School-Time Movement Behaviors and Fundamental Movement Skills in Preschoolers: An Isotemporal Reallocation Analysis

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ABSTRACT

BACKGROUND: Little is known on how relocations of time spent in different movement behaviours during pre-school hours could relate to preschooler's fundamental movement skills (FMS), a key predictor of later physical activity (PA). Thus, the aim of this study was to examine whether the school-time composition was associated with FMS; and to investigate predicted differences in FMS when a fixed duration of time was reallocated from one activity behaviour to another in preschool children. **METHODS:** A cross-sectional representative data of an intervention study with Brazilian low-income preschoolers. Two hundred and four preschoolers of both sexes (4.5 ± 0.8 years-old; 101boys) provided 10 hours of school-time objectively assessed PA and sedentary behaviour (SB) data (Actigraph wGT3X), and FMS assessments (TGMD-2). Association of school-time composition of movement behaviuors with FMS and its reallocations during school-time was explored using compositional analysis in R (version 1.40-1), robCompositions (version 0.92-7), and lmtest (version 0.9-35) packages. **RESULTS:** The isotemporal reallocation showed that for manipulative skills, an increasing pattern was observed (0.14, 0.28, and 0.42-units) when reallocating 5, 10 and 15 minutes,

respectively, from light PA to SB. **CONCLUSIONS:** The current study highlights that school-time composition is a significant predictor of FMS. Moreover, a modest increase in SB, at the expense of LPA, during the school-time may elicit a positive change in manipulative skills.

Key-words: motor skills, physical activity, children, preschool

INTRODUCTION

Adequate amounts of physical activity (PA), reduced sedentary behaviour (SB) and a good quality/quantity sleep (SLP) during early childhood (e.g. 0 to 5 years) are key behavioural components for short and long-term health outcomes (WHO, 2019). Although in children under 5 years-old, PA has been associated with a healthy skeletal, cardiometabolic, and motor and cognitive skills profiles (Carson, Tremblay, Chaput, McGregor, & Chastin, 2019), ~~contributing to the increased prevalence of overweight and obesity (WHO, 2019),~~ a large proportion of children worldwide do not engage sufficiently in moderate to vigorous physical activity (MVPA) (Berglind & Tynelius, 2017; Santos et al., 2017), have excessive SB, and do not accrue adequate amounts of sleep, all of which are not conducive to health benefits (Chaput et al., 2017; Chaput et al., 2016; De Craemer, McGregor, Androutsos, Manios, & Cardon, 2018).

In early childhood, fundamental motor skills (FMS), operationally defined as the basis of more complex movements required to participate in sports, games, or other context specific PA, are developed as a consequence of physical maturation, and practice (Goodway, Ozmun, & Gallahue, 2019), playing an essential role in the development of children's movement patterns (Hardy, Reinten-Reynolds, Espinel, Zask, & Okely, 2012). Therefore, early childhood is critical for the development of FMS. An optimal

performance in such skills may facilitate ones participation in daily and sports activities (Stodden et al., 2008) , and is key in future health and academic achievement (Jaakkola, Hillman, Kalaja, & Liukkonen, 2015).

Considering that behaviours track from childhood to adulthood (Telama, 2009), the school has long been appointed as a place of enhancing PA opportunities for children (de Rezende et al., 2015), as it provides access to a large number of children for prolonged periods each day (Ward, Vaughn, McWilliams, & Hales, 2010), and provides an infrastructure which can, theoretically, be used to facilitate healthy behaviours (Story, Nanney, & Schwartz, 2009). Of particular importance, children from low-income families, living in vulnerable zones, spend more than 60% of their waking time in a preschool setting. Preschoolers from low-income families are less likely to be engaged in structured PA opportunities, spend a great ammount of time being sedentary, and engage in a high amount of screen time. So, for these particular children, their ability to meet international movement guidelines (WHO, 2019) is highly influenced by the amount of PA and SB, including naps, accumulated at the preschool setting (O'Brien, Vanderloo, Bruijns, Truelove, & Tucker, 2018), which may conceivably influence early childhood developmental processes. Indeed, PA facilities in socially vulnerable areas are scarce, and children living in these areas have a greater chance of a delay in the development of their FMS. Moreover, differently of "quality" sedentary time, recreational sedentary time,

based on screen media use in preschool years, may pose concerns regarding children's neurobiological development, affecting how children play and learn.

More recently, a growing body of evidence has advocated the adoption of a compositional approach to understand the effect of movement behaviours in health outcomes, to mirror the 24-h nature of many international guidelines (WHO, 2019). Such work demonstrates the time-bound nature of behaviour, i.e. 24-h or 1-day, and when considering any singular portion of a composition, any theoretical increase or decrease must result in an equal reduction among the remaining behaviours (Aitchison, 1982). Indeed, when considering behaviours compositionally, positive health changes have been shown to be achievable by reallocating time between these behaviours among youth, adults, and the elderly (Biddle et al., 2018; Garcia-Hermoso, Saavedra, Ramirez-Velez, Ekelund, & Del Pozo-Cruz, 2017; Pelclova et al., 2020), respectively. A recent study suggested that replacing a percentage of time spent being sedentary and in light PA with time in MVPA during school hours may be an effective strategy to improve children´s FMS in low-income elementary school-aged children (Burns, Kim, Byun, & Brusseau, 2019). However, to date, there is no empirical data regarding the movement behaviours of preschooler's, or indeed the impact of substituting time in one intensity/activity for another. Furthermore, little is known about how these relocations could relate to preschoolers FMS, a key predictor of later PA. Therefore, the aims of this study were twofold; (1) to examine whether the school-time composition was associated with FMS,

and (2) to investigate predicted differences in FMS when a fixed duration of time was reallocated from one activity behaviour to another.

METHODS

This cross-sectional study uses baseline data from the school-based PA intervention program "Movement´s cool", which aims to analyze the associations between movement behaviours and health outcomes in low-income preschoolers.

Participants

In João Pessoa, the preschool public education zone is divided into nine poles, where eighty-six early childhood education and care services (ECEC) are located. From those, fifty institutions have 3-to-5 years old registered children, and ten of them, located in vulnerable zones, were previously selected. A representative number of ECEC by poles was calculated and six were randomly selected and included in the study, which corresponds to 573 preschoolers of varying ages, corresponding to the study´s population (Figure 1 - Panel A). All the six preschools were located in deprived areas of city (Human Development Index - HDI=0.7), with low socio-economic status (SES): 62.5% of the mothers or fathers were unemployed and over 45% of the mothers and 54% of the fathers had finished the 9th grade or less. The HDI of the ECEC´s areas range from 0.3 to 0.5.

The number of participants required in the study was estimated using G*Power (3.1.0). It was considered using a prevalence of 50%, 95% confidence interval, 5%

maximum tolerable error, and using a design effect of 1.0. The required number of subjects was estimated in 230. This number was increased by 20%, to account for attrition (drop out and hardware failure). A total of 276 healthy preschool children, with no chronic problems, aged 3- to- 5 years old was called for assessments, but 39 parents did not give consent for their children to participate. Accelerometer measurements were performed with 237 children, and a total of 204 (86.07%) provided valid measurements based on the data reduction criteria (Figure 1 - Panel B).

************Insert figure 1**********

Measurements

Anthropometric measures

Height (cm) and weight (kg) were determined using a *Holtain* stadiometer, and by digitized weighing scales (Seca 708), while the participant was lightly dressed and barefoot, following a standardized procedure ("WHO Child Growth Standards," 2009). Body mass index (BMI) was calculated by dividing body weight with the squared height in meters (kg/m^2).

Physical activity

PA was objectively assessed using accelerometry (Actigraph, model WGT3-X,

Florida), which has been shown to be a valid instrument for measuring PA in preschoolers (Bornstein, Beets, Byun, & McIver, 2011). Parents and preschool teachers received verbal and written instructions for the children´s correct use of the accelerometer, including placement, and the correct positioning. The device initialization, data reduction and analysis were performed using the ActiLife software (Version 6.13.3).

The children were instructed to wear the accelerometer on the right hip for 7 consecutive days (Wednesday morning to Tuesday afternoon), and parents were allowed to remove children´s device during water-based activities, and during the night, and attach when children woke up. During preschool time, accelerometers were removed by teachers around 11am for children´s bath and fastened properly just after it.

Accelerometers were setup to measure acceleration at a 100 Hz sampling rate, using a 15-s epoch length (Cliff, Reilly, & Okely, 2009), and reintegrated to 60-s epochs for analysis, as ActiGraph counts, considering the vector magnitude. Periods of $\geq$20 min of consecutive zero counts were defined as non-wear time and removed from the analysis, and the first day of accelerometer data was omitted from analysis to avoid subject reactivity (Esliger, Copeland, Barnes, & Tremblay, 2005). For the purpose of this study, school-time were delimited as the time between 7am and 5pm on weekdays during at least two days. Only days with a minimum of 6h of wear time between 7am and 5pm were considered valid. So, data from 33 children were not validated. The wear time ranged

from 6 to 10 hours between subjects and mean wear time was 8.5 hours (SD± 2h of wear time between children).

Hourly average values in counts per minute (CPM), was used to describe the children´s daily PA pattern. Time spent in the commonly defined intensity domains light, moderate and vigorous was estimated using the cut-points proposed by Butte et al. (2014) with light intensity defined as 820 to 3.907 counts, moderate intensity defined as 3.908 to 6.111 counts and vigorous intensity as >6.112 counts. The amount of time spent sedentary was estimated as ≤819 counts, in addition to requiring the activity to be sustain for 10 consecutive min or more, as done in a previous study (Andersen et al., 2017). Habitual PA for the preschool time was estimated as the average counts per minute for the time between 7am and 5pm.

Fundamental movement skills

Fundamental movement skills were measured using the Test of Gross Motor Development - Second Edition (TGMD-2). The TGMD-2 is valid and reliable for use in Brazilian children (Valentini, 2012), and evaluates gross motor performance in children aged 3 to 10 years, and consists of two domains: six locomotor skills (run, gallop, hop, leap, jump and slide) and six object control skills (strike, bounce, catch, kick, throw and underhand roll).

The TGMD-2 was administered according to the guidelines recommended by Ulrich (2000). Before the assessment of each skill, children were given a visual demonstration of the skill by the researcher using the correct technique, but were not told what components of the skill were being assessed. Children were then called individually to perform the skill twice. General encouragement but no verbal feedback on performance was given during or after the tests. All skills were video-recorded and later assessed by one trained evaluator who do not administered the tests. After viewing each trial, the trained assessor analyzed each skill component. A "1" indicated that the component was present in the performance of the skill for that trial or a "0" indicated the component was not present. The video analysis was performed by two expert evaluators. A high agreement for the locomotor score: ICC = 0.93 (95% CI: 0.69–0.98), for the object control score: ICC = 0.98 (95% CI: 0.93–0.99) and for total motor score (MS): ICC: 0.96; (95% CI: 0.82–0.99) were observed. Per the TGMD-2 manual, locomotor and object control scores were based on the presence (one) or absence (zero) of each of the performance criteria. For each subtest, the sum of the raw scores ranged from 0–48 points.

Procedure

Children enrolled in ECEC´s program, attend preschool from Monday to Friday, starting at 7am, and finish at 5pm. In this study, only the accelerometer data from the preschool period was analyzed. Measurements were performed during a three-month

period, between March and May 2018. Time in PA and SB was observed between 7am and 5pm from Wednesday to Tuesday by specialized and trained project staff (PE teachers and graduate students).

All the schools and parents were informed about the project´s protocols and procedures in meetings with the project coordinator (one meeting in each school) and agreed to participate. The children were drawn from a school list until sufficient data were obtained, according to the proportional distribution calculated for each school, and for each of the ages (3, 4 and 5 years).

Socio-demographic data (children´s age, birth date, parent´s contact and address) was provided by the school administration. Anthropometric (body mass and stature) and movement skills data were collected at pre-schools, and the accelerometer was worn for seven consecutive days by the participating children.

Data analysis

The analysis in the present study was conducted based on a compositional data paradigm. Compositional data analysis represents field of statistics which has been used exstensively in diverse, multivariable proportion-type data (ROS). Standard and compositional descriptive statistics were computed for comparison; where, alternate to the standard arithmetic mean, the compositional mean is obtained by computing the geometric mean for each isolated behaviour and subsequently normalizing the data to the

same constant as the raw data, i.e. 1. Indeed, this measure is coherent with the relative and symmetrical scale of the time-use data (AITCHISON). Moreover, univariate statistical measures of dispersion, for instance standard deviation, are not coherent with the intrinsic inter-dependent multivariable nature of compositional data; where the univariate variance of a compositional variable contains no usable information, as the variability of the time spent in an isolated behaviour is intrinsically linked to the variability of the time spent in another behaviour (CHAYES), such that disregarding the inarguable compositional nature of 24-hour movement behaviours, will lead to reporting of spurious associations (CHASTIN). Thus, the dispersion of compositional data is robustly estimated using the variation matrix (AITCHISON), which summarizes the variability structure of a data by means of log-ratio variances (CHASTIN). The variability of the data was summarized in a variation matrix that contains all pair-wise log-ratio variances, where a value close to zero indicates that time spent in two respective behaviours are highly proportional, whilst a value close to one indicates the opposite. We adopted a compositional approach based on an isometric log-ratio (ilr) data transformation, adapted from Hron (REF) (see Mota et al (REF); Bezerra et al (REF)) to adequately adjust the models for time spent in the other behaviours. Briefly, the ilr coordinates were created using a sequential binary partition (SBP) process (EGOZCUE), which were obtained by partitioning the composition, where one set is designated to appear in the numerator of the first ilr coordinate, and the other in the denominator, next,

one of the previously constructed sets is further partitioned into two sets, again coding the parts to be in the numerator (+1), the denominator (-1), and uninvolved parts (0). The final ilr's were constructed as normalized log ratios of the geometric mean of parts (DUMUID).

All compositional data analyses were conducted in R (http://cran.r-project.org) using the compositions (version 1.40-1) (van den Boogaart & Tolosana-Delgado, 2008), robCompositions (version 0.92-7) (Pawlowsky-Glahn & Buccianti, 2011; Templ, Hron, & Filzmoser, 2011), and lmtest (version 0.9-35) packages.

The school day composition (daily school time spent in SB, LPA, and MVPA) was referred to in terms of central tendency, i.e. the geometric mean of time spent in each component, linearly adjusted so that all components summed to the total school day for interpretation in minutes per day for interpretation in percentages of the school day, which for purposes of this study, was bound to 600 minutes (7am – 5pm). Multivariate dispersion of the school day composition was described using pairwise log-ratio variation (Aitchison, 1982; Chastin, Palarea-Albaladejo, Dontje, & Skelton, 2015).

Multiple linear regression models were used to investigate the relationship between school day activity behaviour composition (explanatory variable) and each motor competence tenet (dependent variable). Prior to inclusion in the regression model, the composition was expressed as a set of two isometric log ratio (*ilr*) co-ordinates.

Covariates (age, BMI, and sex) were additionally included as explanatory variables. The outcome variables were total motor competence (MC), locomotor skill, and manipulative skill. The *ilr* multiple linear regression models were further checked for linearity, normality, homoscedasticity, and outlying observations to ensure assumptions were not violated. The significance of the school day activity behaviour composition (i.e., the set of *ilr* coordinates) was examined with the '*car::Anova()*' function, which uses Wald Chi squared to calculate Type II tests, according to the principle of marginality, testing each covariate after all others (Fox & Weisberg, 2018).

The above *ilr* multiple linear regression models were used to predict differences in the outcome variables associated with the reallocation of a fixed duration of time (5 min) between two activity behaviours, whilst the third remains unchanged. This was achieved by systematically creating a range of new activity compositions to mimic the reallocation of 5 min between all activity behaviour pairs, using the mean composition of the sample as the baseline, or starting composition. The new compositions were expressed as *ilr* coordinate sets, and each subtracted from the mean composition *ilr* coordinates, to generate *ilr* differences. These *ilr* differences (each representing a 5-minute reallocation between two behaviours) were used in the linear models to determine estimated differences (95% CI) in all outcomes. Predictions were repeated for pairwise reallocations of 5, 10, and 15 minutes, respectively. The decision was made to only go up to 15 minutes reallocation so to reflect the potential for real or actual change in MVPA. Beyond 15

minutes, there is too high a proportion of MVPA being reallocated and inferences from reallocating such a high proportion of overall MVPA will likely result in distorted outputs.

The MATLAB function, alchemist/ternplot (Sandrock & Afshari, 2016), was used to produce ternary plots with a continuous response surface, where increasing red saturation represents a more favourable outcome, and increasing blue saturation less favourable association with the outcome variable.

RESULTS

A total of 204 preschoolers (4.51years-old; mean body mass = 18.17 ± 3.71kg; mean height = 106.00 ± 7.06 cm) of both sexes (101 boys) participated in the study. Compositional means for SB, LPA, and MVPA, and locomotor, manipulative and total motor competence scores showed that Children spent 69% of the school-time being sedentary, and approximately 32% of the school-period engaged in LPA. MVPA was responsible for 7% of their time at school.

The variability of the data was explored in a variation matrix containing all pair-wise log-ratio variances. A value close to zero suggested that the time spent in the two respective behaviours were highly proportional. For instance, the variance of log (Sedentary/LPA) is 0.15, which reflects the (proportional) relationship or co-dependence

between the two behaviours. The highest log-ratio variance involved MVPA and SB, suggesting that time spent in MVPA was the least co-dependent on SB (S1).

When data were considered as a composition, adjusted for age, BMI and sex, the school-time composition significantly predicted locomotor score ($P=0.01$; $r^2=0.05$), manipulative score ($P<0.0001$; $r^2=0.08$), and total MC score ($P=0.0002$; $r^2=0.09$), respectively. Ternary plots for the PA composition, with a continuous response surface, where increasing red saturation represents a more favourable outcome, and increasing blue saturation equates to a less favourable association with the outcome variables, namely; locomotor skill, manipulative skill, and total MC score (Figure 2)

********* Insert figure 2************

Based on the 95% CI's, total MC improved 0.18 units higher than the predicted mean when 5 minutes were reallocated from LPA to SB. Whilst for manipulative skills, a 0.14, 0.28, and 0.42-unit increase, vs. the predicted mean, was found when reallocating 5, 10 and 15 minutes, respectively, from LPA to SB (Table 1).

********* Insert Table 1************

DISCUSSION

Prior studies have examined the isotemporal reallocation of movement behaviours and health outcomes in several age groups (Grgic et al., 2018). However, this is the first study conducted in pre-school children to offer a unique insight into whether the school-time composition was associated with FMS, and to investigate predicted differences in FMS when a fixed duration of time is reallocated from one behaviour to another. In addition, the majority of prior studies have examined how the replacing time is related to body composition (Garcia-Hermoso et al., 2017), fitness (Fairclough et al., 2017) and cardiometabolic (Macgregor, Borghese, & Janssen, 2019) outcomes in later childhood (up to 6y) children from high-income countries, whilst few data are available concerning preschoolers from a low-income background. In accord with the aims of our study, we found that the participants of this study spent almost 70% of their school-time in SB, and when the spectrum of behaviours was treated as a composition, they significantly predicted locomotor, manipulative, and total MC scores, suggesting that the composition of several behaviours may potentiate children´s MC.

Children´s movement hours are predominantly composed of SB. Indeed, in a review of PA and SB in preschoolers, Hnatiuk et al. (2014) reported that the proportion of time spent in MVPA and SB during awake hours ranged from 2 to 41%, and from 34 to 94%, respectively. O´Brien et al. (2018) observed that time in PA and in SB in child-care hours were highly varied and inconsistent between studies, although preschoolers were noted to participate in high rates of SB in this setting. Likewise, different studies have

investigated the adherence of preschool children to 24-hour movement behaviours, with numerous reporting that the majority of children do not meet the recommendations, regardless of the ethnic or geographic context (Berglind & Tynelius, 2017; Chaput et al., 2017; De Craemer et al., 2018). When analyzing the existing evidence on the relationship between PA and FMS in childhood, results are equivocal. So, it is conceivable that this relationship in young children has been masked by the type of analysis used when processing data.

Concerning isotemporal reallocation, this study adds that for manipulative skills, an increasing pattern was observed (0.14, 0.28, and 0.42-units) when reallocating 5, 10 and 15 minutes, respectively, from LPA to SB. Stamatakis et al. (2013) reported that, albeit in children aged 2 to 12, TV viewing, but no other type of screen time, was associated with cardiovascular risk markers independently of PA, and using a single marker of screen time/ SB may conceal specific associations. Indeed, when considering the present study, TV viewing is highly unlikely to feature in the typical pre-school day, whilst fine-motor developmental tasks are a staple of the early years' curriculum, exemplifying the need to better discern types of sedentary behaviour (Stamatakis et al., 2013).

In similar work conducted with children (8.4±1.8 years-old), Burns et al. (2019) examined the relationships among school-time in SB, LPA and MVPA with FMS, and showed that replacing of SB and LPA with MVPA during school hours was significantly associated with higher FMS total scores in children. ~~In preschoolers, Leppänen et al.~~

(2016) used an isotemporal approach with Swedish 4-year-olds and observed that substituting 5 min per day of SB, LPA or MPA with 5 min per day of VPA was associated with higher fat free mass index and better scores for fitness tests. Although reducing time in low intensity for high intensity activities has been associated with a better FMS profile in children, our data showed that based on a compositional approach, more SB is associated with better manipulative skills scores in preschoolers.

It is also important to highlight that although locomotor and object control subscales are reasonably well correlated (r = 0.84–0.96) (Cools, Martelaer, Samaey, & Andries, 2009), they should be differentiated, given their independent importance towards predicting health behaviours (Robinson et al., 2015). The results of this study might suggest that the time being sedentary at preschool settings may not be so deleterious, at least when considering its repercussion in manipulative skills at these young ages. Thus, we could suggest that a "high-quality" SB at pre-schools (i.e. playing with puzzles and blocks, painting) may have a positive impact on manipulative skills. In this sense, the exploration of SB patterns and activities and its relationship with FMS could be considered an area for further exploration.

Indeed, a focus on manipulative is a key consideration in the context of the population in the present study. Writing ability in preschoolers develops as a gross motor activity, where finer movements are controlled by the forearm with power and strength in the shoulder and elbow pivots being central to control of movement (El-Dayem, Salem, &

El-Hadidy, 2015). Consequently, the use of a shoulder, elbow, wrist pivot is key in early development of writing skill. This is strikingly similar to the developmental process in acquiring overarm throwing skill (Langendorfer, Roberton, & Stodden, 2011) and prior studies have reported significant relationships between gross motor skills and handwriting skills in 5-6 year olds (El-Dayem et al., 2015). In this study, the link between SB and gross motor skill might therefore be explained, or at least influenced by the fact that in preschoolers, writing, painting, utensil use and similar sedentary tasks tend to be more gross in nature and share some similarities in early developmental trajectory to object manipulation skills such as throwing, as both involve a complex interaction between psychomotor skills, nervous system and muscular strength (Accardo, Genna, & Borean, 2013; Hamstra-Bletz & Blote, 1990).

We can also argue that the sedentary electronic lifestyle of young children, characterized by the use of smartphones (Kabali et al., 2015) may, at least partly, explain the current results, particularly when nearing its patterns to those of preschoolers from high-income countries. In a study with Australian preschoolers, Barnett et al. showed that the use of interactive and non-interactive electronic games showed a positive association with object control competence and no association for locomotor competence (Barnett, Hinkley, Okely, Hesketh, & Salmon, 2012). So, assuming manipulative technologies increase the manipulative skills to a certain standard, the current results suggest this

competence may be improved when adding "non-screen" manipulation activities during the school hours.

Moreover, our results showed a small but significant improvement of total MC when 5 minutes were reallocated from LPA to SB. Nonetheless, for the 5 min substitution, there was a narrow CI for locomotor skills, and positive for the manipulative ones. So, the total MC score appeared to improve, although the improvements are solely down to the changes in manipulative skill.

FMS emerge within a dynamic system consisting of a task, performed by a learner, in a particular environment (Newell, 1984). In this system, environmental considerations may influence motor development. So, relative to high-income countries, children from low-income families, as the assessed in this study, are less likely to meet the SB, and PA guidelines (Kracht, Webster, & Staiano, 2019), and have lower FMS proficiency (Bellows et al., 2017), which might be attributed to a lack of resources in the local environment, therein offering fewer developmental situations and learning experiences. ~~Giagazoglou et al. (2007) found that children of highly educated mothers had a higher mean developmental quotient on both locomotor and eye-hand coordination scales. In a study with American preschoolers, it was observed that compared to a norm-referenced sample, at-risk preschoolers were developmentally delayed in manipulative skills (Bellows et al., 2017). Similarly,~~ Indeed, Playford et al. (2017) indicated that SES was only associated with preschool children's fine motor skills and not with their gross motor

skills, and parent´s economic characteristics was confirmed as a correlate of preschoolers FMS in a systematic review study (Iivonen & Sääkslahti, 2014), although data on this field are still reduced and contradictory.

Moreover, the current compositional data was performed for school-time, and thus, unstructured high intensity activities outside school may have a positive impact on children´s FMS (Foweather et al., 2015), despite of the argument that teaching, practice and reinforcement are necessary to support the development of FMS in preschool children (Robinson & Goodway, 2009).

Thus, this study highlighted an important health issue concerning FMS, and provided useful information for teachers´ physical educationalists, and health professionals. Moreover, the development of all healthy movement behaviours should be a priority public health strategy in this age group.

Strengths and limitations of the study

The principal strengths of this study were that considering of the whole school-time as a predictor of FMS in preschoolers. Highlighting that relocating time from PA to SB is associated with an improved manipulative performance in a population in which studies are scarce is another strength of this study, as it extends understanding of movement behaviours and FMS in the broad context of preschoolers. Nonetheless, some limitations should be highlighted. The compositional approach used does not discriminate between

the type of activity children were performing while sedentary. There is evidence in the literature that classroom naps support learning in preschool children by enhancing memories acquired earlier in the day, compared with equivalent intervals spent awake (Kurdziel, Duclos, & Spencer, 2013). Likewise, the school-time schedule varies according to cultural context. Our study was developed with a specific low-income sample, whose PA opportunities that could improve their motor performance inside and outside school are scarce, and the lack of generalizability should be highlighted, as it may not reflect other context´s reality. Nonetheless, this study covers a specific low-income sample, which demographic characteristics are quite similar to those of children from other low-income geographical regions. Additionally, the number of children who meet the minimum wear-time criteria for accelerometer measurement inclusion (86%) must be acknowledged. This value is above the average observed in a study with the same age group, and considering the specificity of the evaluated population (living in vulnerable zones, some living without parents, many absences at school), it could be seen as a strength point.

Conclusion

The current study presents compositional data on school-time behaviours and FMS in preschoolers and highlights that school-time composition is a significant predictor of FMS. Moreover, a modest increase in ST, at the expense of LPA, during the school-time

may elicit a positive change in manipulative skills. There is an urgent need to better discern types of sedentary behaviour, prior to admonishing this very broadly defined behaviour.

IMPLICATIONS FOR SCHOOL HEALTH

Our study contributes to the growth of evidence concerning the importance of movement behaviours during school-time and its implication in preschooler´s fundamental movement skills. Interventions to promote locomotor and object control skills improvement should focus on the composition of all movement behaviours at preschool settings, considering short-period reallocation between movements behaviours along the day. These findings are key for pedagogical practices and future intervention studies.

Human Subjects Approval Statement

All the Helsinki Declarations' ethical aspects were followed (Association, 2013). The evaluation methods and procedures were approved by the Research Ethics Committee of Health Science Center of Federal University of Local University (protocol n. 2.727.698), and by the Education Board of city.

Conflict of Interest

The authors declare no conflicts of interest.

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Table 1. Isotemporal substitutions for 5, 10, and 15-minute reallocations

		Total MC	Locomotor	Manipulative
Add	**Remove**	**Total (95% CI)**	**Total (95% CI)**	**Total (95% CI)**
		5 minutes		

Sedentary	Light	**0.18***	**0.02**	**0.34**	0.04	-0.09	0.17	**0.14***	**0.01**	**0.26**
Sedentary	MVPA	0.28	-0.22	0.78	0.22	-0.08	0.51	0.06	-0.24	0.36
Light	Sedentary	-0.18	-0.39	0.03	-0.04	-0.17	0.08	-0.14	-0.26	-0.01
Light	MVPA	0.10	-0.54	0.75	0.18	-0.21	0.56	-0.08	-0.46	0.31
MVPA	Sedentary	-0.26	-0.70	0.19	-0.20	-0.46	0.07	-0.06	-0.32	0.20
MVPA	Light	-0.08	-0.67	0.52	-0.16	-0.51	0.20	0.08	-0.27	0.43
10 minutes										
Sedentary	Light	0.36	-0.07	0.79	0.08	-0.18	0.34	**0.28***	**0.02**	**0.53**
Sedentary	MVPA	0.58	-0.49	1.66	0.46	-0.18	1.10	0.12	-0.52	0.76
Light	Sedentary	-0.35	-0.77	0.07	-0.08	-0.33	0.17	-0.27	-0.52	-0.02
Light	MVPA	0.24	-1.13	1.60	0.38	-0.43	1.19	-0.15	-0.96	0.66
MVPA	Sedentary	-0.49	-1.34	0.35	-0.38	-0.87	0.12	-0.12	-0.62	0.38
MVPA	Light	-0.13	-1.28	1.01	-0.29	-0.97	0.38	0.16	-0.52	0.84
15 minutes										
Sedentary	Light	0.54	-0.11	1.19	0.12	-0.27	0.51	**0.42***	**0.03**	**0.81**
Sedentary	MVPA	0.93	-0.83	2.68	0.74	-0.30	1.78	0.18	-0.86	1.22
Light	Sedentary	-0.53	-1.15	0.10	-0.12	-0.49	0.25	-0.40	-0.77	-0.03
Light	MVPA	0.41	-1.77	2.59	0.63	-0.66	1.91	-0.21	-1.51	1.08
MVPA	Sedentary	-0.72	-1.92	0.48	-0.54	-1.25	0.17	-0.18	-0.89	0.54
MVPA	Light	-0.17	-1.83	1.49	-0.42	-1.40	0.57	0.25	-0.74	1.23

Note: * Significant at $P<0.05$, based on 95% CI. MC: motor competence; MVPA: moderate-to-vigorous physical activity
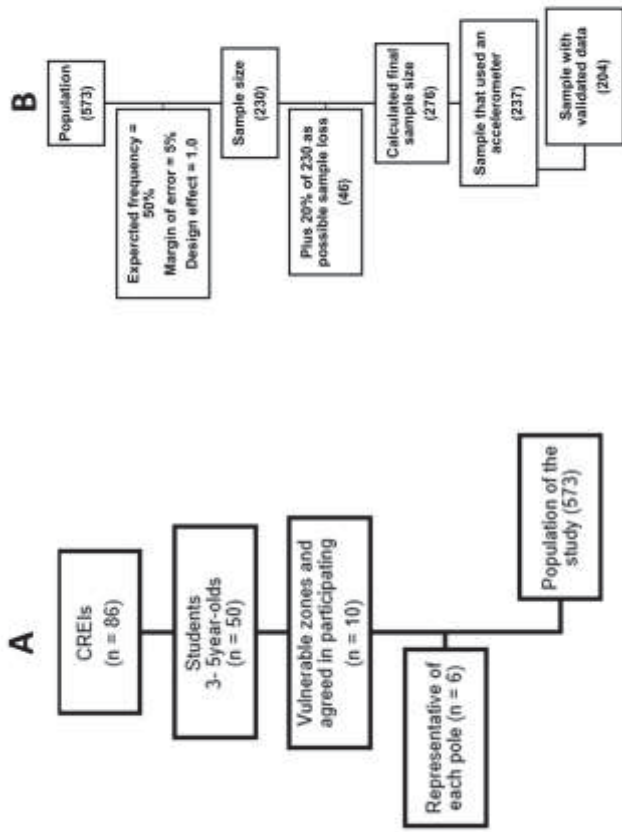
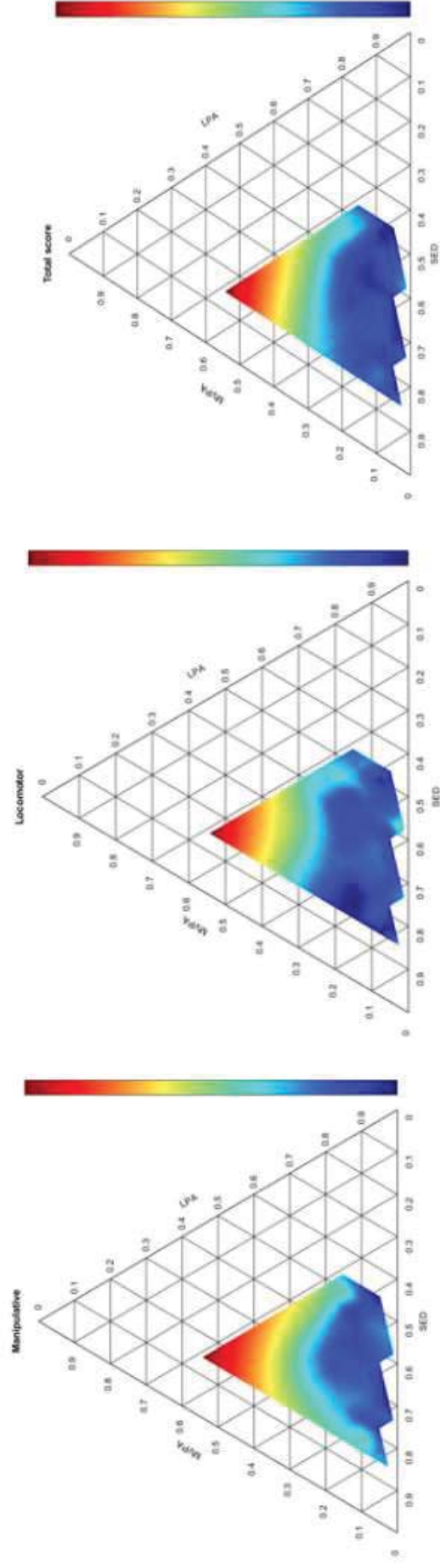Figure 1. CREI's and sample´s flowchart

Figure 2. Ternary plot of PA composition and manipulative, locomotor and total motor competence skill. The edges of the triangles are the pseudo-time axes, where each grid line represents 10% of the school-time composition, i.e., 0.1 = 10% of 600 min, = 60 min. The continuous response surface is coloured according to manipulative score, where red gradation represents comparably higher scores, while blue color gradation represents comparably lower scores.