Acta Scientiarum

http://periodicos.uem.br/ojs
ISSN on-line: 1807-8648
Doi: 10.4025/actascihealthsci.v45i1.59093

Relationship between motor proficiency and blood pressure: the role of mediated by nutritional status

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ABSTRACT. Motor skills during childhood are extremely important for having an active lifestyle in adulthood; however, with the technological advance several plays and even the family environment have undergone changes, which affected the lifestyle adopted by the population. The present study aimed at investigating motor proficiency and blood pressure, as well as assessing the mediating role of nutritional status in such a correlation. This is a cross-sectional study carried out with 374 children aged 7 to 10 from the city of Maringá-PR. The nutritional status was measured by using the Body Mass Index (BMI) according to age and sex. The Bruininks-Oseretsky Test of Motor Proficiency, Second Edition, (BOT-2), was used to evaluate motor proficiency; the blood pressure was measured by using the Omron Deluxe HEM-7200® digital meter. The results showed a negative correlation between motor proficiency and body mass index and systolic and diastolic blood pressure. The analysis of structural equations revealed that there was no statistically significant direct impact of motor proficiency on blood pressure. However, when the mediation of nutritional status was included, a significant negative correlation between motor proficiency and nutritional status was seen, but positive in relation to systolic and diastolic blood pressure. In conclusion, motor proficiency has no direct influence on blood pressure; however, when mediated by nutritional status, the effect becomes significant. It is worth mentioning that the lower the motor proficiency and the higher the body mass, the higher the systolic and diastolic blood pressure was.

Keywords: motor performance; obesity; blood pressure; children.

Received on May 5, 2021.
Accepted on February 2, 2022.

Introduction

With the technological advance, several plays and even the family environment have undergone changes, which affected the lifestyle adopted by the population nowadays. Furthermore, due to factors, such as insecurity and urban violence, parents only allow children to play at home or places close to their house (Bichara, Modesto, França, Medeiros, & Cotrim, 2011). This fact has influenced children's motor behavior, since they spend more time indoors, which restrict their motor experiences and increases the rate of obese and inactive children (Corso et al., 2012; Silva et al., 2018). Obese children show greater impairments with regard to motor proficiency, strength and endurance, besides participating in less physical activity (Nunez-Gaunaurd, Moore, Roach, Miller, & Kirksanchez, 2013; Marmeleira,Veiga, Cansado, & Raimundo, 2017). Motor proficiency is significantly related to a number of measures aimed at children's health and, thus, it should be investigated in children with low health-related fitness, since motor incompetence might be an underlying factor that contributes to the child's poor physical health (Milne, Leong, & Hing, 2016).

Therefore, it is common to find school-age children who have motor difficulties that make them to avoid exposing their motor skills. This leads them to be excluded from activities by their peers and to adopt sedentary lifestyles, thus, being overweight is a consequence (Spessato, Gabbard, & Valentini, 2013; Milne et al., 2016). Studies have revealed that obesity is one of the main reasons for children to stay away from sport activities (Spessato, Gabbard, Robinson, 2012), which shows that children with lower motor proficiency are less physically active (Stodden, Gao, Goodway, & Langendorfer, 2014; Meester et al., 2016; Silva et al., 2018).

Several studies have investigated body weight, pointing out that the higher the body mass index, the lower the motor proficiency (Berleze, Haeffner, & Valentini, 2007; Corso et al., 2012; Lopes, Santos, Pereira,

&Lopes, 2012; Roberts, Veneri, Decker, & Gannotti, 2012). There is convincing evidence suggesting that being overweight causes numerous damages to children's health, such as metabolic changes (diabetes mellitus and high cholesterol), in addition to cardiovascular diseases and increased blood pressure values (Lombardi et al., 2016; Santos,Andaki, Guedes, & Mendes, 2016); and, when combined with low levels of physical activity, children and adolescents tend to have lower cardiorespiratory capacity and altered blood pressure values (Andaki et al., 2013; Jiménez-Pavón et al., 2013; Silva, Silva Junior, Ferreira, & Simões, 2017).

Although Pereira, Teixeira, Kac, Soares, and Ribeiro (2020) showed that overweight and obesity significantly increase the chance of hypertension in 6-10-year-old children, little is known about the correlation between motor proficiency and blood pressure in such individuals. However, it is understood that greater motor proficiency leads children to be more physically active (Wrotniak, Epstein, Dorn, Jones, & Kondil, 2006) with a higher cardiorespiratory capacity, when compared to children with low levels of physical activity, who tend to show lower cardiorespiratory capacity (Milne et al., 2016). A study carried out by Farpour-Lambert et al. (2009) found that children who practice physical exercises significantly reduced the levels of systolic and diastolic blood pressure. However, little is known about the influence of motor proficiency on children's blood pressure (Milne et al., 2016). Therefore, the present study aimed at investigating motor proficiency and blood pressure, as well as to assess the mediating role of nutritional status related to this correlation in 7-10-year-old children.

Specifically, the interest of the present study was to determine which components of motor proficiency (Fine Manual Control, Manual Coordination, Body Coordination, Strength and Agility) are associated with blood pressure. The nutritional status, blood pressure and proficiency according to age were also assessed in order to identify at which ages the highest rates of overweight, hypertension and motor difficulties are found among children. The hypothesis established is that children with lower motor proficiency have high blood pressure levels, regardless of their nutritional status.

Methods

Subjects

The sample size calculation was carried out according to information obtained from the Department of Education of Maringá, which has 16.202 children enrolled in 49 municipal Elementary Schools in the initial years. Children should be enrolled and aged between seven and ten, besides not having a diagnosis of physical, motor, cognitive disorders or other pathologies. A total of 564 Free Informed Consent Forms (FICFs) were delivered, and 374 of them returned, correctly filled in, 63 of which were 7-year-old children (37 girls, 26 boys); 119 aged 8 (57 girls, 62 boys); 121 aged 9 (73 girls; 48 boys); 71 aged 10 (40 girls, 31 boys).

To determine the number of children to participate in the sample, Motta (2006) formula was used for sample calculation; a confidence interval of 95% and a prevalence of 50% were adopted.

Instruments

In order to assess motor proficiency, the Bruininks-Oseretsky Test of Motor Proficiency, Second Edition, (BOT-2), was used. This instrument was developed by Bruininks and Bruininks (2005). BOT-2 is a standardized test that assesses motor proficiency in individuals aged between 4 and 21. It measures the performance of fine and gross motor skills through 53 items divided into four motor component areas, that is, fine manual control, manual coordination, body coordination, and strength and agility. Composite scores are derived from eight subtests. The BOT-2 was administered in a distraction-free space for the child and took about 40 to 60 minutes to be filled. Considering the purposes of this study, norms related to each sex were used. Standard scores and descriptive categories based on standard scores (well-above average [70 or greater], above average [60-69], on average [41-59], below average [31-40], well-below average [30 or less]) were used.

To calculate the nutritional status, the Body Mass Index (BMI) was adopted, measured with a portable digital scale with a resolution of 0.05 kg; the body weight was measured with a portable digital scale with a resolution of 0.05 kg and a capacity of 150 kg; and height was measured by using an English Leicesters-type stadiometer (0.1 cm scale), coupled to a base that allowed height measurement in the field, manufactured by Child Growth Foundation®. Thus, the BMI was calculated by using the following formula: BMI= weight/height^2.

The children's blood pressure (BP) was measured with an automatic digital arm blood pressure monitor by Omron Deluxe HEM-7200®. The cuff was centered over the wrist brachial artery, proximal and medial to the cubital fossa, and below the lower border of the cuff (about 2 cm above the cubital fossa). To measure the variable, the subjects should avoid any type of food derived from caffeine and the practice of physical activity 24 hours before the evaluation. To classify children's blood pressure, some variables were considered, that is, sex, height and age so as to have the percentiles of systolic and diastolic blood pressure. The values were based on data from the Report of the Second Task Force on Blood Pressure Control in Children - 1987 - Task Force on Blood Pressure Control in Children National Heart, Lung and Blood Institute, Bethesda, Maryland (Malachias et al., 2016). Blood pressure values were classified as normal (BP < 90th percentile), borderline (BP between 90 to 95th percentiles; or if BP exceeded 120/80 mmHg, always >90 percentile to <95th percentile), stage 1 hypertension (95 percentile to 99th plus 5 mmHg), stage 2 hypertension (BP > 99th percentile plus 5 mmHg).

Procedures

This study was approved by the Committee on Ethical Research with Humans of a Brazilian college referred to as *Faculdade Assis Gurgacz*, under opinion number 1.207.141/2015 (Registration No. 46775715.2.0000.5219). The assessments regarding motor proficiency and anthropometric measurements were carried out on the same day and time, in the physical facilities of each municipal school. When the child was called for the tests, the evaluator filled in the student's form with all the registration information and used weight and height measurement techniques. Then, the child was directed to the space where the motor test had previously been organized with the materials, away from noise and distractions. The evaluator accompanied the child during the execution of the 53 tasks and explained how the test would take place with the necessary physical or verbal instructions as proposed by the test manual. Considering blood pressure, one day before the blood pressure measurement, a communication was given to the children, which warned them about the practice of physical activity and the use of caffeine derivatives. Thus, at the time of collection, the children were asked about the previous recommendations and the answers were registered through writing or drawings, in the case of the children who did not know how to write the name of the food ingested.

Data analysis

The IBM Statistical Package for the Social Sciences- SPSS software was used for data analysis, with a significance level of 95%. Numerical data on motor proficiency, nutritional status and blood pressure were expressed as mean and standard deviation for a better understanding of the purposes of this study. The one-way ANOVA with Bonferroni's Post Hoc Test was used for comparing the age groups by considering motor proficiency, blood pressure and nutritional status variables.

To determine the correlation among the numerical variables, Spearman correlations were used; then, an explanatory model of structural equations was developed to analyze the association between motor proficiency and blood pressure, mediated by nutritional status. The model was adjusted according to sex and age by using the Stata software to test the models; the program itself removed the 'missing' data, in order not to use lost data for analysis.

Results

Regarding total motor proficiency, the average score obtained by the children was 45.3±7.1; 27.3% were classified as having motor proficiency 'well-below average'; 69.5% of the children were classified as 'on average', and 3.2% 'above average'. Regarding the children's body characteristics, the general mean weight was 34.5±10.1 kg and the height was 135.6±9.0 cm. The mean BMI was 18.5±3.7 kg m^{-2}; 54.2% of the children were classified as being eutrophic, 16.6% overweight, and 29.1% obese. Considering blood pressure, the mean systolic blood pressure was 94.1±9.8 mmHg, whereas the systolic blood pressure was 57.6±7.1 mmHg; 97.6% of the children were classified as having normal BP, 1.3% as borderline and 1.1% (4 children) with hypertension. Table 1 shows the variables related to motor proficiency, body characteristics and blood pressure per age group.

When comparing the age groups by having motor proficiency as a reference (Table 1), significant differences (p <0.00) were found for the total motor proficiency in 10-year-old children with lower values (41.9±5.1) when compared with children aged 9 (45.6±7.6), 8 (46.7±7.2) and 7 (45.7±6.7). It is noteworthy that the post hoc found significant differences in the area of fine manual control among the age groups. The comparison between the 7-year-olds (41.4±5.7) and 8-year-old ones (40.5±5.8) showed no differences, however, differences were found between the children aged 9 (38.6±5.6) and the ones aged 10 (36.1±4.1), only in each group. On the other hand, the post hoc showed statistical differences among all ages when comparing the children aged 9 and 10 to the groups separately.

Table 1. Comparison of weight, BMI, SBP, DBP, and motor proficiency with regard to age.

	7 years old[a] (n=63)	8 years old[b] (n=119)	9 years old[c] (n=121)	10 years old[d] (n=71)	F	P
Weight (kg)	27.5±6.7[b.c.d]	32.8±8.2[a.c.d]	36.6±9.9[a.b]	40.0±11.5[a.b]	23.42	.00*
Height (cm)	125.4±5.5 [b.c.d]	133.4±6.5 [a.c.d]	139.0±7.1 [a.b. d]	142.7±8.7[a.b.c]	80.44	.00*
BMI (kg m^{-2})	17.3±3.3[d]	18.3±3.4	18.7±3.9	19.3±3.7[a]	3.66	.01*
SBP (mmHg)	89.2±9.9[b.c.d]	94.6±9.6[a]	94.9±9.2[a.]	96.3±9.7[a]	7.00	.00*
DBP (mmHg)	56.3±8.3	57.8±6.7	57.9±6.9	58.0±6.4	0.922	.43
FMC	41.4±5.7[c.d]	40.5±5.8[c.d]	38.6±5.6[a.b.d]	36.1±4.1[a.b.c]	14.12	.00*
MC	48.0±7.9	49.3±8.0[d]	49.5±9.5[d]	45.7±7.1[b.c]	3.52	.01*
BC	50.2±7.8	52.0±8.6	51.0±8.5	50.3±9.1	0.86	.46
Strength Agility	48.7±8.4	49.4±8.1[d]	48.5±7.6	46.2±5.7[b]	2.77	.04*
Total composition	45.7±6.7[d]	46.7±7.2[d]	45.6±7.6[d]	41.9±5.1[a.b.c]	7.30	.00*

BMI: Body Mass Index; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; FMC: Fine Manual Control; MC: Manual Coordination; BC: Body Coordination.Source:the authors

Considering manual coordination, differences were found in 10-year-old children when compared with children aged 8 and 9; the 10-year-old children showed the lowest value. Regarding strength and agility, only one statistical difference was seen in 8-year-old children when compared with children aged 10; the 8-year-old children expressed a higher value than the ones aged 10.

Concerning the BMI, the post hoc test found significant differences only for the 7-year-old group when compared with the 10-year-old group, with a higher BMI for the 10-year-old group (19.3±3.7 Kg m^{-2}). Considering the children's general systolic blood pressure, significant differences were found in the 7-year-old group (89.2±9.9 mmHg) when compared with children aged 8 (94.6±9.6 mmHg), 9 (94. 9±9.2 mmHg) and 10 (96.3±9.7 mmHg). The 7-seven-year-old children showed a lower value and, as age increases, the SBP increases. Table 2 shows the correlations among the variables, that is, motor proficiency, body characteristics and blood pressure.

Table 2. Correlation among the areas of the motor proficiency test, BMI, SBP and DBP.

	BMI	Fine manual control	Manual Coordination	Body coordination	SAg	TMP	SBP
FMC	-0.11*	-	-	-	-	-	-
MC	-0.09	0.29**	-	-	-	-	-
BC	-0.18**	0.22**	0.26**	-	-	-	-
SAg	-0.26**	0.30**	0.48**	0.38**	-	-	-
TMP	-0.22**	0.56**	0.73**	0.67**	0.77**	-	-
SBP	0.55**	-0.13*	-0.09	-0.12*	-0.08	-0.12*	-
DBP	0.47**	-0.11*	-0.02	-0.12*	-0.14**	-0.13*	0.70**

*p <0.05. ** p <0.01. FMC: Fine Manual Control; MC: Manual Coordination; BC: Body Coordination; SAg: Strength and Agility; TPM: Total Motor Proficiency; SBP: Systolic Body Pressure; DBP: Diastolic Body Pressure. Source: the authors

The results (Table 2) showed negative, weak and significant correlations between motor proficiency and the variables: BMI (r=-0.22; p=0.00), SBP (r=-0.11; p=0.05) and DBP (r=-0.12; p=0.05). The findings also indicated negative, weak and significant correlations among the areas of BOT-2 (fine manual control, body coordination and strength and agility) with BMI, SBP and DBP, except for manual coordination, which did not show significant associations among the variables. Figures 1, 2, 3 and 4 include the mediation models regarding motor proficiency, BMI and systolic and diastolic blood pressure.

Considering the mediation analysis, it was seen that motor proficiency had a negative and significant impact on BMI (r^2=-0.22; 95% CI =-0.32; -0.13; p=0.00, consequently, the BMI had a significant positive impact on systolic (r^2=0.56; 95% CI =0.49; 0.63; p=0.00) and diastolic (r^2=0.45; 95% CI = 0.37; 0.54; p=0.00) blood pressure. When analyzing the direct correlation between motor proficiency and systolic or diastolic blood pressure, there was no statistically significant correlation. In order to verify the impact of nutritional status in more detail, the four areas of BOT-2 proficiency were used.

Therefore, it was found that the 'strength and agility' subscale was the only one that showed a significant negative correlation with BMI (r=-0.23; 95% CI= -0.35; -0.12; p=0.00). The mediation of this variable for blood pressure was significant, both for systolic blood pressure (r=0.59; 95% CI= 0.51; 0.66; p=0.00) (Figure 3) and diastolic blood pressure (r =0.45; 95% CI= 0.36; 0.53; p=0.000) (Figure 4).

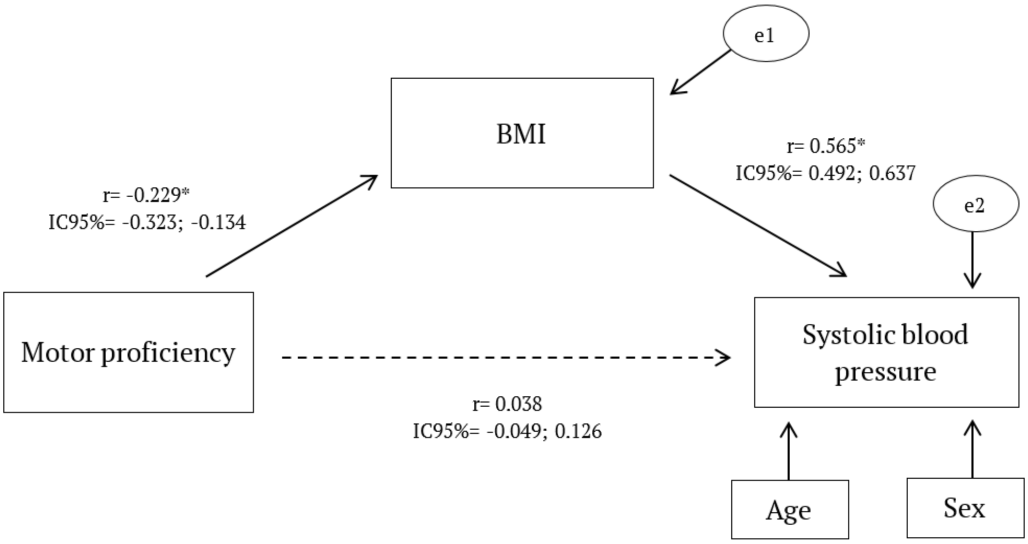

Figure 1. Mediation model of nutritional status in the association between motor proficiency and systolic blood pressure in children.
Source: the authors.

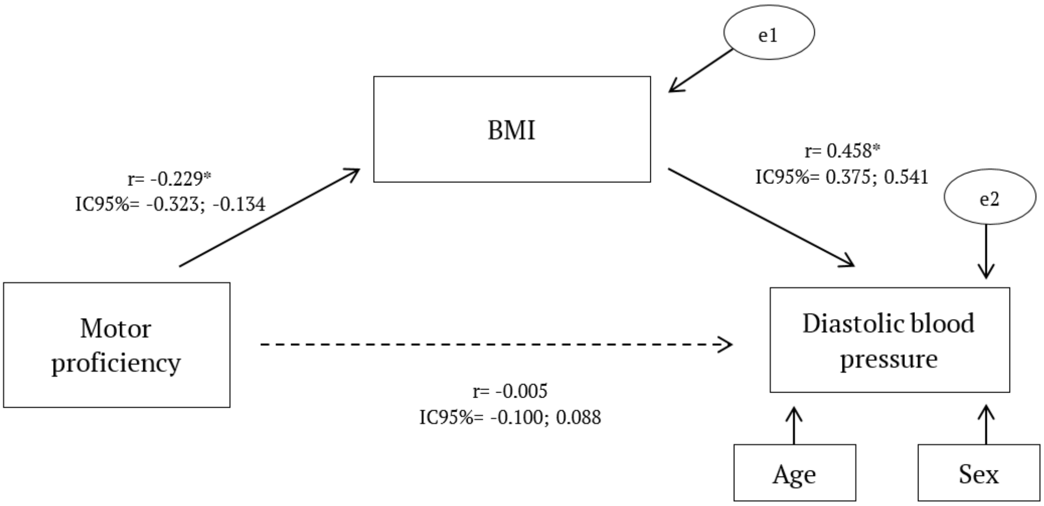

Figure 2. Mediation model of nutritional status in the association between motor proficiency and diastolic blood pressure in children.
Source: the authors.

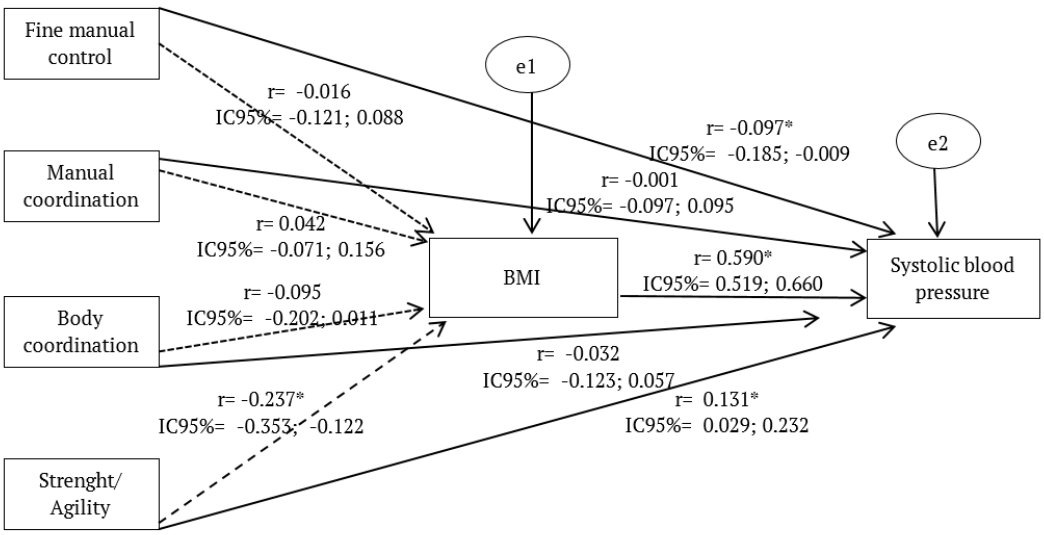

Figure 3. Mediation model of nutritional status in the association between motor proficiency areas and systolic blood pressure in children.
Source: the authors.

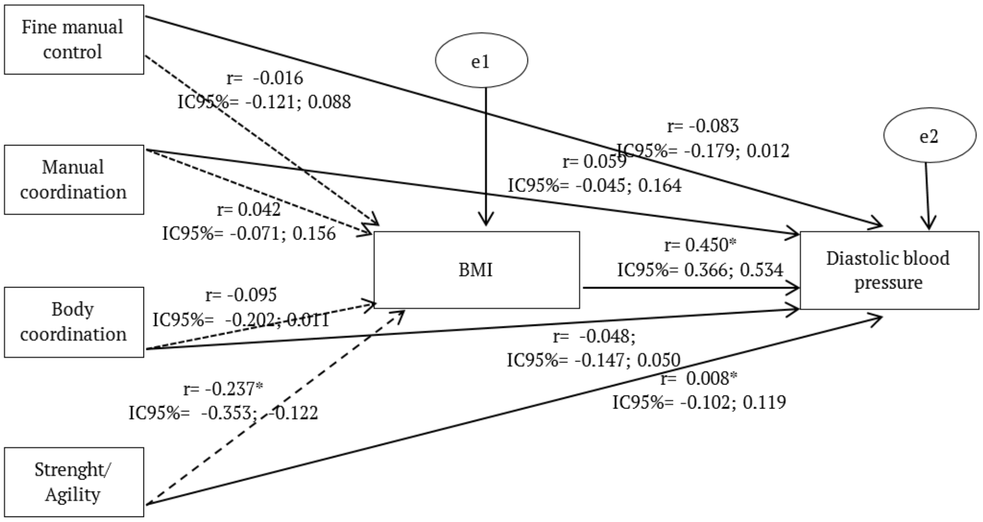

Figure 4. Mediation model of nutritional status in the association between the motor proficiency areas and diastolic blood pressure in children. Source: the authors.

Discussion

This study aimed at assessing the correlation between motor proficiency and blood pressure, in addition to evaluate the role of the mediating nutritional status regarding this correlation in 7-10-year-old children. The results showed that SBP and DBP increase with increasing age (Rosaneli et al., 2014). These findings reinforce the importance of monitoring children in their development phase in order to verify the factors that determine motor, nutritional and performance problems and those related to physical health in general that have a cumulative effect on the onset of childhood (Milne et al., 2016), especially regarding blood pressure, which is a silent disease and might lead to other comorbidities (Andrade et al., 2018).

Regarding motor proficiency, it was seen that 69.5% of the children were classified as 'on average' in the performance of total motor proficiency. In addition, considering the differences associated with the children's age, it is noteworthy mentioning that the children's motor proficiency was lower for the 10-year-old age group, with a significant difference when compared to the other age groups (7, 8 and 9 years old). This fact was also reported in a study carried out in Ireland that found similar results by showing decreasing scores for BOT-2 in older children (Gaul & Issartel, 2016). It is assumed that the 10-year-old children included in the present sample did not meet the expectation of increasing proficiency with increasing age. Such a statement can be supported in part by the lack of motor experience that several children reflect nowadays (Pimenta & Palma, 2001).

Considering the correlation between total motor proficiency and BOT-2 areas with the anthropometric variables, it was seen that the higher the motor proficiency, the lower the BMI, SBP and DBP; the inverse was also true (Table 2). Even though the correlations shown in this study were not so strong, it can be inferred that this result is a warning about taking care of children to avoid future problems related to obesity, hypertension and motor difficulties. In this sense, studies have shown evidence that overweight children tend to have motor difficulties (Cairney, Hay, Faught, & Hawes, 2005) and to be less active (Stodden et al., 2008). The correlation between motor skills mainly with BMI has been investigated in the literature. Ghosh, Ghosh, Chowdhury, Wrotniak, & Chandra (2016) found that children with high nutritional status had a lower average in motor proficiency. A study about the correlation between performance in the KTK test (Korperkoordination Test fur Kinder) and BMI, showed negative associations among the variables, that is, the higher the motor proficiency, the lower the BMI value among children (Milne et al., 2016). In the same line of research, the results found by Pinheiro, Mello, Gaya, and Gaya (2021) emphasized that the variables 'waist-to-height ratio', BMI and fat percentage indicated a positive association with standardized blood pressure; on the other hand, moderate-to-vigorous physical activity and cardiorespiratory fitness indicated a negative correlation with blood pressure.

It is also noteworthy that the results related to the correlations assessed in the present study indicated an association between BMI and blood pressure and diastolic levels, that is, the higher the BMI, the higher the systolic and diastolic blood pressure levels (Table 2). The results confirm interdependence among the data, since the increase in blood pressure is closely associated with excess weight (Rosaneli et al., 2014). This leads to the significance of taking care of health and controlling the anthropometric variables, so as to avoid comorbidities (Oduwole, Ladapo, Fajolu, Ekure, & Adeniyi, 2012). The results corroborate the findings by Fernandes et al. (2010) and Sagrilo Junior et al. (2016), who verified the possible associations between arterial hypertension and overweight in children. The authors found a significant correlation among these variables. Thus, it was not surprising to find an association between adiposity and blood pressure, since this information is a consensus in the literature (Fernandes et al., 2010; Malachias et al., 2016).

Considering the analysis of BMI mediation related to the association of motor proficiency and blood pressure (Figures 1 and 2), no significant effects were seen when motor proficiency is directly related to blood pressure. However, with the addition of nutritional status mediation, the results expressed another meaning, that is, motor proficiency had a statistically significant and negative impact on BMI, and consequently, the BMI had a significant and positive impact on systolic and diastolic blood pressure levels. Thus, it is understood that the children included in the present study with a higher motor proficiency have a lower BMI within age-appropriate levels, in addition to showing lower and age-appropriate systolic and diastolic blood pressure.

These results reinforce the importance of having motor experiences for obtaining better motor proficiency and being engaged in sport activities, which results in a better health condition, that is, an adequate BMI and normal blood pressure, since a child with motor difficulties tends to increase the likelihood of being overweight. Obese children with lower motor proficiency might have more difficulties in joining sport activities (Nunez-Gaunaurd et al., 2013; Milne et al., 2016). The authors found negative associations with systolic and diastolic blood pressure, weight, BMI and waist circumference, especially among children with lower motor skills. The study by Nunez-Gaunaurd et al. (2013) found that obese children had a lower score in BOT-2 short version when compared to healthy weight children; in addition, the obese individuals had higher systolic blood pressure; 53% of the children had pre-hypertension.

Considering the mediation model of nutritional status in the association between the motor proficiency areas and systolic (Figure 3) and diastolic (Figure 4) blood pressure, it was seen that the strength and agility subscale had a significant negative impact on BMI, and BMI had a positive effect on SBP and DBP, that is, the better the strength and agility performance, the lower the BMI indexes and, consequently, lower blood pressure levels. Thus, the presence of a cycle is perceived, assuming that when the best results of strength and agility are obtained, there is a predisposition for having an active lifestyle, better motor proficiency, and maintenance or even reduction of body weight and control of blood pressure levels. However, Ré (2011) pointed out that strength and agility were associated with physical growth and biological maturation, that is, it is understood that as changes and physical increase combined with the speed of maturation occur, the evolution of physical capabilities is also seen. This also happens with blood pressure, which will increase as height changes with physical growth. Thus, it is assumed that the direct correlation of strength and agility with systolic blood pressure was significantly positive, since they are measures that follow physical changes.

The present study has some significant limitations to be highlighted. The maturational state was not evaluated, considering that this is a biological phenomenon related to the maturation of the functions of different organs and systems, and it happens differently for each subject. Another limiting factor of the study is the lack of knowledge on the context of the home and sport environments offered to the children. It is understood that the lack of appropriate spaces and materials for motor experiences can restrict children's motor proficiency and negatively interfere in the development of motor skills, in addition to contributing to overweight and high blood pressure. Furthermore, studies that analyzed motor proficiency and blood pressure in this specific age group were not found. The evidence suggests that they are different measurements, in the sense that motor proficiency involves the development of skills, whereas blood pressure is related to the development of physical fitness. Further studies that include the analysis of physical activity levels and children's participation in sports are suggested in order to confirm the results found.

Conclusion

In conclusion, motor proficiency was not directly related to the children's blood pressure level. However, when assessing the mediation effect of nutritional status regarding the correlation between motor proficiency and blood pressure, it was seen that the results were modified, that is, a higher motor proficiency led to a lower BMI and, consequently, a lower level of blood pressure; the opposite was also true. Therefore, nutritional status has an impact on blood pressure level and motor proficiency. These results point to the importance of monitoring motor development, paying special attention to the child's nutritional status, verifying life habits and motor experiences. Furthermore, it is noticeable that the variables evaluated have different measurements, but that follow linearity, that is, both increased with age, except for motor proficiency in the 10-year-old age group.

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