Twenty-four-hour movement behaviours and fundamental movement skills in preschool children: A compositional and isotemporal substitution analysis

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24-hour movement behaviours and fundamental movement skills in pre-school children: a compositional and isotemporal substitution analysis

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ABSTRACT

Studies that have analyzed the association between the different movement behaviours and fundamental movement skills (FMS), have considered it in an independent manner, disregarding the compositional nature of 24-hour movement behaviours (24h MB). The aim of this study was to investigate the relationship between the 24h MB and FMS in preschoolers using a compositional data analysis approach. Two hundred and four preschoolers of both sexes, provided assessed physical activity (PA) and sedentary time (ST) data (Actigraph wGT3X), and FMS assessments (TGMD-2). Sleep duration (SD) was reported by parents through interview. Association of daily time composition of movement behaviours with FMS was explored using compositional analysis and isotemporal substitution (R Core Team, 3.6.1). When data were considered as a 24h MB composition based on PA, ST and SD, adjusted for age, BMI and sex, the composition significantly predicted locomotor (r^2=0.31), object (r^2=0.19), and total motor score (r^2=0.35), respectively (all P<0.001). Reallocation of time from light to moderate-to-vigorous PA was associated with greatest positive changes in total motor score. It is evident that achieving adequate balance between movement behaviours over the 24-hour period, and its' relationship with both locomotor and manipulative skills should be acutely considered and further investigated in early childhood.

KEYWORDS

24-hour movement behaviours, compositional analysis, fundamental movement skills, preschoolers

1.INTRODUCTION

The benefits of daily healthy behaviours such as adequate physical activity (PA), low exposure to sedentary behaviours (SB) and adequate sleep time (ST) in childhood are evidenced across empirical investigations [1].

Behaviours established in childhood impacts child's life [2] and track throughout life [3]. Physical inactivity in children under 5 years-old is associated with poor skeletal health, cardiometabolic risk factors and poor development of motor and cognitive skills [4], and contributes to the increased prevalence of overweight and obesity [5]. To compound the issue, it has been established that a large proportion of children do not engage sufficiently in moderate to vigorous physical activity (MVPA) [6,7], have excessive exposure to SB, and spend a few hours of the day to sleep [8,9], increasing the risk of deleterious effects on health and negatively contributing to their daily routines [5].

The integrative 24-hour movement guidelines [5] stated that infants should spend at least 180 minutes on various physical activities of any intensity and that at least 60 minutes are on MVPA. Moreover, it is suggested that good quality, regular sleep, lasting from 10 to 13 hours is essential for children´s health [1,2], though various studies universally suggest that a significant proportion of children do not adhere to the guidelines [8,9]. This is particularly important for low SES children, once PA facilities are scarce and a child of a low-income area has a greater chance of a delay in the development of their fundamental movement skills (FMS), operationally defined as the basis of more complex movements required to participate in sports, games, or other context specific PA, as running, jumping, throwing and catching, for example[10].

Studies that have analyzed the association between the different movement behaviours and FMS, have considered it in an independent manner, disregarding the compositional nature of 24-hour movement behaviours, and therein likely reporting spurious associations [2]. Low levels of adherence to PA guidelines in childhood may be related to low levels of FMS, and subsequently a greater risk of obesity [11], though the existing results show a weak to moderate degree of evidence [12,13]. There is also evidence that preschoolers who spend excessive time in SB are more likely to have lower FMS scores [14]. In addition, it is well known that an adequate amount of sleep plays a fundamental role in the memory consolidation process, and in the acquisition and retention of information [15], which is a privileged window for offline processing of new and ecologically relevant information.

Nonetheless, to the best of our knowledge, no study has applied a compositional data analysis approach to estimate FMS when reallocating fixed durations of time between movement behaviours in a sample of Brazilian preschool children, which is key for effective public health intervention development. Therefore, the aim of the present study was to investigate the relationship between the 24h-movement behaviours and FMS in preschoolers using a compositional data analysis approach.

2. METHODS

2.1 Study Description

This cross-sectional study uses baseline data from the school-based PA intervention program “Movement´s cool”. The program aims to promote PA after-school classes for low-income preschool children. All the Helsinki Declarations’ ethical aspects were followed [16].

2.2 Population and sample

Preschool children aged 3-to 5-year-old, of both sexes, and regularly registered in 2018 in the Child Education Reference Centers (CREI’s) of João Pessoa/PB were eligible for the study. In João Pessoa, the Preschool public education zone is divided in nine poles, where the eighty-six CREI’s are located. From those, fifty institutions have 3-to-5 years registered students, and ten institutions, located in vulnerable zones of each of the six poles agreed in participating in the study.

From the ten CREI´s previously selected, a representative number of CREI´s by poles was calculated and six were randomly selected and included in the study. These six CREI´s were distributed in each of the six different educational poles, with a total of 573 children, corresponding to the study´s population (Figure 1 - Panel A).

All the six preschools were located in deprived areas, 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 Human Development Index (HDI) [17] of the CREI´s areas range from 0.4 to 0.5.

The number of participants required in the study was estimated using G*Power (3.1.0). It was considered 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 potential loss (drop out and hardware failure). A total of 276 preschool children was considered/invited for assessments in the study, but 39 parents did not give consent for their children to participate. Accelerometer measurements were performed with 237 children. A total of 204 low-income children (86.07%) provided valid measurements based on the data reduction criteria (mean age = 4.51years-old; SD=0.42); mean body mass = 18.17 ±

3.71kg; mean height = 106.00 ± 7.06 cm; 101 boys) (Figure 1 - Panel B). The *a posteriori* calculated sample´s power was > 0.9.

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

2.3 Study design

Children enrolled in CREI´s program, attend preschool Monday to Friday, starting at 7am, and finish at 5 pm. In this study, only the preschool period was analyzed. Measurements were performed during a three-month period between March and May 2018. Levels and patterns of PA and sedentary time (ST) were 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).

All socio-demographic data (children´s age, birth date, parent´s contact and address) was provided by the school administration. Each parent was asked about their children´s participation in structured PA outside school. Anthropometric (body mass and stature) and motor skills data were collected, and the accelerometer was worn for seven consecutive days by the participating children.

2.4 Variables and protocols

Anthropometric measurements

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 [18]. Body mass index (BMI) was calculated by dividing body weight with the squared height in meters (kg/m^2).

Movement behaviours

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 [19]. The preschool teachers of the CREI's received verbal and written instructions for the correct use of the accelerometer, including placement, and the correct positioning. The teachers were instructed to register an activity diary of wear and non-wear time. The device initialization, data reduction and analysis were performed using the ActiLife software (Version 6.13.3).

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

Accelerometers were setup to measure acceleration at a 30 Hz sampling rate and analyzed as ActiGraph counts considering vector magnitude and using a 15-s epoch length [20]. Periods of ≥20 min of consecutive zero counts were defined as non-wear time and removed from the analysis, using ActiLife standard approaches. The first day of accelerometer data was omitted from analysis to avoid subject reactivity [21]. For the purpose of this study, preschool 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 was considered valid. 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 for vector magnitude proposed by Butte et al. [22], 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 using the 819 counts/15 s cut-point, in addition to requiring the activity to be sustain for 10 consecutive min or more, as done in previous study [23]. Habitual PA for the preschool time was estimated as the average counts per minute for the time between 7am and 5 pm and for the whole day.

Parents reported children’s usual daily sleep hours. This approach has been validated against estimates from sleep logs and objective actigraphy in young children [24]. Parents were asked to recall the total average hours their child sleep as follows: “On weekdays, how many hours of sleep does your child usually have during the night?” and “On weekend days, how many hours of sleep does your child usually have during the night?”. The questions were made separately for weekdays and weekend days and reunited to analyzes. Overall sleep hours were calculated as follows: ((Sleep on weekdays x 5) + (Sleep on weekend days x 2))/7.

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 [25]. This test evaluates gross motor performance in children aged 3 to 10 years [25], and consists of two factors: 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 at preschool, according to the guidelines recommended by Ulrich [26]. Before the testing of each skill, participants 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. Participants 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 assessor who do not administered the tests. The time taken to assess each child was approximately 40 minutes.

Using the Media Player Classic software, a total of 4.896 videos, referring to 204 children were analyzed to evaluate skills´ criteria. Two Professors in the Motor Behaviour field (professors in Brazilian institutions), with experience in assessing the TGMD-2, carried out a training process on the protocol´s criteria with a master student who did not participate in data assessment. The training process was carried out during two weeks. Approximately 10% of the videos were randomly analyzed twice by the evaluator, with an interval of ten days between each evaluation, to determine the intraclass correlation coefficient (ICC). It was observed a high agreement for the locomotion score: ICC= 0.93 (95% CI: 0.69 - 0.98), for object control score: ICC= 0.98 (95%CI: 0.93 – 0.99), and for total motor score: ICC: 0.96; (95% CI: 0.82 – 0.99).

The locomotion and object control scores are based on the presence (one) or absence (zero) of each of the performance criteria. For each subtest the sum of the raw scores varies from (0-48 points).

2.5 Statistical analysis

The analysis conducted in the present study was based on a compositional data paradigm. Compositional data analysis represents well-established field of statistics which has been used in diverse, multivariable proportion-type data, including nutrition (e.g. food compositions) [27] as example. Standard and compositional descriptive statistics were computed for comparison; where, alternate to the standard arithmetic mean, the compositional mean is obtained by, firstly, computing the geometric mean for each individual behaviour and subsequently normalizing the data to the same constant as the raw data, i.e. 1. This measure is coherent with the relative and symmetrical scale of the data [28]. Moreover, univariate statistical measures of dispersion, for instance standard deviation, are not coherent with the intrinsic inter-dependent multivariable nature of compositional data. The univariate variance of a compositional variable contains no information as the variability of the time spent on a single behaviour is intrinsically linked to the variability of the time spent in another behaviour [29]. Thus, the dispersion of compositional data is robustly estimated using the variation matrix [28], which summarizes the variability structure of a data by means of log-ratio variances [2]. 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 1 indicates the opposite. We adopted a compositional approach based on an isometric log-ratio (ilr) data transformation, adapted from Hron [30] (For a detailed step-by-step guide, see Chastin[2]) 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 [31], 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 [32].

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 between activity behaviours, whilst the third and fourth remained unchanged. This was achieved by systematically creating a range of new activity compositions to mimic the reallocation of 10 and 20 min, respectively, 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 (representing a 10- and 20-min reallocation between two behaviours) were used to determine estimated differences (95% CI) in all outcomes. The children from the current study spend 10 hours per day at preschool settings. Physical activity guidelines recommend preschool-aged children should engage in at least 15 minutes per hour of total activity (light, moderate, and vigorous intensity) in the child care setting [33]. So, we chose to do 10- and 20-minutes reallocations, to provide practical and applicable implications at children's context.

Concordant with Dumuid et al. [32], in the compositional regression models, the compositional predictor (expressed as a set of ilr coordinates) was used as the exposure variable. Confounders were entered in the models as covariates by backward elimination and were retained if the corresponding p-values were <0.2, and were the same for both linear and compositional regression models for each outcome. The linearity of the association between predictors and outcome examined, and in accord with STROBE guidelines, a sensitivity analysis [34] was conducted for each model by removing 10% of cases randomly and checking for a statistically significant change in the results. Statistical significance was accepted at P<0.05. All analyses were conducted in R (R Core Team, version 3.6.1, 2019).

3. RESULTS

Descriptive statistics

Descriptive statistics of the proportion of time spent in the four behaviours and locomotor, object control and total motor score are displayed in Table 1. The most obvious difference is found with the mean relative amount of time spent in MVPA, which is under-estimated by the arithmetic mean with respect to the compositional alternative by ~1% of the day (equating to roughly 14 minutes). The distribution of the children's time-use composition is presented in Figure 1 as ternary plot matrices with three behaviours represented at a time. Ternary plots can be understood as the scatterplots of compositions [2]. The dispersion structure is represented by 25%, 50%, 75%, 90%, 95% and 99% normal-based probability regions around the compositional center.

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

The variability of the data is summarized in the variation matrix (Table 2) containing all pair-wise log-ratio variances. A value close to zero suggests that the time spent in the two respective behaviours are highly proportional. For instance, the variance of log (Sedentary/LPA) is 0.11, which reflects the (proportional) relationship or co-dependence between the two behaviours. The highest log-ratio variance involves MVPA, suggesting that time spent in MVPA is the least co-dependent on the other behaviours.

*******************Insert Table 2***********************

Compositional analysis

When data were considered as a 24-hour movement composition based on PA in two intensities (light and moderate-to-vigorous), sedentary time and sleep time, and adjusted for age, BMI and sex**,** the children's time-use composition significantly predicted locomotor score (P<0.0001; r^2=0.31), object control score (P<0.0001; r^2=0.19), and total motor score (P<0.0001; r^2=0.35), respectively.

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

Isotemporal reallocation

Based on the 95% CI's, adding MVPA at the expense of LPA was found to have the greatest theoretical influence on total MS. However, adding MVPA at the expense of any other behaviour was equivocal. Reallocation of behaviours yielded significant theoretical changes in manipulative skills, but had an equivocal impact on locomotor skills. Table 3 details all pairwise reallocations, for 10 and 20 minutes, respectively.

*******************Insert Table 3***********************

4. DISCUSSION

Although prior studies have examined the association between PA and FMS [35] or SB and FMS [14] in preschool children, to the best of authors knowledge, this is the first study to analyze the association between the 24-hour compositional movement behaviours and FMS of children at these ages. In addition, the majority of prior studies have examined this composition in samples of children from high-income countries [7,8].

Understanding the movement behaviour-FMS relationship in preschool children from low-income environments is a key first step to promoting positive changes in children's health and well-being via FMS. Moreover, although some previous studies have examined the isotemporal reallocation of movement behaviours and health outcomes in several age groups [36], this is the first study to addresses how 24-hour movement associates with FMS, according to a compositional and isotemporal substitution framework approach.

Previously, the lack of association between PA (at various intensities) and FMS and sleep outcomes were tenuously explained by the limited variance in the PA data and the overall high levels of LMVPA (>500 min/d), and FMS proficiency (93% ranked as average or better) of preschool children from low-income settings [37]. The children from our study highlighted an average amount of 230min/day of objectively measured light, moderate and vigorous PA, and low FMS scores for age and sex. However, the use of traditional linear regressions for compositional data is flawed, as in commonplace, it assumes no time-bounds, and leads to the spurious inference that movement behaviour does not predict locomotor, object control or total motor score. Considering each movement behaviour in an isolated manner is a flawed approach, given that movement behaviours are necessarily bound to 1440 minutes per day. All incumbent movement behaviours co-exist as a whole or composition, and thus, the time spent in one behaviour effects, and is affected by the other behaviours during the remaining time of the day [38]. Accordingly, we demonstrated that, following isotemporal reallocation of time between activity pairs, MVPA elicited the greatest positive impact on total MS.

Even considering the low to moderate degree of evidence between PA and motor development [12], in a systematic review study, no association was seen between time spent in SB and motor performance in FMS [39], and although the importance of sleep duration is evident for health outcomes, no association with FMS was highlighted until then. In our study, the associations between movement behaviours and FMS were seen when data were considered as a children's time-use composition, adjusted for age, BMI and sex, and might explain the contradictory findings reported in observational studies [14,40]. As a 24-hour movement composition, behaviours significantly predicted locomotor, object control, and total motor scores. According to Stodden et al. [41], during early childhood, longer exposure to different physical practices and consequent increase in PA levels favors to new motor experiences. Already in older children and adolescents this process occurs in reverse, where the levels of motor performance determine the levels of PA, because the most skillful children tend to engage in different physical activities and, consequently, have higher levels of PA compared to the less skilled. Nonetheless, there is currently little or no evidence regarding the relationship between 24-hour movement behaviours with FMS in preschoolers. Based upon this gap in the literature, we may suggest that the composition of several behaviours may potentiates positive/negative trajectories with FMS. Early childhood represents a critical period for FMS development [42]. Indeed, studies have suggested that mastering these basic skills in the early years is crucial for participation and engagement in sports, games, and other forms of PA during childhood and adolescence [41], and a higher motor proficiency during childhood has been associated with adherence to PA guidelines in adulthood [43]. Thereby facilitating children to increase their PA engagement and /or participation as well as potentiate the enjoyment of being active, leading towards the accrual of greater health benefits [44].

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 [7-9], and only 10 to 20% of the children worldwide meet movement behaviours guidelines [6,9]. The depicted ternary plots of the 24-hour movement compositions provided a visual representation of the proportion of each behaviour, as part of a whole, and reinforce the previously reported great amount of time spent in SB by preschool children. Moreover, relative to high-income countries, children from low-income countries are less likely to meet the sleep, ST, and PA guidelines [45], which might be attributed to a lack of resources in the local environment, therein offering fewer developmental situations, learning experiences, and opportunities for sports practice.

Our data also showed that increasing time spent in MVPA at the expense of LPA was found to have the greatest theoretical influence on total MS. However, adding MVPA at the expense of any other behaviour was equivocal, as sedentary time also has a theoretical influence on total MS and on object control skills. These results might therefore be explained, or at least influenced, by the fact that in early developmental trajectory, predominant activities, such as writing, painting, and similar sedentary activities, share similarities to object control skills, such as throwing, as both involve a complex interaction between psychomotor skills, the nervous system, and muscular strength [46].

The overarching strength of the present study is the use of a sensitive compositional and isotemporal approach based on objectively and validated measurement of PA and SB to assess movement behaviours in preschool children. The use of a compositional approach allows all movement behaviours to be considered, without being hindered by co-linearity, thereby permitting meaningful and accurate inferences to be drawn [2]. In addition, the assessment of a process-orientated measure of FMS in children aged three to five years, a particularly important group, given the closeness to adiposity rebound and the vulnerability of those living in low-income settings is a strength to highlight. Our study has limitations that should be highlighted. As there are no prior published studies that the authors are aware of, which have used a compositional behaviour analysis to associate with FMS or worked specifically with low-income preschool population, direct comparisons with other studies are difficult to make. However, this clearly highlights the need for further examinations of the compositional nature of movement across ethnic and geographic locations, according to specific contexts. Finally, the use of parents reported sleep time is a limitation and may be considered an area to adapt or refine for future research.

Our study suggests that the 24-hour composition is important in understanding FMS in children, and represents an important finding, particularly given the proliferation of 24-h movement guidelines (including Sleep, PA, SB). Researchers must consider the composition and interaction of whole-day behaviours for creating and optimizing interventions to benefit children's movement skills.

5. CONCLUSION

This is the first study to analyze the 24-hour movement behaviours and FMS in preschool children using a compositional and isotemporal reallocation approach. Our results highlighted that increasing MVPA, but only at the expense of LPA, was associated with positive changes in total MS. Furthermore, adding MVPA at the expense of any other behaviour was equivocal; whilst reallocation of behaviours yielded significant theoretical changes in object control skills, but had an equivocal impact on locomotor skills. It is evident that achieving adequate balance between movement behaviours over 24 hours, and its' relationship with both locomotor and object control skills should be further investigated in early childhood. Thus, the development of all healthy movement behaviours should be a priority public health strategy in this age group, and such information is key for parents, teachers, physical educationalists, and those working with young children.

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Table

Table 1. Descriptive statistics of time in movement behaviors

	Sleep	SB	LPA	MVPA	Locomotor	Object control	Total MS
Min/day - mean	835.2 (187.2)	374.4 (144)	187.2 (72)	43.2 (14.4)	18.17 (6.62)	18.94 (6.94)	37.11 (11.48)
Arithmetic mean	0.58 (0.13) [58%]	0.26 (0.10) [26%]	0.13 (0.05) [13%]	0.03 (0.01) [3%]	-	-	-
Compositional mean	0.54 [54%]	0.27 [27%]	0.15 [15%]	0.04 [4%]	-	-	-

Min/day: minutes per day; SB: sedentary behaviour; LPA: light physical activity; MVPA: moderate-to-vigorous physical activity; Total MS: Total motor score. Data are presented as mean (Standard Deviation (SD) [%time per day], except for *"compositional mean"*, which cannot include SD.

Table 2. Variation matrix

	Sleep	Sedentary	LPA	MVPA
Sleep	0.000	0.293	0.303	0.350
Sedentary	0.293	0.000	0.112	0.243
LPA	0.303	0.112	0.000	0.123
MVPA	0.350	0.243	0.123	0.000

LPA: light physical activity; MVPA: moderate-to-vigorous physical activity. A value approaching "0" indicates high proportionality between pairs of behaviors, whilst a value approaching "1" indicates the opposite.

Table 3. Isotemporal substation of activity behaviors

		Total MS	Locomotor	Object control
Add	**Remove**	**Total (95% CI)**	**Total (95% CI)**	**Total (95% CI)**
		10 minutes reallocated		
Sleep	Sedentary	**-0.18*** (-0.32, -0.04)	-0.07 (-0.15, 0.01)	**-0.11*** (-0.21, -0.02)
Sleep	Light	**0.42*** (0.12, 0.72)	0.14 (-0.03, 0.32)	**0.27*** (0.07, 0.47)
Sleep	MVPA	-0.58 (-1.15, 0.01)	-0.22 (-0.44, 0.01)	-0.36 (-0.74, 0.02)
Sedentary	Sleep	**0.18*** (0.04, 0.31)	0.06 (-0.01, 0.14)	**0.11*** (0.02, 0.2)
Sedentary	Light	**0.59*** (0.21, 0.98)	0.21 (-0.02, 0.43)	**0.38*** (0.13, 0.64)
Sedentary	MVPA	-0.4 (-0.97, 0.16)	-0.15 (-0.48, 0.17)	-0.25 (-0.63, 0.13)
Light	Sleep	**-0.4*** (-0.68, -0.11)	-0.14 (-0.3, 0.03)	**-0.26*** (-0.45, -0.07)
Light	Sedentary	**-0.58*** (-0.95, -0.21)	-0.2 (-0.42, 0.02)	**-0.38*** (-0.63, -0.12)
Light	MVPA	**-0.98*** (-1.77, -0.19)	-0.36 (-0.82, 0.11)	**-0.62*** (-1.16, -0.09)
MVPA	Sleep	0.5 (-0.05, 0.95)	0.19 (-0.1, 0.48)	0.31 (-0.02, 0.65)
MVPA	Sedentary	0.33 (-0.16, 0.81)	0.12 (-0.16, 0.41)	0.2 (-0.13, 0.53)
MVPA	Light	**0.92*** (0.19, 1.65)	0.33 (-0.09, 0.76)	**0.59*** (0.1, 1.08)
		20 minutes reallocated		
Sleep	Sedentary	**-0.33*** (-0.62, -0.11)	-0.13 (-0.29, 0.03)	**-0.23*** (-0.42, -0.04)
Sleep	Light	**0.86*** (0.25, 1.46)	0.3 (-0.06, 0.65)	**0.56*** (0.15, 0.97)
Sleep	MVPA	-1.26 (-2.5, 0.2)	-0.47 (-1.2, 0.25)	-0.79 (-1.62, 0.05)
Sedentary	Sleep	**0.35*** (0.08, 0.61)	0.13 (-0.03, 0.28)	**0.22*** (0.04, 0.4)
Sedentary	Light	**1.2*** (0.42, 1.98)	0.42 (-0.03, 0.88)	**0.78*** (0.26, 1.3)
Sedentary	MVPA	-0.92 (-2.14, 0.31)	-0.35 (-1.06, 0.37)	**-0.57*** (-1.39, 0.26)
Light	Sleep	**-0.78*** (-1.34, -0.22)	-0.27 (-0.6, 0.06)	**-0.51*** (-0.89, -0.13)
Light	Sedentary	**-1.14*** (-1.88, -0.41)	-0.4 (-0.83, 0.03)	**-0.74*** (-1.24, -0.24)
Light	MVPA	**-2.04*** (-3.71, -0.37)	-0.74 (-1.72, 0.23)	**-1.3*** (-2.43, -0.17)
MVPA	Sleep	0.95 (-0.12, 1.88)	0.36 (-0.18, 0.9)	0.59 (-0.03, 1.22)
MVPA	Sedentary	0.59 (-0.33, 1.51)	0.23 (-0.31, 0.76)	0.36 (-0.26, 0.98)
MVPA	Light	**1.81*** (0.39, 3.22)	0.65 (-0.17, 1.48)	**1.15*** (0.2, 2.11)

Note: * Significant at P<0.05, based on 95% CI. Total MC: Total Motor Score.

Figure

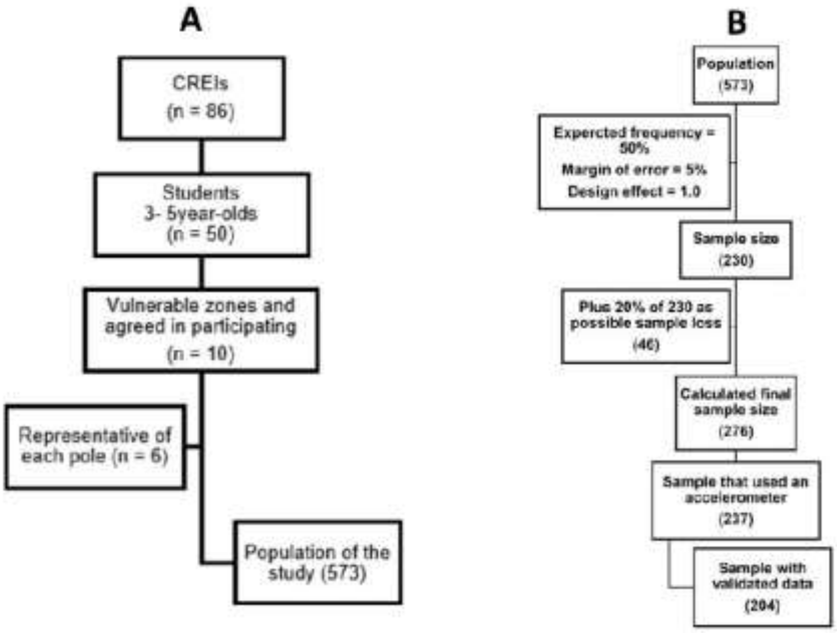

Figure 1. CREI´s (Panel A) and sample´s (Panel B) flowcharts.

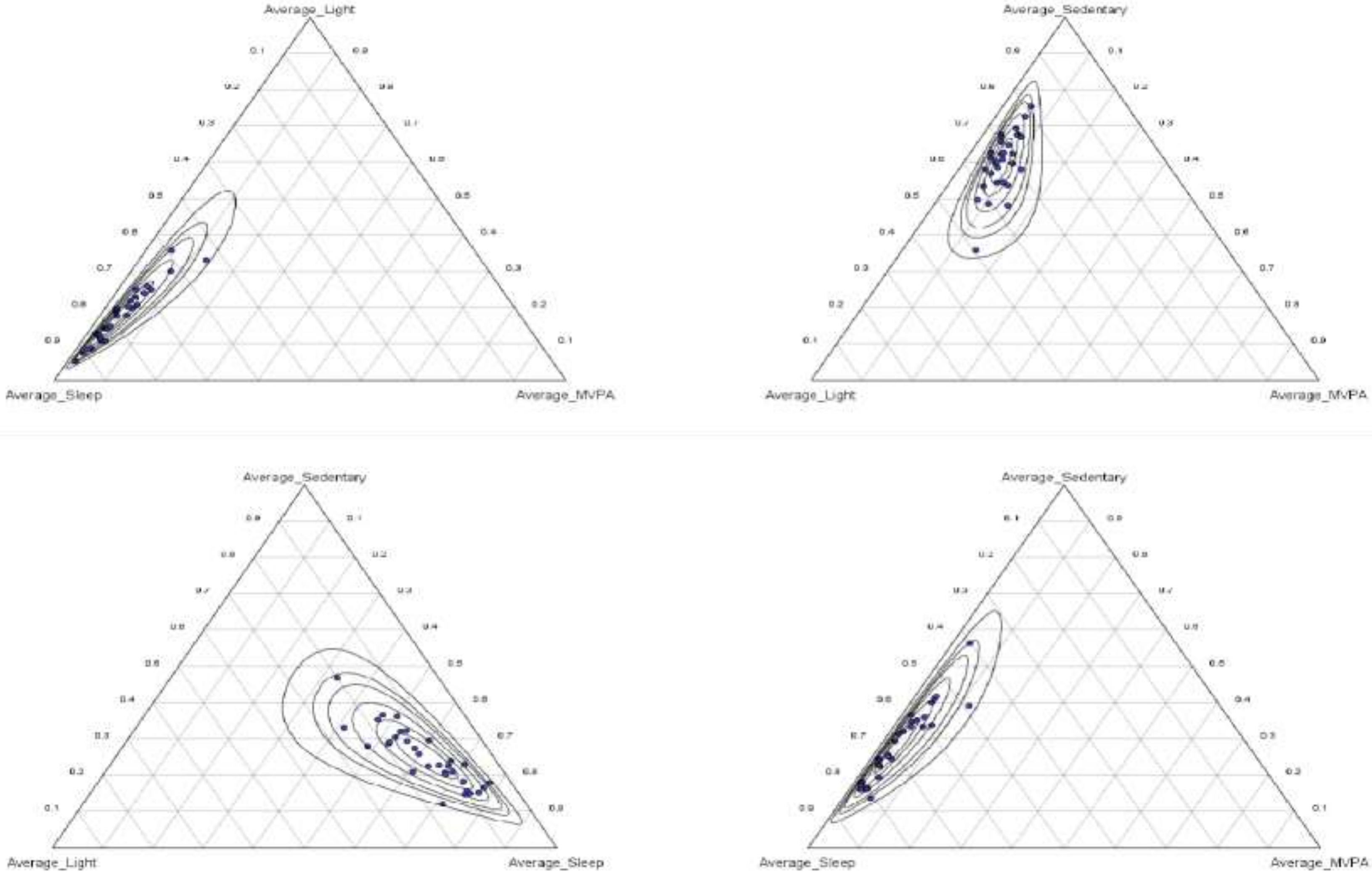

Figure 2. Ternary plots of the 24-hour movement compositions, where the probability regions are around compositional centre