

Measuring the Environment for Physical Activity in Early Childhood: A Narrative and Systematic Literature Review

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Abstract

The aim of this study was to systematically review the protocols to assess the built environment in the context of early childhood and physical activity. Three databases were systematically searched for studies that examined associations between the built environment and preschoolers' physical activity levels. A total of 27 studies were included in the analysis. Results show a clear distinction between approaches administered in the neighborhoods and childcare domains. Although Geographic Information Systems are employed in most studies in the neighborhood domain and have been understood as an objective approach, findings have indicated a lack of specificity regarding early childhood environmental variables, which can compromise protocols content validity. Further, although self-perceived approaches were found in only three studies, analysis of instrument content validity and cross-cultural adaptation also showed limited validation evidence. In the childcare context, the micro-scale built environment is a strong trend in customization of measurement protocols in early childhood. However, present findings have indicated the necessity for enhancements to validation procedures, particularly regarding internal consistency and content validity to develop needed customization. Therefore, future research should utilize more rigorous validation techniques to address the micro-scale built environment within the context of early childhood physical activity levels.

Keywords : physical environment, measuring the built environment, early childhood, physical activity levels

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Introduction

Research that focuses on physical activity (PA) levels in early childhood is a most critical tenet for life-long health promotion. A conducive environment for PA is one of the key areas to support healthy behavior in children (Boldemann et al., 2006; Tonge et al., 2016). That said, although previous reviews approached the matter of measurements of the built environment for PA (Brownson et al., 2009; Sallis, 2009), to the best of our knowledge, no reviews have addressed the protocols used to analyze the physical environment in the specific context of early childhood PA levels. The present study addressed the following research question: In the context of preschoolers' PA levels, to what extent do environment measurement protocols consider early childhood environmental specificities? Thus, the purpose of this study was to analyze approaches, associated validation procedures, and trends of the protocols utilized in current research on the built environment within the context of PA patterns in early childhood.

The understanding of this topic is essential to provide accurate evidence to explore PA patterns at all ages. Adulthood patterns of PA are strongly related to adolescence (Batista et al., 2019; Bentham et al., 2017; Kjønniksen et al., 2008), childhood (Batista et al., 2019; Telama et al., 2014), and early childhood (3-5 years-old) PA levels (Rovio et al., 2018; Telama et al., 2014). For instance, a longitudinal study demonstrated that the PA levels of a three-year-old, evaluated by the mother, could predict the child's PA behavior at the age of 15 for boys and 24-years old for girls (Telama et al., 2014). Evidently, PA policies targeting early ages can help promote long-lasting physically active lifestyles.

Apart from the association to further life periods, recent evidence has shown that preschoolers can benefit from an active lifestyle in a variety of ways (Carson et al., 2017; Tandon et al., 2016). Preschoolers' PA levels are positively associated with cognitive function (Carson et al., 2017; Tandon et al., 2016), motor competence (Carson et al., 2017; Cattuzzo et al., 2016), academic achievement (Tandon et al., 2016), psychosocial function (Carson et al., 2017; Tandon et al., 2016), physical fitness (Carson et al., 2017; Martinez-Tellez et al., 2016; Steinberger et al., 2016), and obesity (Zhang et al., 2018). Aside from all of this evidence, the American Heart Association contended that most children experience a decline in PA levels over time (Steinberger et al., 2016).

Research focusing on PA and the environment has increased since the late 1990s when PA behavior became more thoroughly understood through an multidomain perspective, including the environment as a critical domain (Sallis, 2009). PA environment is described as the place where people have the opportunity to be physically active in a natural or a built environment (i.e., school, workplace, neighborhood, recreation areas) (Sallis, 2009). In early childhood, research has demonstrated that the childhood environment has an impact on weight control (Berg, 2015), later disability (Devarajan et al., 2020), screen time exposure (Timperio et al., 2017), aspects of children's developmental vulnerability (Christian et al., 2017), as well as popular environmental concerns such as carbon emissions and global warming (Devarajan et al., 2020) and PA levels in early childhood (Tonge et al., 2016). Neighborhood infrastructure, including parks, green spaces and playgrounds, is correlated to PA levels related to children, adolescents, and adults (An et al., 2019; Devarajan et al., 2020). Finally, the childcare environment influences 50% of the PA variance in preschoolers and, therefore, is an essential and the most frequent variable studied in PA in early childhood (Bower et al., 2008; Gray et al., 2015; Määtä et al., 2019; Tonge et al., 2016).

The PA pattern related to the environment in early childhood may vary considerably (Christian et al., 2017). For instance, one study found that the presence of water (e.g. lake, pool, pond, river) was positively associated with preschoolers' PA levels. Conversely, the presence of bike lanes and the quality of sidewalks were not (Aarts et al., 2010). Similarly, a school playground with more free space and portable equipment is strongly associated with early childhood PA (Berg, 2015). The presence of swings and sandboxes is negatively related to children's PA (Gubbels et al., 2012). From a neighborhood perspective, the well-known walkability index is not always associated with early childhood PA, likely because playing seems more relevant than walking for young children. Finally, the availability of parks or playgrounds is insufficient to provide a notion on individual accessibility (Xu et al., 2017) since the playground characteristics are crucial to determine childhood PA (Berg, 2015; Driediger et al., 2019). In fact, recent developments on urban planning for children defends that a child-friendly urban planning should consider structures beyond the fences of the traditional playgrounds (Gill, 2021). This fact expands and reinforces the necessity of creating assessment protocols based on early childhood needs and specificities. Finally, a systematic review showed that the physical environment domain in the context of PA and

preschoolers' sedentary and healthy behaviors could present at least 12 variables to analyze (Tonge et al., 2016).

It is unclear whether the current research has employed validated measurement protocols that cover early childhood specificities and variables, such as playground equipment characteristics, opportunities to play outside the traditional playgrounds, presence of water, and playing opportunities. Further, interventions in increasing PA levels may be compromised if the physical environment is not adequately analyzed (Driediger et al., 2019). Therefore, a systematic literature review is fundamental to identify the measurement protocols, validation procedures, and trends within the context of physical environment in such a peculiar life period as early childhood.

Method

Eligibility Criteria

To be included in this paper, studies that met the following criteria were included: (1) offered data that could be directly applied to subjects in early years (i.e., 0 to five years old); (2) presented the protocol for the measurement or analysis of the physical environment; (3) showed the PA levels or outdoor play as one outcome; (4) was a peer-review article; and (5) articles written in English. Studies were not included if they were literature reviews or meta-analyses.

Search Strategy

The search procedure was conducted using the databases Medline, Science Direct, and Web of Science. Refined searches were developed to find articles that presented the combination of the targeted keywords in the title or the abstract, based on three groups: (1) environment (“environment”, “built environment”, “neighborhood”, “outdoor”, “playground”, “child care”, “parks”, “green space”), (2) targeted life period (“preschool”, “early childhood”, “preschoolers”, “early years”, “children”, “young children”, “child”,

“toddlers), and (3) physical activity (“physical activity”, “physical inactivity”, “physical exercise”, “exercise”, “physical fitness”, “sedentary”, “sedentarism”, “outdoor activity”). Preliminary searches revealed that, to appropriately narrow the search process, syntaxes should be developed and tested using one keyword of each of the group, with the logical operator “AND” targeting articles abstract and title. This search strategy was determined to ensure that all three necessary groups (Environment, Life Period and Physical Activity) were presented in the articles selected. All keywords were revised, and final searches were conducted until July 15th, 2020, to ensure full coverage. A time limit was not defined in the search criteria, as it was intended to cover all research available on the topic to date. The retrieved articles were imported to Mendeley (reference manager) (Foeckler et al., 2020) to check duplicates. Syntaxes that produced at least one relevant article are presented in table 1.

Table 1. *Results of the Search Strategy*

Syntaxes	Articles
(1) "environment"; (2) "early childhood"; (3) "physical activity"	116
(1) "built environment"; (2) early childhood; (3) "physical activity"	17
(1) "neighbourhood"; (2) early childhood; (3) "physical activity"	37
(1) "neighborhood"; (2) "preschoolers"; (3) "physical activity"	14
(1) "physical environment"; (2) "young children"; (3) "physical activity"	52
(1) "environment"; (2) "early years"; (3) "physical activity"	45
(1) "environment"; (2) "preschool children"; (3) "exercise"	4
(1) "environment"; (2) "toddlers"; (3) physical activity	3
Total	288

Data Extraction

The data analysis was considered according to various aspects related to the measurements of the physical environment. We described separate data tables according to the type of physical environment: one for the neighborhood environment and another for the childcare environment (the studies that analyzed both environments were allocated in both tables). The tables were composed of the following aspects: reference, study design, country, age (years), sample, protocol name, approach, environmental factors (i.e., physical variables), validation

process, and reference. In the group for the physical environment of the neighborhood, the approach aspect was divided into three categories based on a previous review (Brownson et al., 2009): Perceived (Self-Reported), Objective Measure, and Observational or Audit. A category named “Observational or Audit (Facility Self-assessment)” was created by the authors and included in the childcare group. Additionally, the “environmental factors” characteristic was composed of the domains that each protocol approached to provide details and specificity of the protocol. Although many protocols offer several measurement domains, in this paper, only the physical variables were considered in the analysis.

Results

General Description of the Studies

A total of 313 studies were identified. The removal of 25 duplicates resulted in 288 papers to submit to the eligibility criteria. The 288 references were submitted to a previous title, and abstract screening and 193 articles were excluded. Further, the remaining 93 full-text articles were assessed for eligibility, and 27 were included in the review.

Essential Characteristics of the Studies

The study's characteristics are summarized in Tables 1 and 2. Of the 27 papers included, nine were developed in Australia, five in the United States, five in Canada, three in the Netherlands, and one in China, Finland, Germany, Sweden, and Switzerland. As expected, the majority of studies were cross-sectional designed (24; 88.8%), followed by two longitudinal investigations, one protocol description, and one validation study. The neighborhood physical structure was present in 15 references (see Table 1), and twelve studies approached the childcare space (see Table 2). One investigation was conducted in both environments (Christian et al., 2016).

Table 2. Measures of Built Environment in the Neighborhood Domain

Study	Study Design	Country	Age (years)	Sample	Technique name	Approach	Environmental Factors (Physical Variables)	Validation Process
Aarts et al. (2010)	Cross-sectional	Netherlands	4-6	6470	Dutch Questionnaires	Perceived (Self-Reported)	Type of Neighborhood. Presence of the Green in the neighborhood. Presence of water (lake, pool, pond, or river) in the neighborhood; Traffic situation; Quality of sidewalks and bike lanes, Diversity of routes; Distance to facilities; Satisfaction with play facilities; Satisfaction with public space and green space.	NA
Bringolf-Isler et al. (2015)	Cross-sectional	Switzerland	4-7	611	Geographic Information System (GIS)	Objective Measure	Main streets; Building density; Mixed land use; Green space; Woods; School children density. Land use mix; Playgrounds per km ² ; Green spaces per km ² ; Parks per km ² ; Intersections per km ² ; Public transit stops; Walkability index; Moveability index.	NA
Buck et al. (2015)	Cross-sectional	Germany	2-9	460	Geographic Information System (GIS)	Objective Measure	Function: Walkability; Safety: Road speed; Facilities: Outdoor play/activity space, recreation facilities, distance to closest park, yard space.	N/A
Carson et al. (2014)	Cross-sectional	Canada	0-5	511	Geographic Information System (GIS)	Objective Measure	Outdoor space; Greenness; Availability and quality of public open space; Traffic exposure; Walkability index; Access to local amenities. Functional: walkability index Esthetic: tree density Destination: outdoor play/activity space index, toddler recreation density, Park density	NA
Christian et al. (2016)	Protocol	Australia	2-5	2400	Geographic Information System (GIS)	Objective Measure	Block physical disorder and physical decay; Physical condition of the yard, street, and surrounding buildings	Validated using Cronbach's alpha for Internal consistency
Hunter et al., (2019)	Cross-sectional	Canada	2-3	249	Geographic Information System (GIS)	Objective Measure		
Kimbro et al. (2011)	Cross-sectional	USA	5	1822	Simplified version of the block physical disorder and physical decay measures created by Sampson and Raudenbush (2004) and questions about the physical condition of the yard, street, and surrounding buildings	Observational or Audit		

Lu et al. (2019)	Cross-sectional	Netherlands	5.6±0.9	505	Dutch questionnaires	Perceived (Self-Reported)	Traffic safety, Road network, Number of PA facilities (within 5 min, 10 min, 20 min, 30 min, +30 min, Distance index walk	Validated using Cronbach's alpha for Internal consistency
Lu et al. (2020)	Cross-sectional	China	3-6	1031	Dutch questionnaires	Perceived (Self-Reported)	Traffic safety, Road network, Number of PA facilities (within 5 min, 10 min, 20 min, 30 min, +30 min, Distance index walk	Validated using Cronbach's alpha for Internal consistency
O'Connor et al. (2014)	Cross-sectional	USA	4.5 (average)	234	Customized audit	Observational or Audit	Availability of Active Play Equipment	NA
O'Connor et al. (2014)	Cross-sectional	USA	4.5 (average)	233	A modified version of the recreation places in the neighborhood subscale of the Neighborhood Environment Walkability Scale for Youth	Perceived (Self-Reported)	Signs of physical and social disorder Traffic safety Traffic hazards Stranger danger Availability of active play equipment Places for child's physical activity Neighborhood informal social control	Test-retest reliability.
Sallis et al. (1993)	Cross-sectional	USA	4	347	Behaviors of Eating and Activity for Child Health Evaluation System (BEACHES)	Observational or Audit	Convenient play spaces Time in play spaces Frequency in play spaces Organized activities Toys Neighbourhood green space quantity, Land-use	Test-retest reliability.
Sanders et al. (2015)	Longitudinal	Australia	4-5 (at the first assessment)	4983	Data extracted from the Australian Bureau of Statistics (ABS)	Objective Measure	Land use mix Playgrounds Sports venues 4-way intersections Cul-de-sacs Traffic exposure	N/A
Timperio et al. (2017)	Longitudinal	Australia	5-6 10-12	351	Geographic Information System (GIS)	Objective Measure		N/A
Weimann et al. (2015)	Cross-sectional	Sweden	4-11	205	Geographic Information System (GIS)	Objective Measure	Crime Kilometres of foot and bike paths, Number of non-restricted destinations (playgrounds, schoolyards and playfields) Recreational areas (pine forest, leaf forest and open ground) as a percentage of the total area General perception of the neighborhood Safety	N/A
Xu et al. (2017)	Cross-sectional	Australia	2 and 3.5	912	Questions from Growing up in Australia: The Longitudinal Study of Australian Children	Perceived (Self-Reported)		N/A
Xu et al. (2017)	Cross-sectional	Australia	2 and 3.5	912	Geographic Information System (GIS)	Objective Measure	Walkability	Pearson Correlations and Test-retest reliability.

Table 3. Measures of Built Environment in the Childcare Domain

Study	Study Design	Country	Age (years)	Sample	Technique name	Approach	Environmental Factors (Physical Variables)	Validation Process
Ng et al. (2020)	Cross-sectional	Australia	2-5	297	Environment Assessment and Policy Observation (EPAO) Instrument -ADAPTED	Observational or Audit	Fixed play equipment, Portable play equipment, Outdoor running space, Indoor play space, Vegetation, Paths, Surface material, Slope, Natural features, Play settings	Inter-rater reliability
Berg, S. (2015)	Cross-sectional	Canada	3-5	2268	Geographic Information System (Google Street View)	Objective Measure	Playground size, Playground fixed equipment, Playground portable equipment	NA
Boldemann et al. (2006)	Cross-sectional	Sweden	4-6	198	Semi-structure Questionnaire	Perceived (Self-Reported)	Play environment indoors, Play environment outdoors	Reliability
Boldemann et al. (2006)	Cross-sectional	Sweden	4-6	197	Customized Audit	Observational or Audit	Total outdoor area, Overgrown surface (trees, shrubbery), Integration of play structures	N/A
Christian et al. (2016)	Protocol	Australia	2-5	2400	Environment Assessment and Policy Observation (EPAO) Instrument -ADAPTED	Observational or Audit	Fixed play equipment, Portable play equipment, Outdoor running space, Indoor play space, Vegetation, Paths, Surface material, Slope, Natural features, Play settings	Inter-rater reliability
Gubbels et al. (2012)	Cross-sectional	Netherlands	175	2-3years old	Environment and Policy Assessment and Observation Instrument (EPAO)	Observational or Audit	Portable Play Environment, Fixed Play Environment	Inter-rater reliability
Henderson et al. (2015)	Cross-sectional	USA	3-5	447	Environmental audit	Observational or Audit (Facility Self-assessment)	Suitability of indoor playspace, Classroom area, Playground area, Fixed equipment, Portable equipment, Sedentary equipment, Indoor physical activity space, Availability of natural resources, Use of constructed resources	Criterion validity (observation and interview, using percentage agreement)
Hinkley et al. (2016)	Cross-sectional	Australia	3-5	1002	Customized from pre-existing audits: The Nutrition and Physical Activity Self Assessment for Child Care (NAPSACC), The Environment and Policy Assessment and Observation	Observational or Audit	Indoor activity spaces, Ovals/grassed spaces, Outdoor activity areas, Indoor physical activity space, Outdoor physical activity space, Total physical activity space, Fixed equipment	NA

Study	Study Design	Country	Age (years)	Sample	Technique name	Approach	Environmental Factors (Physical Variables)	Validation Process
Määttä et al. (2019)	Cross-sectional	Finland	3-6	864	Customized from pre-existing audits Items: The Environment and Policy Assessment and Observation (EPAO); The National investigation about the PA conditions in Finnish preschools, and additional items developed to meet the aims of the study	Observational or Audit	Permanent features Portable equipment Sports equipment Natural ground coverings PA equipment in group facilities Fixed equipment indoors Gym in the preschool PA equipment in the gym Surfaces in the preschool grounds Terrain in the playground Shady areas in the playground Fixed PA equipment in the preschool yard PA-promoting elements in the playground Portable equipment in the playground	NA
Maitland et al. (2020)	Validation Study	Australia	2-5	1596	PLAYCE Study Environmental Audit	Observational or Audit	Outdoor physical activity equipment (number, type and condition of portable and fixed); Outdoor play environment (number and type of play spaces, natural features, paths); Indoor physical activity equipment (number, type and condition of portable and fixed); Indoor media equipment (number and type of portable and fixed); Indoor play environment (presence and connection of play spaces)	Construct Validity Intra-rater reliability Inter-rater reliability
Peden et al. (2017)	Cross-sectional	Australia	1-5.9	68 Toddlers 233 preschoolers (3-5.9y)	Environment and Policy Assessment and Observation Instrument (EPAO)	Observational or Audit	Portable Play Environment Fixed Play Environment	Inter-rater reliability
Tucker et al. (2019)	Protocol	Canada	1.5 – 4	218	Environment and Policy Assessment and Observation (EPAO - SR) Instrument	Observational or Audit (Facility Self-assessment)	Natural Elements Fixed Equipment Portable Equipment Sedentary Equipment Inside space for gross motor activity	Reliability (ANOVA) and validity (correlation)
Vanderloo et al. (2014)	Cross-sectional	Canada	4.6	31	Environment and Policy Assessment and Observation Instrument (EPAO)	Observational or Audit	Portable Play Environment Fixed Play Environment	Inter-rater reliability
Zhang et al. (2018)	Cross-sectional	Australia	0 - 30 months	274 27 ECEC centres	Infant/Toddler Environment Rating Scale-revised edition (ITERS-R)	Observational or Audit	Indoor space Furniture for routine care and play Provision for relaxation and comfort Room arrangement	Concurrent and predictive validity Intraclass correlation Internal consistency

Protocols

As a whole, physical environment measurements showed considerable approach variation. Of the studies that administered one protocol, eight studies used Geographic Information Systems (GIS), thirteen applied Observational or Audit Instruments, and three conducted Perceived (Self-Reported) data collection. Three papers employed two protocols (Boldemann et al., 2006; O'Connor et al., 2014; Xu et al., 2017). For O'Connor et al. (2014) and Boldemann et al. (2006), data was collected using Observational or Audit and Perceived (Self-Reported) instruments, while Xu et al. (2017) fused a GIS with a Perceived (Self-Reported) instrument.

As explained above, the context of the physical environment and PA in early childhood presents clear distinctions among environments. Therefore, the results analyzed from an environmental or location perspective offer deeper comprehension; studies that used two or more instruments are mentioned separately.

Physical Environment Protocols

Regarding protocols to assess the neighborhood physical environment (see Table 1), the GIS was used in seven studies, three administered Perceived (Self-Reported) (Aarts et al., 2010; Lu et al., 2019, 2020), and two studies applied Observational or Audit instruments (Kimbrow et al., 2011; Sallis et al., 1993). Two studies applied two instruments (O'Connor et al., 2014; Xu et al., 2017). O'Connor et al. (2014) used an Observational or Audit and a Perceived (Self-Reported), and Xu et al. (2017) used a GIS and a Perceived (Self-Reported) instrument. The Australian Bureau of Statistics (ABS) was used by one study (Sanders et al., 2015). Overall, it is observed that GIS is the most prevalent approach in the neighborhood physical environment, being applied in approximately 53% of the studies. That said, only one study presented data about GIS validation indexes (Xu et al., 2017).

The Perceived (Self-Reported) approaches are mainly composed of questionnaires or scales submitted to several validation processes. In this sense, three studies used questionnaires based on a previous Dutch research questionnaire (Aarts et al., 2010; Lu et al., 2019, 2020) validated using Cronbach's alpha (Cronbach's α : 0.631 to 0.708) tested in the

studies (Aarts et al., 2010; Lu et al., 2019, 2020). The fourth study (O'Connor et al., 2014) employed the subscale of The Neighborhood Environment Walkability Scale for Youth validated by Rosenberg et al. (2009) (Test-retest reliability - (ICC range .56–.87). Finally, Xu et al. (2017) used Questions from Growing up in Australia: The Longitudinal Study of Australian Children, with no validation indexes available. The Observational or Audit protocols were used in three studies: two used customized audits (Kimbrow et al., 2011; O'Connor et al., 2014) and The Eating Out and play Opportunities Questionnaire (Sallis et al., 1993) validated by McKenzie et al. (1991) using test-retest reliability and validity (discriminatory).

Childcare Protocols

As far as the childcare environment is concerned, most of the studies that applied a single approach used Observational or Audit instruments (11; 91%), and one used GIS (external space – playground) (see Table 2). Within the Observational or Audit Instrument category, nine administered an Observational and Audit instrument, and two studies presented data using a facility self-assessment audit. Three studies used the original version of the Environment and Policy Assessment and Observation (EPAO) (Gubbels et al., 2012; Peden et al., 2017; Vanderloo et al., 2014), two proposed adapted EPAO versions for the Australian context (Christian et al., 2016; Ng et al., 2020), and one administered its facility self-assessment version (EPAO-SR) (Tucker et al., 2019). Both EPAO and EPAO-SR present distinct validation studies (Ward et al., 2008; Ward et al., 2015).

Additionally, six articles described different approaches. Customized instruments based on previously validated ones were used by two studies (Hinkley et al., 2016; Määttä et al., 2019). Hinkley et al. (2016) administered purposed-designed audits based on the EPAO and the Nutrition and Physical Activity Self-Assessment for Child Care (validated by Benjamin et al. 2007). Similarly, Määttä et al. (2019) built an audit from the adaptation of the EPAO, the National investigation about the PA conditions in Finnish preschools, and customized items for the study. Although the authors chose to apply pre-validated instruments, no validation evidence was presented for the customized audits developed.

A customized environmental audit was administered by Henderson et al. (2015),

previously validated by the same research group (Henderson et al., 2011). The Infant/Toddler Environment Rating Scale-revised edition (ITERS-R) was used by Zhang et al. (2018) based on the study validation proposed by Harms et al. (2017). The *PLAYCE* audit was employed in one study (Maitland et al., 2020). It was tested for intra-rater reliability, inter-rater reliability achieving excellent intra-class correlation indices ($ICC = 0.80\text{--}0.94$). It also presented a construct validation process based on experts and pre-existing items from instruments with high validity and reliability scores (Maitland et al. 2020). A Perceived (Self-Reported) was applied in one study (Boldemann et al., 2006), and one utilized GIS to analyze external school area (playground) (Berg, 2015). One paper combined the Observational and Audit protocol with a Perceived (Self-Reported) scale to evaluate the childcare space (Boldemann et al., 2006).

Discussion

This study systematically reviewed evidence from 27 articles regarding protocols to measure physical environment targeting to assess early childhood PA patterns. Our data showed that the matter of measurement of the built environment has been assessed differently in the neighborhood environment comparing to the childcare environment. Therefore, to discuss the present data, it is coherent to address these environments separately. From a field perspective, however, it is important to mention that programs should consider both environments to understand children's PA levels.

Regarding the neighborhood domain, GIS is an important technique to be debated. It is considered an objective measurement of the built environment that can integrate spatial information from different sources to analyze and present data related to a geographic location (Porter et al., 2004; Thornton et al., 2011). GIS has been extensively used in combination with Global Positioning Systems (GPS) and accelerometry to understand physical activity outcomes related to the environment (Christian et al., 2016; Yi et al., 2019). Variables obtained using GIS are based on main concepts of structures density, distance from a predetermined reference (i.e., home, childcare setting), and land use as well as indexes such as walkability and moveability (Brownson et al., 2009; Carson et al., 2014; Hunter et al.,

2019). For example, Carson et al. (2014) used a combination of different maps software and applications (e.g., ArcGIS, Google Earth) to analyze Canadian geospatial data resources (e.g., CanMaps®, Streetfiles, Enhanced Points of Interest database [DMTI]). From this GIS approach, the outdoor space was determined by calculating the density by dividing the park area by the total land area. Similarly, recreation facilities (e.g., physical fitness facilities, public golf courses) were assessed by dividing the number of facilities by the total landing area (Carson et al., 2014).

Given the variety of variables that can be assessed using GIS, this approach can be conducted based on a previous framework like the one proposed by Pikora et al. (2003) and used by two studies identified in this review (Carson et al., 2014; Hunter et al., 2019). On the other hand, spatial variables could be customized to the study objectives or based on previous similar studies (Bringolf-Isler et al., 2015; Timperio et al., 2017). In general, although customization seems to be feasible, our data corroborates a recent review (Aguayo et al., 2019) showing that general geographic factors, such as proximity to recreational areas and neighborhood walkability, remain the most frequent GIS variables assessed in PA studies regardless the targeted study population.

Accordingly, it is reasonable to assume a lack of data regarding GIS variables and frameworks based on specificities of early childhood environment and PA patterns. Tonge et al. (2016), through an extensive systematic literature review, found at least 12 physical environment variables associated with preschoolers' PA levels. Portable equipment, fixed equipment, and the height of equipment are essential aspects to assess in early childhood context, particularly in playgrounds and similar structures that might be available to the children (Driediger et al., 2019; Gubbels et al., 2012; Tonge et al., 2016; Weimann et al., 2015). For instance, data obtained by Hunter et al. (2019) showed no associations between neighborhood walkability and toddlers PA, which suggests that preschoolers do not play in the street because they may need specific places and equipment. In short, the current application of GIS in early childhood seems to neglect particularities that could determine the association between preschoolers' PA and the built environment.

This lack of specificity may occur due to GIS data sources and lack of content validity evidence. Firstly, GIS is mainly dependent on previous data sources usually available from government agencies that do not always provide detailed and updated information and are

not primarily collected for research (Brownson et al., 2009). The GIS data sources, therefore, might compromise research and intervention specificity. Porter et al. (2004) highlighted that the expression “*garbage in, garbage out*” applies to GIS; since the quality of data source is compromised, GIS results could become useless. Secondly, and most importantly, the present literature review showed that validation of GIS measurement techniques is scarce, confirming previous research evidence (Brownson et al., 2009), particularly to the matter of GIS content validity criteria (Brownson et al., 2009; Lee et al. 2015). Best practices of instrument validation indicate that it is imperative to test a measurement tool to determine to what extent it can measure the expected contents related to a predetermined construct or idea (Brownson et al., 2009; Lee et al., 2015).

In this sense, considering the early childhood physical environment construct, it is clear that the GIS approach must include aspects of the micro-scale built environment that can offer children opportunities to play (Lee et al., 2020). However, the only study that mentioned GIS validation scores was obtained mainly through test-retest reliability (Xu et al., 2017) with no content validity evidence. Therefore, to our knowledge, no GIS validation study addressed content validity properties in the context of early childhood and PA patterns. For instance, Lee et al. (2015) validated the GIS approach in four aspects, including content validity and factor analysis, in the context of cardiovascular health, which means that this process should be tested in an early childhood built environment. Based on the present evidence, we understand that content validity must be conducted in GIS research in the early childhood context.

Perceptions of the environment is an approach also used in research addressing the built environment and PA. First, self-perceived instruments seem to be an alternative to GIS. However, a recent review showed that objective (GIS) and subjective (self-perceived) might assess distinct associations between the same environmental aspect and PA behavior. It has been recommended that they may not be used interchangeably (Orstad et al., 2017). Accordingly, we assume it should be used as an alternative to GIS with caution.

Further, validation evidence, such as content validity and cross-cultural validation, also seem to be limitations needing to be addressed. Regarding content validity, the present review demonstrated that parents' perception of the neighborhood structure is the most frequent approach. Perception instruments assess the built environment using generic domains, such

as satisfaction with play facilities (Aarts et al., 2010), availability of active play equipment (O'Connor et al., 2014), or general perception of the neighborhood (Aarts et al., 2010; Lu et al., 2019, 2020; Xu et al., 2017). Our data showed, therefore, that this generic self-perceived approach still does not cover specificities of early childhood environment, weakening its application and demonstrating a lack of content validity as detected in GIS. Although studies briefly described the development of language versions (i.e., English, Chinese), validation results of cross-cultural validation were not provided. Beyond translation procedures and internal consistency, it is worth mentioning that the cross-cultural validation also demands full psychometric testing, which includes construct-related validity, criterion-related validity, factor structure, and model fit of the instrument (Arafat et al., 2016; Sousa & Rojjanasrirat, 2011).

Audit tools can capture a broader range of variables than data sources like GIS (Poortinga et al., 2017). From the perspective of a measurement tool, it is reasonable to argue that the audits could be the objective alternative for GIS. It provides a list of environmental attributes to assess by quantification. Mirroring previous studies (Brownson et al., 2009; Poortinga et al., 2017), our data showed that audits are also poorly validated, particularly regarding content validity. First of all, there was no specificity on early childhood necessities in the audits used by Kimbro et al. (2011) and O'Connor et al. (2014). Although O'Connor et al. (2014) analyzed the availability of playing equipment using a customized tool similar to those used in childcare settings, no detailed information is available about the customization and validation process. Besides, pre-validated environmental audits are mainly focused on public resources rather than private spaces, an aspect that may compromise data targeted to understand preschoolers' PA behaviours (Poortinga et al., 2017).

In the case of the childcare environment, the present review detected a clear trend to customization. Studies have been modifying and revalidating previously validated audits to adapt them to a specific culture or geographic location, such as the adapted EPAO developed to assess childcare centers in Australia (Christian et al., 2016; Ng et al., 2020) and the PLAYCE audit, built for the Canadian context (Maitland et al., 2020). Besides, an alternative was found to assess the physical environment based on a particular age group, the Infant/Toddler Environment Rating Scale-revised edition (ITERS-R) used by Zhang et al. (2018).

It is crucial to mention that most of the audit customization found has been based on the EPAO audit. The EPAO protocol was initially validated in 2008 to evaluate the quality of nutrition and physical activity behavior in USA childcare centers (Ng et al., 2020; Ward et al., 2008). It includes a specific session to assess the physical environment (see Section H: Equipment, Environment, and Space). The present review showed that, in the last 12 years, attempts to customize the EPAO have been made in the context of the evaluation of the physical environment (Christian et al., 2016; Gubbels et al., 2012; Ng et al., 2020). The adapted EPAO has shown to have good to excellent intra- and inter-rater reliability scores (Ng et al., 2020), maintaining, therefore, the quality of these particular psychometric aspects of the original validation study (Ward et al. 2008). We hypothesized that this validation consistency could be due to the maintenance of the instrument items structure and the careful generation of the added items based on current research evidence described by Ng et al. (2020).

Most importantly, an important trend identified by the present review is the investment in creating adapted versions of EPAO and new audits. This demonstrates the necessity and researchers' concerns about audit content validity properties. For instance, the adaptations in EPAO made for the Australian context (Christian et al., 2016; Ng et al., 2020) reveal researchers' attention to content validity, which means authors interest in auditing early childhood specificities that could be potentially influencers on the children's PA levels in a particular context. Particularly concerned with content validity, Maitland et al. (2020) recently developed the *PLAYCE* audit. Its development is based on expert analysis, pre-existing items with an excellent level of reliability. The *PLAYCE* obtained elevated levels of psychometric properties. Therefore, the *PLAYCE* validation process matches several aspects considered to be best practices in instrument validation, according to Boateng et al. (2018). Further, the *PLAYCE* audit can cover both inside and outside childcare centers, an aspect that is not present in other options and, from our perspective, strengthen its content validity (Maitland et al., 2020).

The second point is the attempt to create feasible protocols to expand the assessment of childcare environments. Considering the fact that EPAO may be costly and time-consuming to train and certify people to administrate it (Ward et al., 2015), the self-assess version (EPAO-SR) was validated to offer a simple alternative to be used by childcare staff. The

EPAO-SR has been understood as a validated alternative allowing staff to evaluate the childcare environment without requiring trained people. Among the validation procedures, the cross-testing using the original version showed that the EPAO-SR achieved high-reliability scores (ICC: 0.69-0.99) for the module "Physical activity equipment and natural environment." However, low validity levels were observed in portable, natural, and sedentary equipment, obtained by the comparison between the childcare personnel perception employing EPAO-SR and the results from the EPAO obtained by the researchers. Therefore, it is important to mention that future modifications should be tested to strengthen the assessment of these fundamental aspects related to PA in the early childhood environment. Finally, the development and adoption of a more feasible and fast protocol demonstrates an emerging approach aiming to offer a viable way to expand the childcare systematic assessment routine, contributing to more comprehensive Health Education interventions.

Conclusion

This study analyzed the techniques and protocols used to assess the relationship between the environment and PA in early childhood. It has been found that the topic of the physical environment in early childhood is clearly composed of the neighborhood and childcare environments with distinct protocols, albeit comparable approaches. In the neighborhood domain, GIS and audit protocols form the group of objective protocols to measure the built environment. At the same time, self-perceived instruments could be considered the subjective approach, based on the idea that parents' perceptions are a strong influence on children's PA patterns. However, evidence has shown that perceptions of the environment should not be used as an alternative to GIS or audits. Further, although GIS is the most used tool, our analysis showed its lack of specificity in early childhood, a fact that can compromise study outcomes. On the other hand, audits have been employed based on similar protocols used in childcare, showing an attempt to customize early childhood environments. However, audit validation studies are scarce and are required to help add to a more thorough understanding. In the childhood domain, attempts to customization are more frequent, based mostly on the EPAO. The customization has been developed in different but related forms: (1) adding new

items to an existent audit, (2) using a part of another instrument (e.g., EPAO), or (3) creating a new one based on validated ones. Moreover, it has been observed that only the PLAYCE protocol has been developed under contemporary validation procedures, a fact that strengthens its application in childcare settings. Another significant trend is the development of self-assess protocols (e.g., EPAO-SR), which could scale up the environment analysis, contributing to underpinning Health Promotion interventions.

However, for both domains, validation limitations were found, particularly to content validity and internal consistency. The micro-scale built environment analysis is a trend in the field (Lee et al. 2020) and should be considered in the content validation for all instruments. Further, environment measurement protocols should be built based on early childhood frameworks for PA behavior since the other age groups' utilization contradicts aspects of specificity and content validity.

From a statistical standpoint, when internal consistency was assessed, all validation studies applied Cronbach's alpha. Evidence has shown, however, that Cronbach's alpha is inaccurate, particularly for small samples and non-normally distributed data, suggesting that at least two indexes other than Cronbach should be used to test internal consistency (e.g., Greatest-Lower Bound, McDonald's Omega) (Boateng et al., 2018). Therefore, future research should apply more contemporary and accurate internal consistency tests.

Overall, the confirmation of validation scores, nevertheless, is also recommended to be carried out consistently, considering large variations encountered in distinct populations or infrastructures. To that end, pilot studies should be conducted to test and adjust measurement tools at any level. Future research should utilize more rigorous validation techniques to accurately measure the built environment in the context of early childhood PA. Finally, considering many studies pointed out the need for continued validation, it is imperative that early childhood investigators consider the development of comprehensive protocol adaptation based on current research in the field.

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