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Autonomous fundamental motor skills in the school environment: a cross-sectional study

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ABSTRACT

Autonomous fundamental motor skills (A_{FMS}) are understood as movements practiced in a spontaneous, voluntary manner, without any instruction or command. The aim of the study was to compare the frequency of occurrence and the quality of performance of A_{FMS} in children during recess and Physical Education (PE) classes. Elementary school students (n= 148) from a private school were observed during recess and PE classes, and had their A_{FMS} classified by stages (initial; elementary-emergent; proficient). All A_{FMS} were identified in recess and PE classes, except jump. Most skills were classified in the elementary-emergent stage and were slightly more frequent during PE classes, both in the locomotor (27 *vs* 23%) and manipulative (31 *vs* 13%) categories. The A_{FMS} frequency of occurrence was low and the classification showed poor quality at all times observed. Recess was statistically (p< 0.05) less favorable for motor development in 60% of A_{FMS}. The low frequency of A_{FMS}, especially during recess, and poor classification of motor repertoire suggest the need for measures to reverse the motor deficit in the school environment. Strategies are needed to promote A_{FMS} in the school context so that they are more diverse and challenging.

KEYWORDS: autonomous fundamental motor skills; motor development; school; physical education.

INTRODUCTION

Fundamental motor skills (FMS) are understood as a serial organization of basic movements performed by children (Rebelo, Serrano, Duarte-Mendes, Paulo, & Marinho, 2020). They can be classified as locomotor (run, gallop, hop, leap, horizontal jump and slide) and object control (striking a stationary ball, stationary dribble, catch, kick, overhand throw and underhand roll) skills (Gallahue, Ozmun, & Goodway, 2013; Utesch & Bardid, 2019). FMS have a scale of development classified into three stages (initial, elementary-emergent, and proficient). It is desirable that children reach the proficient stage by the age of seven years, as it characterizes mechanically efficient, coordinated and controlled movement performance (Gallahue et al., 2013; Morgan et al., 2013; Wick et al., 2017). Children with proficient FMS are more likely to participate in physical activity (PA) due to their proper motor performance (Barnett, Salmon, & Hesketh, 2016; Utesch, Dreiskämper, Naul, & Geukes, 2018). At this stage, children will have greater control of autonomous FMS (A_{FMS}), which are skills practiced in an autonomous, voluntary way, without any instruction (Morgan et al., 2013).

Early childhood is characterized as a fruitful time for children to improve their FMS (Utesch & Bardid, 2019; Bolger et al., 2021). In this phase, playing, creativity, and the discovery of infinite movement possibilities lead children to value PA participation (Dobell, Pringle, Faghy, & Roscoe, 2020). The new guidelines of the World Health Organization establish that for children with a minimal practice of PA (60 minutes/day; moderate to vigorous intensities) and less sedentary behaviour, the odds of developing chronic diseases

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are smaller (WHO, 2020). In addition, this practice is associated with motor development (MD) (Dobell et al., 2020; Carvalho et al., 2021). Therefore, ensuring the children had an adequate PA level may further to a rich opportunity for developing your FMS. And as they grow up, they are expected to constantly work on their motor skills to acquire a diversified motor repertoire that will enable them to live their daily lives (Palma, Camargo, & Pontes, 2012; Rebelo et al., 2020).

The school environment is an important moment for children's MD, because they offer diverse contexts for movements (Morgan et al., 2013). School physical education (PE) classes are ideal for the free expression of movements and make children aware of the importance of PA in life (Ericsson, 2011). Recess, in turn, is an important moment for autonomous expression of leisure activities, where children share ideas and movements with others (Simões Neto & Almeida, 2020). PE classes and recess are moments of freedom for children to express any movement (Gallahue et al., 2013). The literature indicates that these moments are unique for children's MD, as children are expected to spend 12 years in the school environment (Lopes, Lopes, & Pereira, 2006; Coolkens, Ward, Seghers, & Iserbyt, 2018).

The acquisition and good MD in children depend on the variety of A_{FMS}. For example, the developing A_{FMS} may be considered words in a learner's book. These words may be used in a variety of combinations in the construction of sentences and paragraphs (sport and specialized skills) (Gallahue et al., 2013). If children do not develop the basic principles of letters and words, they will have difficulty with their linguistic development. Similarly, this could happen with children's MD, as children's ability to easily move (a combination of many A_{FMS}) is compromised when they don't acquire basic motor competence during childhood (Bardid et al., 2016, 2017).

The decrease in motor practice impacts the motor deficit in childhood, reducing participation in games/play at school, at home, and in parks (Burns, Fu, Hannon, Brusseau, 2017). Therefore, ensuring children reach the proficient stage in childhood (whether for recreational, competitive, or daily use) can support the adoption of a physically active and healthier lifestyle for life (Gallahue et al., 2013; Vernadakis, Papastergiou, Zetou, & Antoniou, 2015). However, for this to occur, benchmarks and A_{FMS} levels need to be better understood. A relevant contribution to the area would be to identify the manifestation of children's A_{FMS} during specific periods, such as recess and PE classes (Torre, Zacarias, Rezende, & Pereira, 2011; Cafruni, Valadão, & Mello, 2012). Understanding the level of ability and autonomy of children's movements at different times can indicate the influence of the school context on children's autonomous movements.

Given these assumptions, the hypotheses for this study are the recess environment, although facilitating greater freedom of autonomous movement, may restrict motor practice; during PE classes the feeling of freedom in a specific environment for movement should favor the performance of A_{FMS}. However, there is no information on which of these moments promote more A_{FMS}; which A_{FMS} are most manifested, and at what levels of performance. Thus, this study aimed to identify children's $_{A}$FMS and classify/compare performance levels during recess and PE classes.

METHODS

Participants and ethical aspects

This cross-sectional study was conducted at a private school, located in a suburban area of a city in Southeast Brazil. All children (*n*= 174) regularly enrolled in Elementary Education (1st to 5th grades) were invited to participate voluntarily, through an invitation letter and meetings with parents/guardians. Parents/guardians of 153 children agreed to participate in the study. The inclusion criteria for the study were: a) being between six and 10 years old; b) being apparently healthy without medical restrictions, clinical treatment, or taking medicine that could affect metabolism, appetite, or growth (checked with their parents/guardians); and c) without having motor restrictions (e.g., wheelchair users, cerebral palsy) or amputated body parts (both conditions observed by the researcher). Data were excluded from children who: a) did not complete at least 80% of the procedures; and b) were suffering from illnesses or physical limitations during the study. After applying the exclusion criteria, data from five children were excluded from the analysis. Therefore, 148 children were analyzed, 70 boys and 78 girls.

The study was approved by the Institution Research Ethics Committee (CAAE 53535616.0.0000.5393) according to the Helsinki declaration. The parents/guardians received and signed the Free and Informed Consent Form and the children an Informed Consent Form.

Procedures

A_{FMS} were registered during recess and PE classes during a five-month period through direct observation of children's movements to identify and classify FMS stages. Anthropometric measurements (height and weight) were also taken to characterize the children. The researcher (physical education professional) attended the school environment (recess and PE class) for a month before data collection.

This period of familiarization contributed to the development of rapport between researcher and children, to minimize risks of bias by modifying children's habitual motor behavior routines.

Measures

Body mass in kg and height in centimeters (cm) were measured according to standard protocol (Lohmann, Roche, & Martorell, 1988).

The locomotor and manipulative A_{FMS} observed during recess and PE class were recorded and classified according to the current performance stages (initial, elementary-emergent, or proficient (Supplementary Material 1) (Gallahue et al., 2013). This test shows efficiency in classifying FMS as adequate reliability, low cost, and easy applicability (Torre et al., 2011; Gallahue et al., 2013). Its qualitative approach for direct subjective assessment of A_{FMS} considers children in their routine, with no interference in natural movement patterns (Gallahue et al., 2013). In this study, the elementary-emergent stages 2, 3, and 4 (Supplementary Material 2) were grouped to simplify the comparison of levels (1 to 3). This strategy is justified in that some A_{FMS} have similarities between stages (elementary-emergent) (Carvalho, 2019). The categories and performance stages of A_{FMS} considered are described in Table 1.

Recording of A_{FMS} was performed during three school days in the morning or afternoon. First, children were observed during recess for 20 min, totalling 60 minutes of observation at the period of familiarization appointed above. He played the role of assistant PE teacher. Second, students were observed during PE classes for 50 minutes, totalling 150 minutes of observation. The researcher evaluated two groups of five children (one in the morning and one in the afternoon) per day. No child knew when he/she would be observed. The classification of the stages of each skill was recorded, but only the best stage recorded was counted for statistical analysis.

Table 1. Fundamental motor skills according to categories (Locomotors and Manipulatives) and stages of developmental sequences proposed by Gallahue et al. (2013).

Locomotors (5)		Manipulatives (5)	
Run	(Stages 1 to 3)	Throw	(Stages 1 to 3)
Gallop	(Stages 1 to 3)	Catch	(Stages 1 to 3)
Leap	(Stages 1 to 3)	Kick	(Stages 1 to 3)
Hop	(Stages 1 to 3)	Volley	(Stages 1 to 3)
Jump	(Stages 1 to 3)	Strike	(Stages 1 to 3)

Stage 1: Initial; Stage 2: Elementary-emergent; Stage 3: Proficient. Source: adapted of Gallahue et al. (2013).

Statistical analysis

Descriptive statistics with measures of central tendency, 95% confidence interval (95%CI), and relative frequency were used to characterize the sample and describe the stages of A_{FMS} according to each moment (recess and PE class). A normality test (Kolgomorov-Smirnov) was made for quantitative data and normality was present for all variables (not shown). Due to the qualitative nature of A_{FMS} data, the Mann–Whitney U test was used to compare the variance of this variable between the different moments and genders, considering the categories (locomotive/manipulative) at the stages (initial/elementary-emergent/proficient). A Quade's analysis of covariance (ANCOVA) was performed to compare stages of A_{FMS} between recess and PE class, controlling the age effect. All analyzes were performed in SPSS, v. 20.0 (Inc., Chicago, IL, USA), with a previously established level of significance (α= 5%). This manuscript has been produced in accordance with the requirements of the Strengthening the Reporting of Observational studies in Epidemiology (STROBE) checklist for cross-sectional studies.

RESULTS

The flowchart in Figure 1 reports the sample selection and the study stages.

The descriptive statistics of the stages of A_{FMS} observed at different times (recess and PE class) are shown in Table 2 with values of mean, standard deviation (SD), minimum and maximum, range, and 95%CI. The total number of children in the sample (n = 148) had an average age without large age ranges (8.51 SD= 1.34 [95%CI 8.29–8.73] years). The frequency of age was also distributed across the children (6 years= 17.4%; 7 years= 22.1%; 8 years= 20.1%; 9 years= 20.1%; 10 years= 20.1%). Regarding anthropometric measures, the average height (1.33 SD= 0.11 [95%CI 1.31–1.35] m) and weight (33.53 SD= 11.32 [95%CI 31.69–35.44] kg) were within the expected normality and without outliers. The means of all variables are within the 95%CI, revealing the probability that the real value will be different in only 5% of other samples of the population of origin.

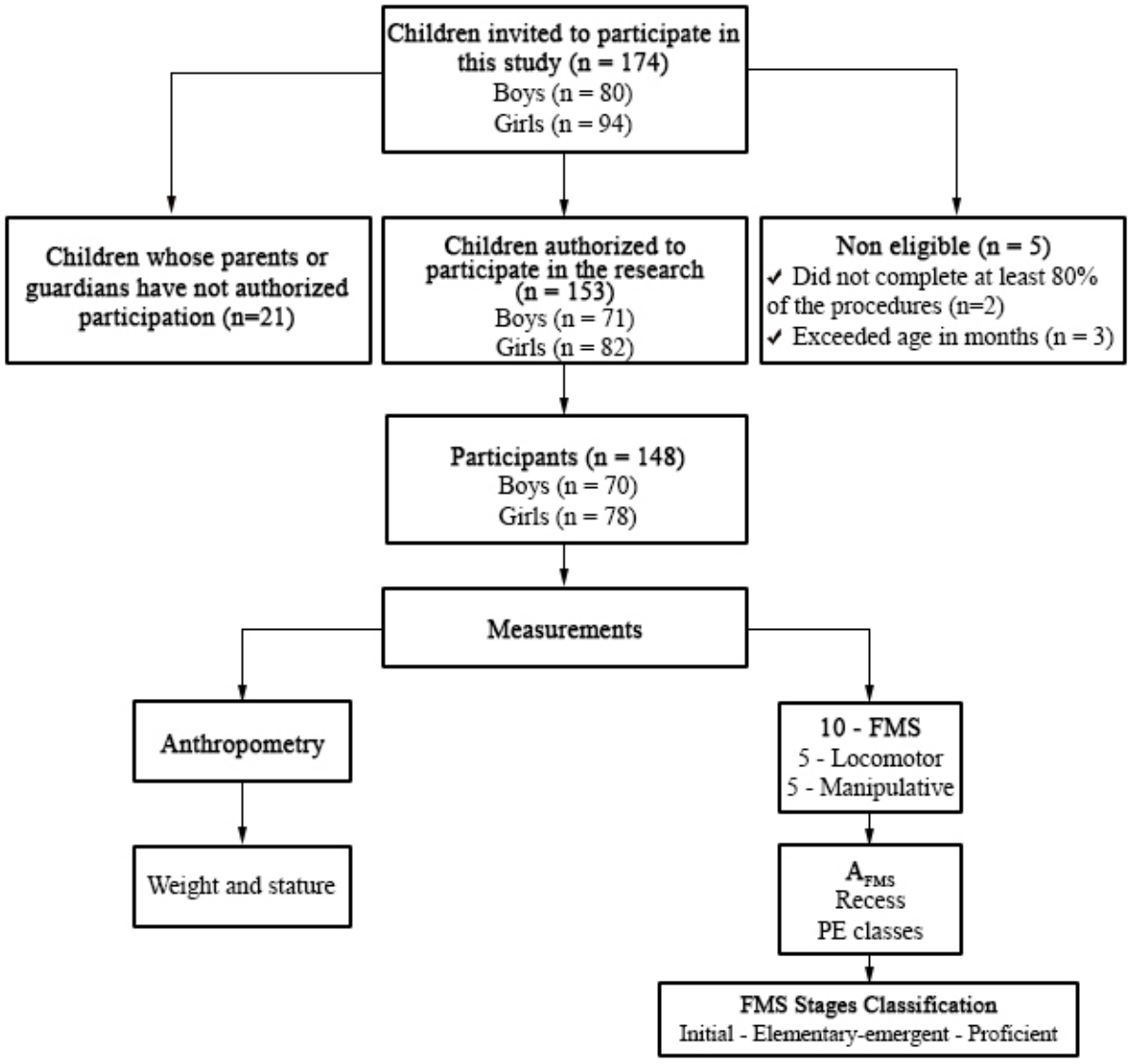
The average of most observed skill scores was less than 1, suggesting the poor qualitative performance of these children's A_{FMS}. Only one skill reached an average compatible with the elementary-emergent stage (run), while three of them were not even executed (leap, volley and strike). No skill achieved a proficient quality level during recess or PE class. When comparing moments (recess vs. PE class), the locomotor run A_{FMS} (Z= -2,120; p= 0.034) and jump (Z= -2,424; p= 0.015) presented higher averages during PE class.

Gallop (Z= -1.508; p= 0.132), leap (Z= 0.001; p= 0.999) and hop (Z= -1.329; p= 0.184) showed no differences between recess and PE class. The manipulative A_{FMS} of throw (Z= -7,939; p<0.001), catch (Z= -6,640; p< 0.001) and kick (Z= -4,716; p< 0.001) had higher averages during PE class, while strike (Z= -2.598; p= 0.009) had the highest average at recess. The volley skill (Z= -1,414; p= 0.157) did not differ between recess and PE class. There is an age effect only for the throw, receive and strike (p< 0.05) during recess, while PE class reported an effect for the hop, jump and kick (p< 0.05). Also, we compared the A_{FMS} between boys and girls, but they presented a very similar profile of these skills (Supplementary Material 1). The unique differences were run, throw (PE classes), gallop (recess), and kick (both moments), always better in boys.

The stages of A_{FMS} were also described quantitatively by relative frequency (%) of occurrence at recess and PE class (Table 3), according to the classification of the observed stages.

The A_{FMS} had a predominance of non-execution in around 70% of the observed movements, except for the skills of running at both times and the skills of catching and throwing in PE classes.

The locomotor A_{FMS} had a higher frequency of execution during PE classes (27% vs. 23% of recess). The proficient stage was present only for the skills run and hop. There was greater proficiency in the skill run in relation



FMS: Fundamental motor skills; A_{FMS}: Autonomous fundamental motor skills; PE: Physical education.

Figure 1. Flowchart of development on the research.

to the other skills, for both moments (Recess= 13%; PE =16%). The skill leap showed a low frequency in the proficient stage (Recess= 3%; PE= 1%). In jump, the children showed a greater predominance of the initial stage (Recess= 0%; PE= 12%), observed only during PE classes. However, when the average frequency was analyzed, the elementary-emergent stage was where most children were classified (17% and 19% for recess and PE, respectively).

The manipulative A_{FMS} (Table 3) were also more frequently performed during PE class when compared to recess (31 to 13%). The proficient stage occurred in most skills (Recess≤ 5%; PE≤ 6%), except for the skills volley and strike that did not show frequency of execution during PE classes. The elementary-emergent stage was also predominant in this category when analyzing the average frequency (7% and 28% for recess and PE, respectively). A_{FMS} at recess and PE classes were a

Table 2. Autonomous fundamental motor skills (A_{FMS}) stages of children (*n*= 148), age effect and differences between recess and Physical Education (PE) classes moments.

Variables	Recess					PE class				
	Mean	SD	95%CI			Mean	SD	95%CI		
Motor Development Sequence (stages, 1-3)										
Locomotor Category										
Run	2.0*	0.5	1.9	to	2.1	2.1	0.5	2.0	to	2.2
Gallop	0.1	0.6	0.04	to	0.2	0.1	0.4	0.03	to	0.2
Leap	-	-	-	-	-	-	-	-	-	-
Hop	0.2	0.7	0.1	to	0.3	0.3 #	0.8	0.2	to	0.5
Jump	0.04*	0.3	0	to	0.1	0.1 #	0.4	0.1	to	0.2
Manipulative Category										
Throw	0.6*#	1.0	0.4	to	0.7	1.5	0.9	1.4	to	1.7
Catch	0.3*#	0.8	0.2	to	0.5	1.0	1.0	0.9	to	1.2
Kick	0.2*	0.7	0.1	to	0.3	0.6#	1.0	0.4	to	0.8
Volley	0.04	0.3	0	to	0.1	-	-	-	-	-
Strike	0.1*#	0.5	0.04	to	0.2	-	-	-	-	-

*(p< 0.05) vs PE class; #(p< 0.05) age effect; Stage 1: Initial; Stage 2: Elementary-emergent; Stage 3: Proficient; SD: Standard deviation; CI: confidence interval.

Table 3. Relative and mean frequency (%) of autonomous fundamental motor skills (A_{FMS}) in locomotor and manipulative categories during recess and Physical Education (PE) class.

A_{FMS}	Not executed		Initial		Elementary-emergent		Proficient	
	Recess	PE	Recess	PE	Recess	PE	Recess	PE
Locomotor Category								
Run	1	0	10	8	76	76	13	16
Gallop	95	96	0	0	5	4	0	0
Leap	100	100	0	0	0	0	0	0
Hop	90	82	3	1	4	16	3	1
Jump	98	87	0	12	2	1	0	0
Mean Frequency	77	73	3	4	17	19	3	3
Manipulative Category								
Throw	71	24	4	4	21	70	4	2
Catch	87	47	1	2	7	50	5	1
Kick	91	73	0	1	7	20	2	6
Volley	99	100	0	0	0	0	1	0
Strike	95	100	3	0	0	0	2	0
Mean Frequency	87	69	2	1	7	28	3	2

little diversified, and slightly more frequent in PE classes. It was also possible to identify the divergence in the classification of A_{FMS} stages expected for age as not all children achieved proficiency in most A_{FMS}, including older children.

DISCUSSION

The frequency of A_{FMS} and the average classification of the motor stages observed were low, both during recess and PE classes. However, higher quantity (frequency observed) and quality (proficiency) of A_{FMS} were observed during PE classes. Although run and hop (Table 3) were the most frequently performed locomotor skills during the observations, it suggests that the children in our study showed a level of motor repertoire considered poor (Ulrich, 2000). Throw and catch (Table 3) were the most performed manipulative skills. In general, children had the highest mean frequencies of A_{FMS} in the elementary-emergent stage. The more complex skills showed a predominance in the initial stage ('jump' and 'strike'), showing a motor deficit for age and suggesting low opportunities for children to practice these A_{FMS}.

The A_{FMS} registered most frequently during PE classes reinforces the argument of how this moment promotes greater opportunities for the development and learning of skills through games and activities conducted indirectly (Fernandes et al., 2017; Quitério et al., 2017; Sgro, Quinto, Platania, & Lipoma, 2019). However, most children did not show proficiency in these and other A_{FMS} and many did not even execute them. This result is worrisome as children are expected to perform these skills at a proficient level between six and seven years of age. The age of the children in this study was (six to 10 years) compatible with that expected for proficiency in FMS (Table 2). This suggests a negative impact of the low levels of locomotor and manipulative FMS on children's motor performance (Ridgers, Carter, Stratton, & McKenzie, 2011, Ridgers, Salmon, & Timperio, 2018). If the skills were well learned, they would possibly manifest themselves proficiently and spontaneously in different contexts (Morgan et al., 2013; Fernandes et al., 2017; Dobell et al., 2020; Bolger et al., 2021).

In the locomotor category, the higher frequency of the skill run was confirmed as the favorite among children (Burns et al., 2017). The A_{FMS} 'hop' had the second highest frequency of execution through the hopscotch game since the schoolyard had paintings on the floor for this activity. Thus, the importance of adapting the school environment to encourage children's acquisition of motor skills is evident (Brauner & Valentini, 2009). It was also possible to observe that the manipulative A_{FMS} "throw" and "catch" (Table 3) had a higher percentage of execution in PE classes compared to recess. In classes, the teacher had different materials and encouraged the participation of all children; while at recess, materials were scarce, often reduced to just a ball and a few jump ropes. In addition, the school "beadle" (children's monitor at recess) was instructed to inhibit children from running, jumping, or performing other movements during this time. In this context, it is possible to infer that the low frequency of manipulative A_{FMS} observed in this study is explained, in part, by the restriction of the environment itself, through a low supply of suitable materials and restricted spaces for free actions (Morgan et al., 2013; Zeng et al., 2017).

Our study showed a smaller average for age, weight, and height (8.5 years; 33.5 kg and 1.33 m) than that of Sgro et al. (2019) study (10 years; 38 kg and 1.40 m), although with similar results in FMS. Even though our sample showed a greater age range (6 to 10 years) compared to the study of Quitério et al. (2017) (6 to 7 years), the gender influence showed that the boys were better in some A_{FMS} (notably for manipulative skills) than girls in both studies. On the other side, our study denotes motor deficiency for both genders when analyzing the average (< 1) of the classifications of the skills observed at recess or PE class (Table 2), where there should be= 3, a value that indicate proficiency (Gallahue et al., 2013; Morgan et al., 2013; Wick et al., 2017). Only a few skills were performed more frequently in the 'elementary-emergent' stage compared to the 'early' stage and three of them were not even performed ('leap', 'strike', and 'volley'). Thus, when the proficient stages of FMS are not reached at the expected age, it is necessary to review the entire educational and environmental context in which the child is inserted and what types of motor tasks they are performing (Dobell et al., 2020). Researchers advise that children do not reach the desired stage of FMS because the curricular focus of school PE can be on pedagogical factors and extended to coexistence contexts. In other words, the focus of the classes should use the movement to develop social, moral, and educational aspects and not only to improve FMS in a purely developmental approach (Loprinzi & Frith, 2017).

One strength of this study was the observation of natural and free (autonomous) task executions. These types of assessments influence minimally children's behavior, improving the ecological validity of data collected and analyzed. However, one limitation of this test is the difficulty of observing children all day. Indeed, considering out-school sports activities or other physical activity participation is important to understand the MD and have a better profile of FMS. In addition, the researcher's presence may cause changes in children's behavior (if the familiarization period is not carried out, as

adopted in this study). Another limitation is the subjective qualification of FMS stages. This implies the possibility of underestimating (or overestimating) a given FMS when the child is in an intermediate zone of category 1, 2, or 3. However, there was a low prevalence of proficiency and high hegemony in the classified skills in this study, which reduced the occurrence of this type of error. The current study had only one observer researcher, and it would be important to calculate inter-observer reliability. However, the school did not allow video recording of the children and the presence of more than one researcher during recess, which did not allow calculation of this error.

Due to the proposals for the organization of PE classes reported in the literature, the suggestion is that we are failing in the way the planning and offering of the 'teaching' of movements in the school PE class is carried out (Barbosa, Coledam, Stabelini Neto, Elias, & Oliveira, 2016; Fernandes et al., 2017; Brusseau & Burns, 2018; Ridgers et al., 2018). It is necessary to rethink the processes of school PE classes, as well as the whole context of daily PA practice. The best results seem to denounce a motor deficit in our children with a low frequency of proficient A_{FMS} for the expected ages. In addition, our findings call attention to the time of sedentary behavior, considering that, unlike in other countries, in Brazil, the child remains in school only part-time (part-time/day). Generally, during this period outside school, the tendency would be for even fewer chances of movement (Raudsepp & Päll, 2006; Barbosa et al., 2016). Still, children with a lack of competence in locomotor and manipulative skills are less likely to access the range of PA options available to establish an active lifestyle (Lloyd, Saunders, Bremer, & Tremblay, 2014). The school would be your biggest opportunity of the day for independent motor practices. Given this, it is necessary to propose activities that challenge children, based on strategies for teaching progressive movements (Strotmeyer, Kehne, & Herrmann, 2021). Regarding recess, the adequacy of the environment and infrastructure should enable children to perform more diversified movements during this period (Raudsepp & Päll, 2006; Strotmeyer et al., 2021). Future research should evaluate the quality of PE classes around the world, to identify which countries have the best strategies for the development of A_{FMS}. As well as the amount of PA practiced by students, observing the influence of PA practice on A_{FMS}.

CONCLUSION

The frequency of A_{FMS} not performed during recess and PE classes was ≅ 76% of the observed time. The run in the locomotive category confirmed the children's preference for this skill, being more frequent during PE classes. The manipulative skills, twice more performed at the time of the PE class, confirmed the importance of offering space and materials available. The low quality of the A_{FMS} and the classification of most children in the elementary-emergent stage indicated that they present a motor deficit. Because most children did not reach the proficient stages, even at the most advanced ages. These results suggest that it is necessary to develop effective strategies to reverse this situation of MD deficit, such as the diversification of school activities, and adaptation of the environment and infrastructure to encourage children to reproduce more diverse and challenging autonomous movements.

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