“Environmental Opportunities for Active Play and Physical Activity Level in Preschoolers: a Multicriteria Analysis.”

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Abstract

Background: Active seem to influence the level of physical activity during childhood. However, a gap remains about which environmental opportunities could have a positive impact on the level of physical activity in preschoolers.

Objectives: (1) To develop an index to measure the environmental opportunities of free active play for preschoolers of middle-income countries; (2) to check the relationship and contribution of the index to explain objectively the level of physical activity.

Methods: A quantitative, cross-sectional, exploratory study with 51 preschool children. The established criteria for the index according to the literature were: (1) Outdoor time on typical days of the week. (2) Outdoor time on a typical weekend day. (3) The presence of internal space and external environment in the child's home that allows playing. (4) Presence of patio with space for games at the school. (5) Presence of a playground with a toy at the school. We applied multi-attribute utility theory for the determination of the multicriteria index. Pearson's correlation analysis and simple linear regression were used to verify the association between the index and the physical activity level. The significance level was set at 5%.

Results: The index showed a positive correlation with the level of physical activity, e.g., the average time of moderate to vigorous physical activity ($r = 0.408$, $p < 0.003$). The univariate linear regression demonstrated that the quality of environmental opportunities for physical activity explained 20% of the preschooler's classification as active and 16% of the time in moderate to vigorous physical activity ($p < 0.001$).

Conclusion: Environmental opportunities for active play have a positive impact on physical activity in preschoolers and should be encouraged in different social segments.

Background

Physical activity (PA) for children is the basis for healthy growth once lifestyle habits are developed throughout childhood affecting adolescence and the adulthood[1]. Sufficient PA in early childhood (under 5 years old), especially at moderate to vigorous intensities (MVPA)[2], can promote immediate metabolic benefits in blood pressure, lipid profile[3], reduce the risk of disease and weight gain[1]. In addition, adequate PA is associated with social, emotional, cognitive improvements [4]. Finally, evidence points that PA in preschoolers can promote the development of important motor skills for success in motor tasks and subsequent engagement in sports influencing a healthy lifestyle in adulthood [1,5,6]. Despite this, a recent study showed an increase in sedentary behavior and a reduction in PA in preschoolers [7]. In addition, a growing number of children worldwide are failing to perform the minimum of recommended PA to acquire a healthy lifestyle [7,8]. As PA levels often decrease throughout the school phase of children and

adolescents [9], preschool phase is considered a crucial period to guarantee the beginning of the PA habit throughout childhood [10].

Although previous study suggested that children's PA levels are mainly influenced by genetic factors [11], evidences also point out the influence of family [12,13], and personal factors on PA levels [14,15,16,17,18]. In this setting, sex and age were determinants of personal factors [19] and, therefore, male preschoolers, older[19] and exposed to the outdoors [20] had higher levels of PA.

Previous studies highlighted the home environment as an important space for the promotion of PA in preschoolers[14,16,17]. Evidence pointed out important facilitators for PA, among which are the home environment, the preschool environment, and their interactions [21].

Few studies specifically examined the PA of preschoolers at home[14], despite being a behavioral environment in which children spend a great deal of time. Briefly, studies showed that playing outdoors at home can be an important source of PA for many preschoolers[22,23,24]. Elements of the home outdoor environment, e.g. presence and attributes of the yard, have been associated with increased PA in preschoolers [25,26]. However, not only the presence of yard, but also to frequent the yard seem to influence the level of PA once participation in activities in the yard is beneficial to reduce the sedentary time[24]. Moreover, studies reinforce the association between outdoor time on weekdays and weekends with PA especially in preschoolers[22,27,28]. On the other hand, once the internal home environment can inhibit or stimulate PA in preschoolers, limited internal space, e.g. apartments lacking spaces, inhibit active opportunities[21,29,30], whereas larger spaces seem to benefit children's PA[31,32]. Studies demonstrated that preschoolers classified as highly active compared with little active are often active in indoor environments[33] reinforcing the idea the indoor environment offers untapped potential to promote and support PA[34].

The daycare physical environment has also the potential to influence PA and general health and the development of children under care [3,34,35]. Thus, we should keep in mind the daycare physical environment should be an ideal setting for promoting PA due to the unique opportunity for structured PA for all children, regardless of children's characteristics and parents' behaviors, attitudes, and resources [19]. In this sense, a greater space per child and open play areas could increase PA in children attending daycare centers [37]. The presence of portable play equipment and a playground [20] were also associated to greater PA in preschoolers [37,38]. Further investigation into the relative value of outdoor game designs, as well as the presence and quality of individual characteristics of the physical environment, e.g. free space, leisure equipment, vegetation, paths and shade, should be clarified to identify the environmental characteristics that best promote PA in the nursery environment [39,40].

The historical process of the nursery environment took place differently worldwide. Thus, in certain middle-income countries is common to find physical spaces restricted and inappropriate for children [41]. Regulatory and operational policy frameworks for the school environment have received little attention [42]

despite evidence about the importance of physical space and the park benefit children's PA[19,20]. Added to this reality, there is a lack of works investigating the influence of the home environment and the daycare center on the preschoolers' PA level [42]. Finally, understanding that child development is a multifactorial construct resulted from the child's reciprocal interactions with the environment [43], multicomponent models have been encouraged [44] to understand how strategies that increase the PA of preschoolers can combine multiple factors. Thus, the aims of our study were (1) To develop an index to measure the environmental opportunities of free active play for preschoolers of middle-income countries. (2) To check the relationship and contribution of the index to explain objectively the level of PA.

Materials And Methods

Study Design

This is a quantitative, exploratory, cross-sectional study, approved by the Research Ethics Committee of the Universidade Federal dos Vales do Jequitinhonha e Mucuri-UFVJM (Protocol number: 2,773,418), with the written informed consent of those responsible and the consent of the participants. Data collection took place from July to December 2019.

Participants

Preschoolers defined as children aged from 3 to 5 years, from public schools in a Brazilian municipality were recruited. Exclusion criteria were premature and low birth weight babies; babies with complications in pregnancy and childbirth; babies with signs of malnutrition or diseases that interfered with growth and development. Children with any condition that interfered with cognitive and motor development were also excluded. The sample size was calculated using the statistical program GPOWER 3.1, from a pilot study with 10 children, using the variables Multicriteria index and level of physical activity at moderate to vigorous intensity. For this, we used a statistical test of correlation (point biserial model), an effect size of 0.47, an error probability set at 1%, and a power of 80%. The sample size was estimated in 51 preschoolers.

Instruments

For the characterization of the participants, a questionnaire was developed with data on the child's birth and health. In addition, the mother's education and the child's family's economic level were checked.

The Brazil economic classification criterion from the Brazilian Association of Research Companies (ABEP) was used to verify the economic level of families. This is a questionnaire that stratifies the general economic classification resulting from this criterion from A1 (higher economic class) to E (lower economic class) [45].

The PA level was measured using an accelerometer (Actigraph®- Model GT9X); for a period of 3 days [46], for a minimum of 570 minutes a day [47], which is considered suitable for preschoolers [46]. Accelerometers were initialized and analyzed using 5-second epochs. In all analyses, consecutive periods of ≥ 20 minutes of zero counts were defined as non-wear time [48], with a sampling rate of 60 Hz. The accelerometer was positioned on the right side of the hip to capture accelerations and decelerations of the body and determine objective measurements of gross acceleration, intensity of physical activity, heart rate intervals and total time of suspension of use [48]. Pediatric cutoff points validated for preschool children, with score values, classify as sedentary (0 to 819 counts / m), mild (820 to 3907), moderate (3908 to 6111) and vigorous (above 6612) [49]. For this study, the child's mean time at these intensities was used. The classification adopted for “active” or “insufficiently active” was established according to the WHO, which considers an active child to be one who has a PA of at least 180 minutes/day, with a minimum of 60 minutes/day in moderate to vigorous PA[50]. The accelerometer data was initially downloaded using ActiLife Software (version 5.10) and then analyzed using custom Excel macros. At each evaluation point, the epoch time was defined as 5 minutes.

The multicriteria index was created based on items from the Early Childhood Home Observation for Measurement of the Environment (EC_HOME)[51], from the questionnaire on outdoor time proposed by Burdette et al., [52] and also from the revised Early Childhood Environmental Rating Scale (ECERS) [53].

The quality of the environment in which the child lives was assessed using the Early Childhood Home Observation for Measurement of the Environment (EC_HOME) [51]. The EC_HOME is applied through observation and semi-structured interviews during home visits, standardized for children aged 3 to 5 years. The instrument contains 55 items divided into 8 scales: I-Learning materials, II-Language stimulation, III-Physical environment, IV-Responsiveness, V-Academic stimulation, VI-Modeling, VII-Variety, and VII-Acceptance. For analysis, the sum of the raw scores of the subscales was used. For the elaboration of the multicriteria proposal, we used two items of the subscale III of the referred instrument, which assesses, among others, the presence of a yard and the internal physical environment of the house considering 30m^2 per inhabitant.

The outdoor time questionnaire proposed by Burdette et al., [52] evaluated the daily time of participation in games and outdoor games and sedentary behavior (daily time watching television) at home. The record was performed by the answers provided by the parents in relation to the child's behavior on a typical day of the week and on a typical day of the weekend, considering three different periods of the day. Each period the time reported by the parents was recorded and the sum of this time outdoors in minutes calculated.

The quality of the school environment was assessed using the Early Childhood Environment Rating Scales (ECERS) [53], which contain inclusive and culturally sensitive indicators for many items. The scale consists of 43 items organized into 7 subscales (1-Space and Furnishings, 2-Personal Care Routines, 3-Language and Literacy, 4-Learning activities, 5-Interactions, 6-Program Structure, 7- Parents and staff).

Each quality indicator was marked, considering its presence or absence in each collective environment (classroom), with the items scored from 1 to 7. The final score of the scale is given by the mean of the seven subscales. It is an ordinal, increasing scale, from 1 to 7, the interpretation of quality being 1: inadequate; 3: minimal (basic); 5: good; 7: excellent. For the elaboration of the study index, two items from subscale 1 were used, which included the presence of a park and toys in addition to the school space.

Procedures

Recruitment took place at the doors of the schools, and the invitation was made to the children's guardians when they left the classroom for the class. After written consent, the subsequent steps were scheduled. The first stage was carried out at the child's home with the completion of questionnaires characterizing the child and his family, time outdoors (Burdette et al., 2004), and application of EC-HOME [51] in addition to guidance on the instrument (accelerometer) that the child used to measure the PA level.

The families were instructed about the use of the accelerometer, delivered by a properly trained researcher and positioned on the child's right hip on every day of use. The family removed the device, placed at 7 am, at 7 pm. The children used the device for three days and, if the data were not captured, the use was repeated in the following week.

The second stage was carried out in the school environment, where it was applied by ECERS. To ensure reliability and internal control, only one experienced researcher applied all tests, measures and questionnaires.

Data analysis

We used the Multi-attribute utility theory (MAUT), a tool used in the setting of the connection and existence of multiple factors in the evaluation process to identify, characterize and combine different variables[54]. Nobre and colleagues, [55] in a study using MAUT also presented a similar methodology describing the phases of MAUT:

Phase 1: Selection of criteria

According to MAUT, selected criteria must faithfully represent what will be assessed and are selected from the literature[56]. Thus, for the environmental opportunities for active play, the selected criteria, based on the literature, were: 1-Time the child spends outdoors on weekdays [24,52,57], 2-Time the child spends outdoors on weekend days [24,52]; 3-Presence of internal and external space in the house available to play [21,32]; 4- External space (patio or court) of the school that allows playing [19,21]; 5- If the school has a playground (playground) [28,58,59].

Phase 2: Establishing a utility scale for scoring each criterion

Thereafter the criteria selected, we established scores for the selected criteria on the same ordinal scale. Within MAUT it may happen that some selected criteria have different units of measure quantified by means of attributes [56]. In our study, the selected criteria quantified responses using attributes described in the second column of Table 1. In this phase, the responses were converted into numerical variables by means of an ordinal scale. For each answer, a positive value was attributed when the practice was considered favorable and null if the criterion did not characterize environmental opportunities for active play.

The first criterion, “Time that the child spends outdoors on days of the week (minutes)” scored 1 the child who spent more than 120 min playing outdoors for days of the week [24,52,57].

The second criterion, "Time the child spends outdoors on weekend days (minutes)" [24,52], scored 1 the child who spent more than 120 minutes playing outdoors on weekends.

The third criterion, “House has an internal environment with a minimum of 30m^2 per inhabitant and an external space that allows play” [21,32], scored 1 the child which presented these two positive points according to the HOME subscale[51].

The fourth criterion, “School has space (patio or court) that allows active play”, scored 1 the child who study in school with a physical space and 0 school without a physical space [19,21].

The fifth criterion, “School has a park with toys”[28,38,58], scored 1 the child who studied at a school that had a park with toys that encourage gross motor coordination and 0 the school that did not have a park with toys, according to ECERS criteria [53]. Thus, based on phase 1, the child with the highest score in the multicriteria analysis of environmental opportunities for PA is the one who spent 120 minutes or more playing outdoors on weekdays and on weekends. This child resided in a house with an internal space of at least 30 m^2 per inhabitant and with a yard or external space that allowed active play and studied in a school that contained a patio or court that allowed movement and a park with toys. Table 1 presents the criteria with the possible scores.

Table 1
Criteria evaluated and possible responses

Criterion	Possible Answers	Pointing
1- Time the child spends outdoors on weekdays (minutes)	35–69 minutes	0.1
	70–119 minutes	0.5
	120 min or more	1
2- Time the child spends outdoors on weekend days (minutes)	35–69 minutes	0.1
	70–119 minutes	0.5
	120 min or more	1
3- Does the house have an internal environment of at least 30m^2 per inhabitant and an external space that allows for play?	Yes	1
	No	0
4- Does the school have a space (patio or court) that allows active play?	Yes	1
	No	0
5- Does the school have a park with toys?	Yes	1
	No	0

Phase 3: Determination of the weight for each multicriteria

The numerical measure that measures the importance of each criterion is weight. If the decision maker understands that one criterion is more relevant than the other (supported by the literature or in the opinion of experts on the subject), it will have greater weight [56]. For the research, equal weights were used for the different criteria, assuming that each selected factor has the same degree of relevance in the process of environmental stimulation opportunities for PA practice experienced by children.

Phase 4: Calculation of the multicriteria index

The multicriteria index refers to the weighted sum of the evaluations of the different evaluated criteria. In our study, the weights considered for each criterion were the same (phase 3); therefore, to calculate the multicriteria index, an average of the evaluations of all criteria were established for each participating child. It is observed, in Eq. 1, how this calculation was made (n = number of criteria evaluated):

$$Multicriteria\ index_{child\ i} = Evaluation\ criterion\ 1_{child\ i}\ weight_{criterion\ 1} + ... + Evaluation\ criterion\ n_{child\ i}\ peso_{criterion\ n}\ \{Equation\ 1\}$$

Phase 5: Validation of results

At this moment, we verified whether the multicriteria methodology carried out meets the objective [54,56]. Our study aimed to verify whether a higher multicriteria index was related to a lower level of sedentary PA, better time at the level of mild, moderate, vigorous, moderate to vigorous physical activity (MVPA) and classification as “active” and “insufficiently active” [50]. Thus, a correlation analysis was carried out between the multicriteria index and the PA level variables collected by the accelerometer.

The Excel Program (version-2010) was used to formulate the multicriteria model, later, for the validation stage; the data were transferred to the Statistical Package for the Social Sciences (version-23.0), to perform Pearson's correlation analysis and simple regression analysis ($p < 0.05$). After applying Shapiro Wilk test on the multicriteria index, we found that the variable had a normal distribution, performing a subsequent Pearson correlation analysis. Then, we analyzed those variables that showed a correlation above 0.20 by simple linear regression analysis in order to verify how much the multicriteria index could explain the variables related to PA.

Results

Table 1 shows the characterization of the study participants. Participated preschoolers enrolled in the Municipal Early Childhood Education Centers, with an average age of 4.5 years (SD ± 0.60), with a slight predominance of boys (53%). Most of the children's families were made up of couples living with partners and more than half of the mothers had 8 years or more of schooling (65.4%). Most families belonged to the lower middle class (class C, 63.4%) and lived in houses classified as medium stimulation environments (78%). Of the group surveyed, most did not performed systematized PA in spaces such as clubs and similar; many accumulated 180 minutes of PA and just over half of the children accumulated 60 minutes in MVPA. The majority (64, 7%) studied in the partial school shift, which totalized an average time of 4 hours and 30 minutes a day in preschool (Table 2). Despite the average time of MVPA of the respondents meeting the WHO recommendations (WHO 2019), the average time in sedentary PA objectively measured ads up to almost 7 hours a day (Table 2).

Table 2
Characterization of participants (n = 51) and correlation with the multicriteria index.

Characteristics	N (%)	r	p value
Age (min-max)	5(3–5)	0.066[a]	0.644
Shift		1.208[c]	-1.364
Integral	18(34.60)		
Evening	16(30.80)		
Morning	18(34.60)		
Sex		3.029[b]	0.082
Male	28(53.80)		
Female	24(46.20)		
Maternal schooling		0.023 [c]	1.019
Fundamental	14(21.20)		
High school	20(38.50)		
University education	7(13.50)		
Marital status		0.333 [c]	-0.067
Economic Classification		1.787 [c]	0.344
Class B	14(26.90)		
Class C	33(63.40)		
Class D e E	5(2.80)		
Quality of the school environment	2.57(1.90–2.92)	-0.050	0.730
Home Classification			
High stimulation	10(19.20)		
Medium Stimulation	42(78.80)		
Classification Active or little Active (180 minutes at any intensity)		1.000[b]	0.635

[1] Classification Level PA 180 minutes at any intensity, with 60 minutes being moderate to vigorous. [a] Pearson's correlation; [b] chi-squared test or fisher exact test. [c] T test for independent samples. * $p < 0.05$

Characteristics	N (%)	r	p value
Active	49(96.10)		
Insufficiently active	2(1.10)		
Classification Level PA (WHO 2019)[1]		8.241[b]	0.004*
Ative	28(54.90)		
Insufficiently active	23(45.10)		
Average sedentary time	393.991(± 45.79)	-0.157 [a]	0.270
Light average time	189.34(± 34.86)	0.177 [a]	0.215
Average time Moderate	40.26(± 10.34)	0.347 [a]	0.013*
Average Vigorous Time	20.09(± 6.47)	0.362 [a]	0.009
Average time Moderate to vigorous	60.37(± 14.53)	0.408 [a]	0.003*
Sum of mild, moderate to vigorous weather	249.70(± 44.98)	0.269[a]	0.056

[1] Classification Level PA 180 minutes at any intensity, with 60 minutes being moderate to vigorous. [a] Pearson's correlation; [b] chi-squared test or fisher exact test. [c] T test for independent samples. * $p < 0.05$

The multicriteria index was calculated following the phases described in the methodology section. Figure 1 shows the validation phase that represents the correlation between the multicriteria index and the variables of the PA level. In graph 1A, children who obtained a higher multicriteria index value (environmental PA opportunities) had a longer time at moderate intensity. So, the correlation between variables was statistically significant ($p \leq 0.001$), positive and moderate ($r = 0.34$). In 1B graph, the children who obtained a higher value of the Multicriteria Index, obtained a longer time in the vigorous PA intensity, statistically significant ($p \leq 0.01$), positive and moderate correlation ($r = 0.36$). In 1C, the children who obtained the highest value in the Multicriteria Index had a longer time in the referred intensities of PA combined (MVPA), statistically positive correlation, significant ($p \leq 0.001$) and moderate ($r = 0.40$).

In Fig. 2, the boxplot shows the relationship between the Multicriteria Index (environmental opportunities for PA) and the classification of children as active and little active. Thus, children who had more quality environmental opportunities for PA (higher value in the multicriteria index) were classified as active. In this sense, the relationship was positive, significant ($p = 0.001$) and moderate ($x^2 = 0.44$).

We also showed linear regression with the outcome variable multicriteria index “environmental opportunities” as a validation of the multicriteria index in Table 3. Thus, have a higher value in the index of environmental opportunities explained 12% of the Moderate intensity (R^2 = 0.12, p = 0.013), 13% of the Vigorous intensity (R^2 = 0.13, p = 0.009) and 16% of MVPA (R^2 = 0.16, p = 0.003). In addition, have environmental opportunities to practice higher quality PA explained 20% of the active classification (R^2 = 0.20, p = 0.001).

For Moderate PA, the study showed a power of 0.86 (considering an alpha error of 0.05, effect size of 0.13). For Vigorous PA, the power was 0.86 (Alpha error of 0.05, effect size of 0.14). For PA MVPA, the power was 0.86 (effect size of 0.19) and for Classification of PA Level, the power presented was 0.86 (effect size of 0.25).

Table 3
Linear regression with the outcome variable “Multicriteria index of physical activity opportunities”

PA variables	**PA opportunities**			
	R^2	**b ± SE**	**β**	**P**
Average sedentary time	0.025	-0.001 ± 0.001	-0.157	0.270
Average light time	0.031	0.001 ± 0.001	0.177	0.215
Average moderate time	0.120	0.007 ± 0.003	0.347	0.013*
Average vigorous time	0.131	0.004 ± .0.362	0.362	0.009*
Average moderate to vigorous time	0.166	0.002 ± 0.408	0.408	0.003*
Sum of mild, moderate to vigorous time physical activity	0.072	0.001 ± 0.001	0.269	0.056
Classification Active or insufficiently active (WHO 2019)	0.200	0.184 ± 0.053	0.447	0.001*

PA = physical activity. R^2 = coefficient of determination (r square adjusted). b = Non-standard coefficient; ±SE = Standard error. β = Standardized Beta. P value = *Statistical significance p < 0.05.

Discussion

Our data revealed a positive relatioship of the multicriteria index with the average time of MVPA. In addition, the environmental opportunities for PA explained 20% of the preschooler’s classification as

active and 16% of the time in MVPA. It is noteworthy the relationship was moderate [60] and is in line with previous study with similar methodology involving child development [55].

The preschool phase is a sensitive moment for the experience of PA. In addition, provides better motor skills[5], creates life habits that tend to last in later stages of life [1], enables the development of motor skills, which may facilitate engagement in sports and healthy lifestyle maintenance [5,61]. A previous study using direct PA measurement in Sweden preschoolers evidenced that the structural characteristics of the preschool, e.g., formalized PA policy and more time spent outdoors, were positively associated with PA of children [62]. Thus, formalized PA policies and outdoor time can be important for promoting children's PA during preschool hours [20]. Moreover, previous studies have advocated the expansion of the time in outdoor recreation associated to a structured PA in the preschool environment [36,44]. Thus, the promotion of PA and opportunities to encourage the natural desire for movement should begin early in life [10].

Studies with PA interventions in preschool have focused on PA from MVPA [63]. The basis for prioritizing MVPA is the improvement of health-related physical fitness conditions [2,64], cognitive development[65] and increased motor competence[66]. However, in the present study, there was no systematized PA in preschools, a fact common in the reality of Brazilian schools [67]. In Brazil, the educational legislation does not make the presence of physical education professionals mandatory to teach the content in preschool and the recreation happens with the class teacher[67,68]. This reality reinforces the importance of the preschool space having in its physical structure parks with equipment and a patio as factors to increase the PA of preschoolers in recreation [58,62], as recommended by some studies [20,69].

Our multicriteria index also pointed the need for investments in home environments[7]. The family environment plays an important role to provide opportunities for physical activities [57,70]. In particular, playing outdoors requires social support and parental supervision[71]. In addition, because parental restrictions can prevent participation in PA and outdoor play in preschoolers [72], our data reinforce the importance of external and internal space for active play at home, since most of the responsibility for promoting healthy behaviors and PA practices currently falls on families [69].

About the evaluation of the quality of home, our data showed that more than half of preschoolers live in medium stimulus environments[51] and belong to class C, e.g., extract that comprises the lower middle class. Thus, for families whose houses do not have external and internal spaces that allow active play [7], the presence of parks and outdoor leisure areas in the neighborhood is essential for children to increase the level of PA [28].

Considering PA time including all the intensities, 96.1% of the Brazilian preschoolers accumulated 180 minutes of daily PA. Furthermore, the quality of environmental opportunities for active play seemed to contribute substantially to the acquisition of moderate intensities ($R^2 = 0.12$, $p = 0.013$), vigorous ($R^2 = 0.13$, $p = 0.003$) and MVPA ($R^2 = 0.16$, $p = 0.056$) and for the child to be classified as active with 180

minutes at any intensity, being 60 minutes in MVPA (R^2 = 0.20; p = 0.001). Surprisingly our data showed that the majority of the Brazilian preschoolers reached the recommended minimum daily PA. In this sense, the daily PA time in Brazilian preschoolers was higher compared to Chinese preschoolers (83.8% of preschoolers in China [73], and probably Chinese preschoolers accumulated daily PA time due to the large proportion of time spent at low intensity [21].

We suppose that the environmental factors together assessed by the multicriteria index corroborate the reach of MVPA. Namely, the mean MVPA values of active children (Mean = 70.68, SD ± 9.09) and of insufficiently active children (Mean = 47.81, SD ± 8.85). Active preschoolers scored higher on the multicriteria index (mean 0.67, SD ± 0.18) compared to those who were insufficiently active (mean 0.49, SD ± 0.18).

Other studies investigated preschoolers with the same time points for the PA classification [50] and our data showed that the percentage of Brazilian preschoolers (54.90%) who meet the daily guidelines[50] was higher than Canada (13.7%) [74] and Sweden (33%) preschoolers[17].

Collectively, our results are in line with Tucker and colleagues study [36] and support the implementation of opportunities that increase children's access to outdoor play, as well as ample spaces, both in pre-school ambient [44,20] and in other places such as the home environment [24,29,32], in order to provide PA opportunities using body movement experiences [44]. Thus, we suggest public policy strategies focusing on increasing the level of daily PA in preschoolers considering all factors above mentioned. Morever, we suggest additional studies using multicriteria modeling to understand the impact of the social context as well as barriers and difficulties that limit or hinder physical activity [7,57]. Therefore, public policies focusing on the logistical support and encouragement of integrated practices of PA for the whole family are crucial especially nowadays face in the new context of Covid-19 [69].

Our study has strengths and limitations. The cross-sectional design of the present study does not allow inferring cause and effect. Aspects related to social modeling, parental encouragement, and logistical support for PA should be considered in future works.

Although accelerometry is considered a gold standard to measure PA level among preschoolers [47] and used in many studies [69], accelerometry is a measure unable to PA level in activities such as cycling or upper body movements. However, the direct measurement of daily PA level avoided the risk of bias related to the self-reported measures such as memory difficulties and social desirability. Moreover, we used validated questionnaires [52] that allowed the assessment of the quality of the home [51] and school [53] environments allowing the elaboration of the multicriteria index to evaluate PA opportunities.

Conclusions

The multicriteria index designed to check the opportunities for PA experiences in preschoolers showed potential for application. Environmental opportunities were decisive for the higher intensities of PA. So,

playing outdoors, living at home with a yard and indoor space, studying in schools with a patio and playground increase the possibilities for preschoolers to experience MVPA.

Abbreviations

ABEP: Associação brasileira de estatística e pesquisa

EC-HOME: Early Childhood Home Observation for Measurement of the Environment

ECERS: Early Childhood Environment Rating Scales

MAUT: Multi-attribute utility theory

MVPA: Moderate to vigorous physical activity

PA: physical activity

UFVJM: Universidade Federal dos Vales do Jequitinhonha e Mucuri

WHO: World Health Organization

Declarations

Availability of data and materials:

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Ethics declarations

Ethics approval and consent to participate:

All protocols was carried out in accordance with relevant guidelines and regulations. This study was approved by the Research Ethics Committee of the Universidade Federal dos Vales do Jequitinhonha e

Mucuri (Protocol: 2.773.418), authorized by the Municipal Education Secretariat of Diamantina (MG), Brazil.

Consent to participate:

We declare that all parents of the children or legal guardians signed the informed consent form in writing, authorizing participation in the study.

Consent for publication:

Not applicable.

Competing interests:

We declare no competing interests.

Authors' contributions:

JNPN: Conceptualization , Formal analysis, Data Curation, Methodology; RLSM: Writing Review & Editing – Original Draft; BVP: Formal analysis, Review; ACF: Conceptualization, Formal analysis, Data Curation; AAV: Methodology, Writing; PHSF: Review & Editing; HSC: Review & Editing; ACRC: Review & Editing; MAA: Review & Editing; VAM: Review & Editing; ACRL: Conceptualization, Data Curation, Writing, Review & Editing – Original Draft. All authors have read and approved the manuscript.

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Figures

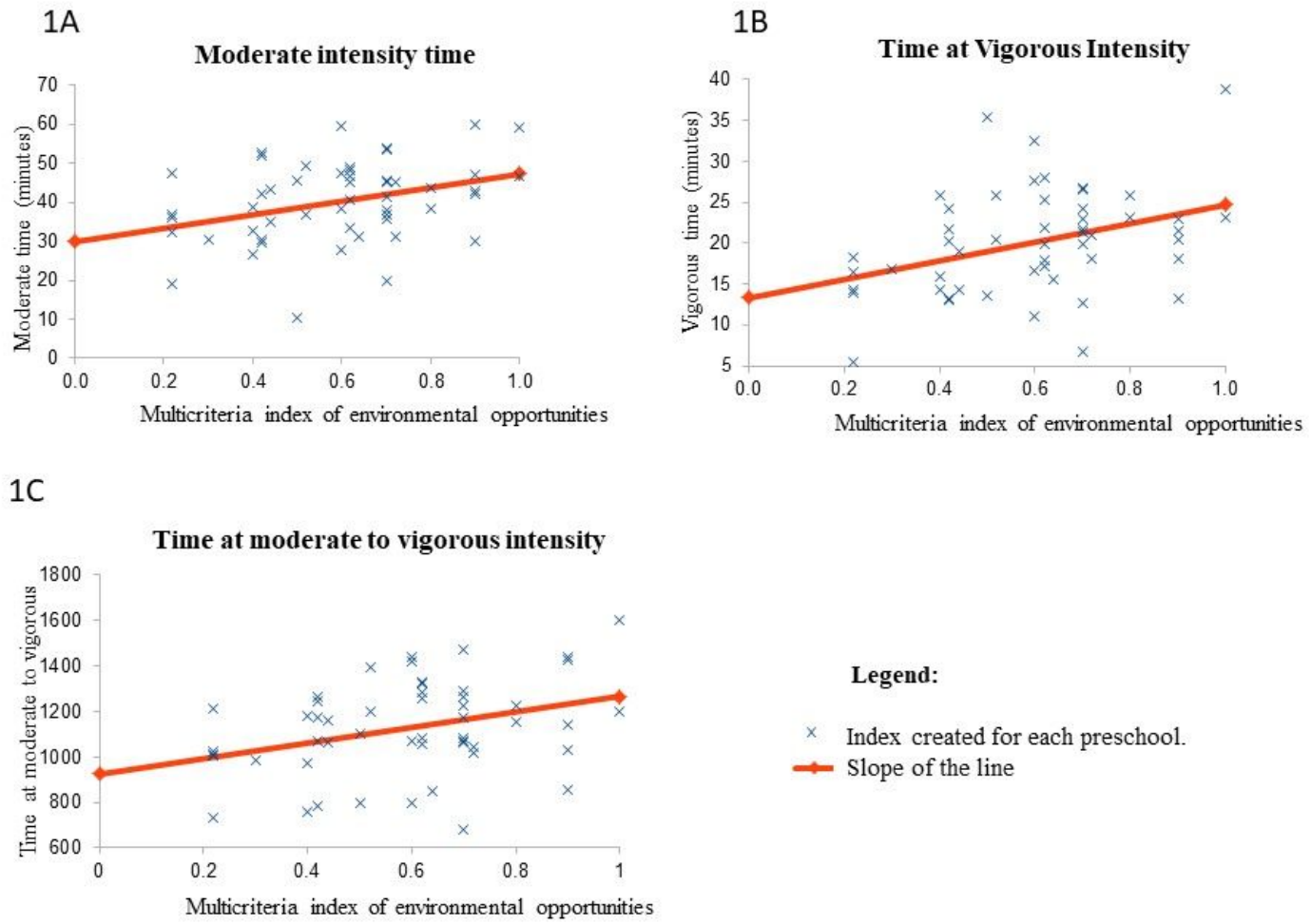

Figure 1

Correlation graphs between the Multicriteria Environmental Opportunities for PA index and PA Variables

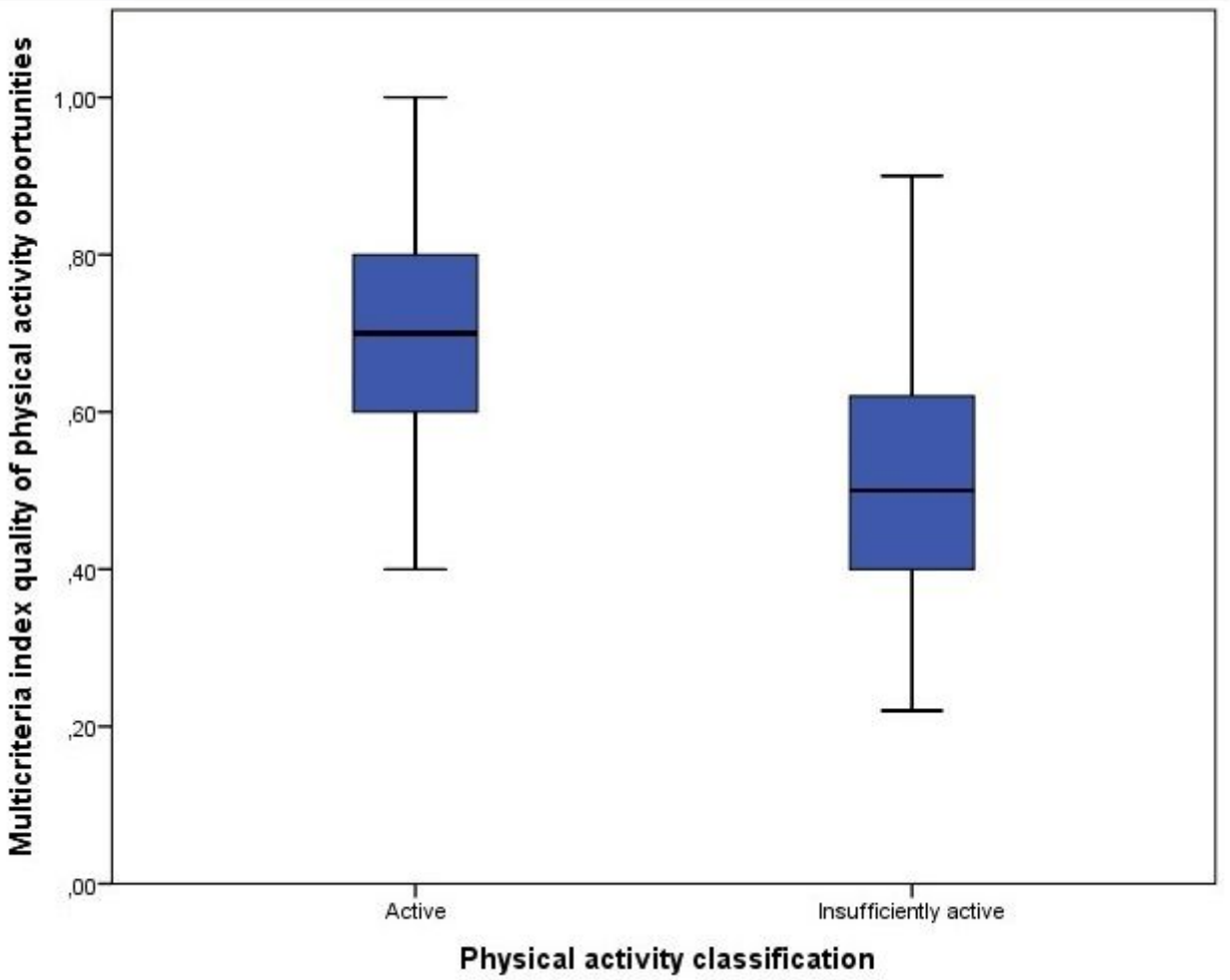

Figure 2

Mean difference between the active or insufficiently active classification and the Environmental opportunities for active play index.