (cm)	133.2	7.1	119	149	133.8	7.8	116	152	0.60
MAGV (MS)	-3.9	0.6	-5.0	-2.8	-3.9	0.6	-5.1	-2.7	0.69
BMI (kg/m2)	19.5	3.6	12.2	31.5	19.8	3.4	12.6	31.5	0.55
Balance at the Rear (score.)	36.8	10	14	59	33	12.2	9	65	0.02*
Single leg jumps (score)	30.2	9.4	6	49	32.2	11.8	10	62	0.21
Side jumps (score)	38.3	13.8	6	70	45.6	17.7	7	82	0.01*
Lateral transposition (score)	23.3	6.9	10	38	26.6	8.6	11	49	0.01*
Total Test KTK (score)	128.6	25	68	178	137.4	36	54	224	0.05*

* significant difference between sexes $p < 0.05$

Note: MAGV- Peak Growth Velocity Acceleration; MS- Maturity Status; BMI- Body Mass Index

Table 2 shows the relationship between BMI and anthropometric indicators (body weight and height) with the MC tests. In women, there is an inverse and negative relationship between body weight and BMI with the Lateral Transposition test ($r = -0.36$; $r = -0.42$ respectively; $p < 0.01$), in addition a weak positive direct relationship is observed between height and Lateral Jumps ($r = 0.24$; $p < 0.05$). In men, there is an inverse and negative relationship between BMI and Monopedal Jumps ($r = -0.24$; $p < 0.05$), along with that height shows a direct and positive relationship with Lateral Jumps ($r = 0.21$; $p < 0.05$), Lateral Transposition ($r = 0.22$; $p < 0.05$) and total KTK test ($r = 0.27$; $p < 0.05$). In contrast, Rearguard Balance does not show statistically significant relationships with BMI or anthropometric indicators ($p>0.05$).

Table 2

Relationship between BMI and anthropometric indicators (body weight and height) with MC tests.

	Females (n=90)	Males (n=90)

	Body weight (kg)	Height (cm)	BMI (kg/m²)	Body weight (kg)	Height (cm)	BMI (kg/m²)
	r	r	r	r	r	r
Balance at the Back (score)	0.01	0.09	-0.03	0.01	0.17	-0.09
Single leg jumps (score)	-0.14	0.02	-0.17	-0.09	0.16	-0.24*
Side jumps (score)	0.14	0.24*	0.07	0.11	0.21*	0.03
Lateral transposition (score)	-0.36**	-0.12	-0.42**	0.02	0.22*	-0.12
Total Test KTK (score)	-0.08	0.15	-0.16	0.03	0.27*	-0.12
* The correlation is significant at the <0.05 level						
** The correlation is significant at the <0.01 level						
Note: BMI- Body Mass Index						

Table 3 shows the mean and standard deviation (SD) values of the MC tests by sex according to the BMI classification category. In women, significant differences were found for the Lateral Transposition test in the Normal weight group compared to the Overweight and Obesity groups ($p<0.05$). In men, there was a significant difference for the Monopedal Jump test in the Normal weight group compared to the Obesity group ($p<0.05$).

Table 3

Comparison of motor coordination tests by sex according to BMI classification category.

Variables	Females					
	Normal weight (n=37)		Overweight (n=24)		Obesity (n=29)	
	Mean	SD	Mean	SD	Mean	SD
Balance at the Back (score)	38.2	11.3	35.2	8.1	36.6	9.7
Single leg jumps (score)	31.5	9.4	31.2	10.6	27.6	8.1
Side jumps (score)	38.2	12.8	34.1	15.2	41.9	13.3
Lateral transposition (score)	26.8[ab]	6.5	22	7	20	5.3
Total Test KTK (score)	134.7	25.7	122.4	24	126	23.9
[a]: significant difference with the Obesity group; [b]: significant difference with the overweight group						
Variables	Males					
	Normal weight (n=26)		Overweight (n=27)		Obesity (n=37)	
	Mean	SD	Mean	SD	Mean	SD
Balance at the Back (score)	35	13.3	33.9	12	32.5	11.8
Single leg jumps (score)	35.6[a]	11.7	34.4	12.4	28.1	10.4
Side jumps (score)	47.7	16.2	42.9	18.7	46	18.1
Lateral transposition (score)	28.2	8.9	25.4	8.4	26.5	8.5
Total Test KTK (score)	144.4	37.8	136.6	36.7	133.1	34.4
[a]: significant difference with Obesity group						

DISCUSSION

The aim of the study was to analyze the relationship between MC and BMI in Chilean

schoolchildren between 7 and 9 years old. The results show that there are lower scores in the four MC tests of overweight and obese schoolchildren, with significant differences in the Lateral Transposition test, where women in the Normal weight condition outperformed those with Overweight and Obesity ($p<0.05$). In the case of men, in the Single-Pedal Jump test the Normal weight group achieved a better performance than those who were Obese ($p<0.05$). In addition, when analyzing the differences between sexes, women reported higher scores than men in the Rear Balance test ($p<0.05$), while men showed better performance in the Lateral Jumps, Lateral Transposition and in the total score of the KTK test ($p<0.05$). The findings regarding the MC deficit in girls and boys with high BMI, specifically in Lateral Transposition tests such as Single-Pedal Jumps respectively, are consistent with other studies, where it has been observed that a high BMI is negatively correlated with motor performance, specifically, in balance, jumping and coordination tests (Bucco-dos Santos & Zubiaur-González, 2013; Gomez-Campos et al., 2019; Herlitz et al., 2021; Oliveira et al., 2010), which shows that MC would be an important predictor of the level of PA and physical condition in boys and girls (Malina et al., 2004). Therefore, it is suggested that the period of childhood is ideal to start with motor intervention activities, as they allow to increase the motor repertoire (Fort-Vanmeerhaeghe et al., 2017; Hinkley et al., 2012). Similarly, boys and girls who are not exposed to motor-stimulating environments have a lower chance of being active during adolescence and even in adulthood (Fort-Vanmeerhaeghe et al., 2017). In addition, it has been described that motor behavior in the child population has a positive influence on cognitive functioning and executive functions, especially in the long term (Reloba et al., 2016; Sibley & Etnier, 2003).

On the other hand, the differences in the MC between sexes are similar to other studies in children and adolescents where, in general, men show higher average values than women (Bucco-dos Santos & Zubiaur-González, 2013; Lopes et al., 2011). Specifically, the difference in the Rear Balance test in favor of women is consistent with the results obtained by Herlitz et al. (2021), along the same lines, men showed better results in tests that required higher levels of strength and speed of execution (jumps and lateral transpositions), and in the total score of the KTK test, which is similar to that reported by Torralba et al. (2016), Vidarte-Claros et al. (2018). These differences between men and women during childhood have been attributed mainly to socio-cultural elements, which act as facilitators or obstacles to motor practice and access to the diversity of motor actions (Valdivia et al., 2008), especially sports activity, which has historically been attributed in a particular way to males over women (Aznar et al., 2010; Nieto et al., 2011), causing motor differences such as those reported in the results of this study. The above causes that, from an early age, men show superiority over women in motor performance, PA levels and physical condition (Aguilar et al., 2011; Gomez-Campos et al., 2019; Malina et al., 2004).

The results of the present study pose the challenge of implementing motor intervention actions from an early age, specifically at school level. Thus, it seems especially necessary to consider what Hyndman & Telford (2015) suggest, who indicate that, to encourage motor activities in women, non-competitive games should be used and a wide variety of materials should be provided in the school playground, in order to improve interest in motor games and increase PA levels. In this same sense, the practice of physical exercise and sport, but at an extracurricular level, has been linked to better levels of motor development (Pradenas et al., 2017), also

promoting optimal muscle development, helping to combat excess body weight and improving physical condition (Malina et al., 2004). In addition, motor interventions can be very beneficial to improve the overall quality of the educational process of schoolchildren, since they provide comprehensive, meaningful and motivating activities, both for academic achievement and for personal development (Gil-Espinosa et al., 2018).

It should be noted that this study has limitations, such as being limited to a specific geographic area in Chile and in subsidized educational establishments, which may restrict its transfer to other populations. Secondly, the cross-sectional design that was used may affect the observations recorded, both in the interactions between the variables analyzed, and in the influence of physical, biological and cognitive factors not evaluated, which may intervene in the results achieved. On the other hand, the strengths of the study lie in the fact that this topic has been relatively little explored at the Chilean level, despite the high interest observed in public policies in the health and education areas. In addition to the above, the use of MC tests and simple, fast and inexpensive anthropometric measurements increases the potential for reproducing the research. Therefore, the findings recorded in this study can be a concrete input both for the development of educational proposals and for future research in an area that still requires more evidence.

CONCLUSION

Considering the results obtained, it is concluded that there is a lower rate of MC in schoolchildren with high BMI, specifically in Lateral Transposition in women and in Monopedal Jumps in men. The study, in turn, shows significant differences between men and women in the Balance, Lateral Jumps, Lateral Transposition tests and the total score of the KTK test. These results highlight the value of periodically monitoring the motor condition and nutritional status of schoolchildren, in order to implement pedagogical interventions that are appropriate and adjusted to the characteristics of children and young people.

REFERENCES

Aguilar, A. C., Pradilla, A., Mosquera, M., Gracia, A. B., Ortega, J. G., Leiva, J. H., & Ramírez-Vélez, R. (2011). Percentiles de condición física de niños y adolescentes de Santiago de Cali, Colombia. *Biomédica, 31*(2), 242-249. https://doi.org/10.7705/biomedica.v31i2.318

Albala, C., Vio, F., Kain, J., & Uauy, R. (2002). Nutrition transition in Chile: Determinants and consequences. *Public Health Nutrition, 5*(1a), 123-128. https://doi.org/10.1079/phn2001283

Alberga, A. S., Sigal, R. J., Goldfield, G., Prud'homme, D., & Kenny, G. P. (2012). Overweight and obese teenagers: Why is adolescence a critical period? *Pediatric Obesity, 7*(4), 261-273. https://doi.org/10.1111/j.2047-6310.2011.00046.x

Álvarez, C. E., Monge, M. F. H., González, E. H., Víquez, G. V., & Vargas, G. A. (2020). Sobrepeso, obesidad, niveles de actividad física y autoestima de la niñez centroamericana: Un análisis comparativo entre países. *Retos, 37*, 238-246. https://doi.org/10.47197/retos.v37i37.71680

Aznar, S., Naylor, P. J., Silva, P., Pérez, M., Angulo, T., Laguna, M., Lara, M. T., & López-Chicharro, J. (2010). Patterns of physical activity in Spanish children: A descriptive pilot study. *Child: Care, Health and Development, 37*(3), 322-328. https://doi.org/10.1111/j.1365-2214.2010.01175.x

Benjumea, J. M. C., Afonso, J. R., Pineda, S. M., & Truan, J. C. F. (2017). Test de coordinación motriz 3JS: Cómo valorar y analizar su ejecución. *Retos*, 32, 189-193. https://doi.org/10.47197/retos.v0i32.52720

Bucco-dos Santos, L., & Zubiaur-González, M. (2013). Desarrollo de las habilidades motoras fundamentales en función del sexo y del índice de masa corporal en escolares. *Cuadernos de Psicología del Deporte, 13*(2), 63-72. https://doi.org/10.4321/S1578-84232013000200007

Díaz, J. J., Rojas, W. S., & Morera, M. (2015). Diferencias en el desempeño de los patrones básicos de movimiento según la edad y el sexo (versión traducida al español). *Pensar en Movimiento: Revista de Ciencias del Ejercicio y la Salud, 13*(2), 17-33. https://doi.org/10.15517/pensarmov.v13i2.22024

Díaz, J. J., & Vargas, G. A. (2009). Efecto de una intervención motriz en el desarrollo motor, rendimiento académico y creatividad en preescolares. *Pensar En Movimiento: Revista de Ciencias Del Ejercicio y La Salud, 7*(1), 11-22. https://doi.org/10.15517/pensarmov.v7i1.373

Flores Rivera, C., Luna Villouta, P., Fuentealba Urra, S., Garrido Méndez, A., Muñoz Sabando, G., & Torres Esparza, A. (2021). Significados atribuidos a la práctica de actividad física, ejercicio físico y deporte como medio de configuración de redes sociales y participación ciudadana. *Retos, 42*, 831–840. https://doi.org/10.47197/retos.v42i0.65967

Fort-Vanmeerhaeghe, A., Román-Viñas, B., & Font-Lladó, R. (2017). ¿Por qué es

importante desarrollar la competencia motriz en la infancia y la adolescencia? Base para un estilo de vida saludable. *Apunts. Medicina de l'Esport, 52*(195), 103-112. https://doi.org/10.1016/j.apunts.2016.11.001

Gil-Espinosa, F. J., García, Á. R. R., & Rodríguez, A. N. (2018). Juego y actividad física como indicadores de calidad en Educación Infantil. *Retos*, 34, 252-257. https://doi.org/10.47197/retos.v0i34.60391

Gomez-Campos, R., Cruz-Flores, I., Mendez-Cornejo, J., Pezoa-Fuentes, P., Urra-Albornoz, C., & Cossio-Bolaños, M. A. (2019). La adiposidad corporal se relaciona con el rendimiento del salto horizontal en niños. *Retos*, 36, 370-375. https://doi.org/10.47197/retos.v36i36.68966

Herlitz, M. J., Rodriguez, J., David, G., Carrasco-Lopez, S., Gomez-Campos, R., Urra-Albornoz, C., Campos, L. F. C. C. de., Vega-Novoa, S., & Cossio-Bolaños, M. A. (2021). Relación entre coordinación motora con indicadores de adiposidad corporal en niños. *Retos, 39*, 125-128. https://doi.org/10.47197/retos.v0i39.78378

Hinkley, T., Salmon, J., Okely, A. D., Crawford, D., & Hesketh, K. (2012). Preschoolers' physical activity, screen time, and compliance with recommendations. *Medicine and Science in Sports and Exercise, 44*(3), 458-465. https://doi.org/10.1249/MSS.0b013e318233763b

Hurtado Almonacid, J. G., Páez Herrera, J., Abusleme Allimant, R., Olate Gómez, F., Follegati Shore, S., Briones Oyanedel, V., & Mallea Díaz, V. (2023). Nivel de coordinación motriz de niños y niñas participantes del programa escuelas deportivas integrales del Ministerio del Deporte de Chile. *Pensar en Movimiento: Revista de Ciencias del Ejercicio y la Salud, 21*(1), e51279. https://doi.org/10.15517/pensarmov.v21i1.51279

Hyndman, B. P., & Telford, A. (2015). Should Educators be 'Wrapping School Playgrounds in Cotton Wool' to Encourage Physical Activity? Exploring Primary and Secondary Students' Voices from the School Playground. *Australian Journal of Teacher Education, 40*(6), 59-84. https://doi.org/10.14221/ajte.2015v40n6.4

Junta Nacional de Auxilio Escolar y Becas. (2021). *Informe Mapa Nutricional 2019*. https://www.junaeb.cl/wp-content/uploads/2023/03/Informe-Mapa-Nutricional-2019-1.pdf

Kiphard, E. J., & Schilling, V. F. (1974). *Köperkoordinationstest für Kinder: KTK*. Beltz Test.

Kuczmarski, R. J., Ogden, C. L., Grummer-Strawn, L. M., Flegal, K. M., Guo, S. S., Wei, R., Mei, Z., Curtin, L. R., Roche, A. F., & Johnson, C. L. (2000). CDC growth charts: United States. *Advance data,* (314), 1–27. https://pubmed.ncbi.nlm.nih.gov/11183293/

Lopes, L. O., Lopes, V. P., Santos, R., & Pereira, B. (2011). Associações entre actividade física, habilidades e coordenação motora em crianças portuguesas. *Revista Brasileira de Cineantropometria e Desempenho* Humano, 13(1), 15-21. https://doi.org/10.5007/1980-0037.2011v13n1p15

Lopes, V. P. (1992). *Desenvolvimento motor. Indicadores bioculturais e somáticos do rendimento motor em crianças de 5/6*

anos [Tese de Mestrado, Universidade Técnica de Lisboa, Portugal]. https://bibliotecadigital.ipb.pt/handle/10198/500

Luna-Villouta, P., Muñoz, J. A., Huerta, D. J. C., Cofré, C. F., & Peña, F. F. (2016). Efectos en el desarrollo motor de un programa de estimulación de habilidades motrices básicas en escolares de 5o año básico de colegios particulares subvencionados del Gran Concepción. *Ciencias de la Actividad Física UCM, 17*(1), 29-38. https://revistacaf.ucm.cl/article/view/88

Luna, P.V., Rodríguez, V.M., Sandoval, M.C., & Carreño, M.U. (2016). Análisis de patrones motores fundamentales en niños de 4 y 5 años de colegios particulares subvencionados de Concepción. *Ciencias de la Actividad Física UCM, 17*(2), 19-28. https://revistacaf.ucm.cl/article/view/96

Malina, R. M. (2012). Physical Activity as a Factor in Growth and Maturation. En N. Cameron & B. Bogin (Eds.), *Human Growth and Development* (pp. 375-396). Academic Press. https://doi.org/10.1016/B978-0-12-383882-7.00014-3

Malina, R. M., Bouchard, C., & Bar-Or, O. (2004). *Growth, maturation, and physical activity*. Human Kinetics.

Marfell-Jones, M. J., Stewart, A. D., & de Ridder, J. H. (2012). *International standards for anthropometric assessment*. International Society for the Advancement of Kinanthropometry. http://hdl.handle.net/11072/1510

Méndez-Giménez, A. (2020). Beneficios físicos, intrapersonales e interpersonales de las intervenciones en el patio de recreo en educación primaria. *SPORT TK-Revista Euroamericana de Ciencias del Deporte, 9*(2), 47-58. https://doi.org/10.6018/sportk.431111

Moore, S. A., Mckay, H. A., Macdonald, H., Nettlefold, L., Baxter-Jones, A. D. G., Cameron, N., & Brasher, P. M. A. (2015). Enhancing a Somatic Maturity Prediction Model. *Medicine & Science in Sports & Exercise, 47*(8), 1755-1764. https://doi.org/10.1249/MSS.0000000000000588

Muriel, V., Ensenyat, A., García-Molina, A., Aparicio-López, C., & Roig-Rovira, T. (2014). Déficits cognitivos y abordajes terapéuticos en parálisis cerebral infantil. *Acción Psicológica, 11*(1), 107-117. https://www.redalyc.org/pdf/3440/344038005010.pdf

Nieto, M. L., Hernández, M. T., & Aznar, S. (2011). Patrones de Actividad Física en función del género y los niveles de obesidad en población infantil española. Estudio EYHS. *Revista de Psicología del Deporte, 20*(2), 621-636. https://www.redalyc.org/pdf/2351/235122167025.pdf

Oliveira, L. de., Lopes, V. P., Santos, R., & Pereira, B. (2010). Associações entre actividade física, habilidades e coordenação motora em crianças portuguesas. *Revista Brasileira de Cineantropometria e Desempenho Humano, 13*(1), 15-21. https://doi.org/10.5007/1980-0037.2011v13n1p15

Organización Mundial de la Salud (2000*). Informe sobre la salud en el mundo: 2000: mejorar el desempeño de los sistemas de salud*. https://apps.who.int/iris/handle/10665/42357

Otero, I. R., & Ruiz, P. L. M. (2015). Adolescence, motor coordination problems and

competence. *Educación XX1, 18*(2), 189-213. https://doi.org/10.5944/educxx1.14601

Pradenas Vargas, X., Campos García, M., Contreras Sepúlveda, M., Puentes Matus, D., & Luna Villouta, P. (2017). Comparación del desarrollo motor en escolares de 9 y 10 años de edad en clases de educación física y talleres deportivos extracurriculares. *Ciencias de la Actividad Física UCM, 18*(2), 1-8. https://doi.org/10.29035/rcaf.18.2.1

Ruiz Pérez, L. M., Linaza Iglesias, J. L., & Peñaloza Mendes, R. (2008). El estudio del desarrollo motor: entre la tradición y el futuro. *Revista Fuentes, 8,* 243–258. https://revistascientificas.us.es/index.php/fuentes/article/view/2527

Reloba, S., Chirosa, L. J., & Reigal, R. E. (2016). Relación entre actividad física, procesos cognitivos y rendimiento académico de escolares: Revisión de la literatura actual. *Revista Andaluza de Medicina del Deporte,* 9(4), 166-172. https://doi.org/10.1016/j.ramd.2015.05.008

Ruiz, L. M., Mata, E., & Moreno, J. A. (2007). Los problemas evolutivos de coordinación motriz y su tratamiento en la edad escolar: Estado de la cuestión. *Motricidad. European Journal of Human Movement, 18,* 1-17. https://www.redalyc.org/articulo.oa?id=274220374001

Schilling, F., & Kiphard, E. J. (1976). The Body Coordination Test. *Journal of Physical Education and Recreation, 47*(4), 37-39. https://doi.org/10.1080/00971170.1976.10612272

Sibley, B. A., & Etnier, J. L. (2003). The Relationship between Physical Activity and Cognition in Children: A Meta-Analysis. *Pediatric Exercise Science, 15*(3), 243-256. https://doi.org/10.1123/pes.15.3.243

Tishukaj, F., Shalaj, I., Gjaka, M., Ademi, B., Ahmetxhekaj, R., Bachl, N., Tschan, H., & Wessner, B. (2017). Physical fitness and anthropometric characteristics among adolescents living in urban or rural areas of Kosovo. *BMC Public Health, 17*, 1-15. https://doi.org/10.1186/s12889-017-4727-4

Torralba, M. A., Vieira, M. B., Lleixà, T., & Gorla, J. I. (2016). Evaluación de la coordinación motora en educación primaria de Barcelona y provincia. *Revista Internacional de Medicina y Ciencias de la Actividad Física y del Deporte, 16*(62), 355-371. https://doi.org/10.15366/rimcafd2016.62.011

Valdivia, A. B., Cartagena, L. C., Sarria, N. E., Távara, I. S., Seabra, A. F. T. E., Silva, R. M. G. D., & Maia, J. A. R. (2008). Coordinación motora: Influencia de la edad, sexo, estatus socio-económico y niveles de adiposidad en niños peruanos. *Revista Brasileira de Cineantropometria e Desempenho Humano, 10*(1), 25-34. https://doi.org/10.5007/1980-0037.2008v10n1p25

Vidarte-Claros, J. A., Vélez Álvarez, C., & Parra Sánchez, J. H. (2018). Coordinación motriz e índice de masa corporal en escolares de seis ciudades colombianas. *Revista U.D.C.A Actualidad & Divulgación Científica, 21*(1), 15-22. https://doi.org/10.31910/rudca.v21.n1.2018.658

World Medical Association. (2013). World Medical Association Declaration of Helsinki: Ethical Principles for Medical Research Involving Human Subjects. *JAMA,*

310(20), 2191-2194. https://doi.org/10.1001/jama.2013.281053

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