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Measuring child and adolescent behavior in outdoor play environments: a survey among researchers exploring quantitative research methods

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Abstract

Background Outdoor play environments are essential for children's and adolescents' development, making it crucial to understand how to measure their use effectively. This study focuses on quantitative methods, which are well suited to capturing the frequency, intensity, and volume of play, as well as supporting large-scale behavioral and environmental analyses. We synthesized researchers' experiences to identify the strengths, limitations, and appropriate applications of commonly used quantitative methods, and highlight needs for methodological development.

Method Data were collected via a survey of researchers with experience studying children's and adolescents' behavior in outdoor play spaces using quantitative methods. Responses were analyzed using descriptive statistics (close-ended questions) and directed content analysis (open-ended questions) to identify perceived benefits, challenges, recommended contexts of use, and priorities for methodological development.

Results Thirty-one researchers completed the survey, reporting on 62 methods. Researchers reported trade-offs across methods. Wearables provided high-quality, validated, and continuous data but were limited by recruitment challenges and time-intensive processing. Systematic observations imposed minimal participant burden and offered rich contextual detail but lacked scalability due to labor demands and limited temporal coverage. Surveys were highly scalable and complementary but raised concerns regarding child usability and data quality. Methods were most strongly recommended for children aged 6–12 years and in structured settings (schools, early childhood education and care, public open spaces), with gaps identified for younger children and less structured contexts. Key development needs included more scalable observational approaches, user-friendly wearables, improved survey tools, and integrated solutions such as 24-h wearables, automated space monitoring, and multi-source data collection.

Conclusion No single method is without limitations, and selection involves tradeoffs between resources, data quality, and scalability. Wearables dominate individual-level measurement but require further development to capture activity type, context, and social interaction. Systematic observations remain central for assessing space use, though automated monitoring offers promising scalability. Future method development should focus on being feasible in unscheduled settings and for younger children, while minimizing participant burden.

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Keywords Method development · Quantitative measurement · Playground · Outdoor play environments · Wearables · Systematic observations · Surveys

Background

Outdoor play environments, such as playgrounds, form part of many everyday settings, including public open spaces [1], schools [2], and daycare centers [3]. These environments support children's and adolescents' development by providing opportunities for physical activity, social interaction, and risk-taking [1, 4, 5].

To support these developmental opportunities, it is necessary to examine how children and adolescents actually use outdoor play spaces. This includes examining how many users are present, what activities they engage in, how they interact, and how they experience the space. This requires insight into available research methods and how to apply them effectively. This study focuses on quantitative methods, which are particularly suited to capturing the frequency, intensity and volume of play and playground use [6], and supporting large-scale analyses relevant to policy and investment decisions [7]. In contrast, qualitative research methods are often used to explore attitudes, preferences, motivations and experiences [8, 9].

Common quantitative methods for studying children's behavior in outdoor play environments include wearables, systematic observations, and surveys. Wearables include accelerometers and global positioning system (GPS) devices, that provide continuous, objective, individual-level measures of physical activity intensity and location respectively [10, 11]. Accelerometers and GPS are often combined to examine where and how much children are active throughout the day [12–14]. Systematic observations provide objective, momentary measures of space use and behavior within their environmental context and can capture outcomes such as play activities, interactions and patterns of space use through scan- or focal-based approaches [15–17]. Observational methods also include behavioral mapping, which links behaviors to specific environmental features [17, 18]. Surveys provide subjective information through self- or proxy-report and can be tailored to capture a wide range of behaviors related to play and physical activity [19]. As a result, large-scale studies often use surveys [20, 21].

Applying these quantitative research methods in outdoor playgrounds and play environments presents unique challenges, as children's behaviours are highly dynamic and are often unpredictable, and activities may vary widely [22]. In addition, physical features such as fixed play equipment, vegetation, and uneven terrain, as well as environmental factors such as weather conditions, can affect measurement [23]. These behavioural and environmental complexities require careful selection and adaptation of methods.

Previous reviews have summarized methods used to measure children's play and outdoor activity, however these reviews primarily describe the types and frequency of methods used, rather than their practical application. Reported quantitative methods included questionnaires, observations (structured and unstructured, captured using e.g. video, audio or live coding), accelerometry, GPS, heart rate monitors and radio-frequency identification tags [12–14]. Of the three reviews, one focused on free play in school settings and found observational methods as most frequently used [24]. In contrast, the other two reviews reported surveys, primarily parent-recall questionnaires, as the most common method for measuring children's outdoor free play [25, 26]; one focused on unstructured settings such as home and community [26], whereas the other was not restricted to a specific setting for outdoor free play [25]. Overall, these findings suggest that the choice of measurement method may depend on the context in which children's outdoor play is assessed.

Despite a growing body of work evaluating individual methods [27–31], little is known about researchers' practical experiences of implementing these methods in outdoor play environments, including their feasibility, strengths, limitations, and suitability across settings, age groups, and behavior types. To address this gap, this study draws on researchers' experiences with quantitative methods used in outdoor play environments.

The aim of this study was to examine the perceived benefits, challenges, and feasibility of commonly used quantitative methods for measuring children and adolescents' behavior in outdoor play spaces. These methods

included systematic observation, behavioral mapping, accelerometry, GPS, surveys, and camera observations. Specifically, we aimed to: (1) identify benefits and challenges associated with each method; (2) describe contexts for recommended use; and (3) highlight areas for future methodological development.

Method

Participants

Key informants were researchers engaged in studies of children and adolescents' behavior in outdoor play environments (e.g., playgrounds, parks, schoolyards). Eligible participants included those involved in method development, study design, data collection, or data analysis related to these topics.

Eligible researchers were identified in three ways: (1) Based on the authors' knowledge of published literature and leading researchers within this field. (2) A preliminary list of potential participants was compiled using two sources: a) Scopus was searched with the purpose of identifying potential participants rather than conducting a systematic literature review. The search strategy was therefore pragmatically designed to locate researchers with experience using commonly applied quantitative methods within the field. Search terms were selected to represent the main method categories included in this study (e.g., wearables, systematic observations, and surveys) and commonly used measurement tools within these categories. Additional terms related to children, outdoor environments, and play were included when necessary to improve the relevance of the search results. The final combined search was as follows:

TITLE-ABS-KEY(Soplay OR "Tool for Observing Play Outdoors" OR (child* AND ("Behavioural map*" OR (accelerometer AND play* AND (outdoor OR outside)) OR ((gps OR gis) AND (outdoor OR outside OR play*)) OR ((video* OR photo* OR camera*) AND outdoor*))).

Only articles published between 2019 and 2024 were examined to ensure researchers were currently active and familiar with the methods. Relevant articles were identified, and all listed authors were added to the preliminary list. b) ChatGPT was asked to identify leading researchers within the field and add those to the preliminary list. The preliminary list was reviewed by all authors with input from colleagues, and expanded to include relevant researchers from their professional networks [3]. Snowball sampling was used by inviting participants to suggest additional colleagues. The survey was also distributed via LinkedIn. Recruitment was not intended to be exhaustive but to identify researchers with substantial experience using one or more of the included methods.

Responses were excluded if the reported method did not meet all the following criteria: (1) quantitative (2) related to children and adolescent behavior and (3) applied in outdoor play environments. Only responses meeting all criteria were included in the analysis.

Data collection

Data were collected using a self-developed online survey designed to capture expert reflections on the practical use of quantitative methods for measuring children and adolescents' behavior in outdoor play environments. The survey was administered via SurveyXact and was open from November 2024 to February 2025. The full survey is available in Additional file 1. Respondents could choose to be acknowledged in the final publication and indicate whether they were open to follow-up contact or preferred to remain anonymous.

As no existing survey addresses the specific scope of this study, survey items were developed specifically for this project, drawing on findings from a previous review conducted by the authors [32] (for context and age-related items) and the collective experience of the authors and colleagues working in the field. To ensure clarity and relevance, the survey was pilot tested by four other colleagues with experience in the field. Feedback was used to refine the wording and structure of the questions.

The survey consisted of three parts. First, respondents selected up to three quantitative methods for which their practical experience would be most informative. They were encouraged to include methods they used frequently, those they initially hesitated to use but later found valuable, and those they used only once due to unexpected challenges. For each method, respondents reported their level of expertise, the types of projects in which it had been applied, and their role (e.g., primary investigator, planning, data collection, analysis). They also indicated whether study settings included fixed play equipment (e.g. swings, climbing structures, slides), but this information was not used in analysis.

Second, respondents identified contexts in which they would recommend each method, including age groups, settings (e.g., schoolyards, play streets), and outcomes (e.g., physical activity intensity, social interaction or play volume). *Play volume* was defined as the total amount of play activity within a given time and space, calculated as the product of the number of children, duration of play, and area.

Third, respondents selected the three most important benefits and challenges associated with each method from a predefined list (e.g., participant recruitment, cost, equipment usability, data quality, scalability, and compliance with privacy regulations) and provide brief explanations. They could also share examples from their own research and suggest methodological improvements.

Finally, respondents answered an open-ended question on future directions in measuring children's and adolescents' behavior in outdoor play environments and identified outcomes they would like to capture in future studies.

Analysis

Survey responses were analyzed using descriptive statistics and a qualitative approach informed by directed content analysis, a deductive method that applied predefined categories to guide coding and interpretation [33]. Descriptive statistics summarized participant experience, selected methods, contexts for recommended use, and the frequency of reported benefits, challenges, and future outcome priorities. Directed content analysis was applied to open-ended responses to provide deeper insight into experiences with methods and perspectives on future method development.

Methods were grouped into three categories: wearables (accelerometer and GPS), systematic observations (observations on group level, observations on individual level, behavioral mapping, and camera observations) and surveys (self-report and proxy self-report), consistent with classifications reported by Fitzgibbon et al. [24].

Four responses were excluded based on the predefined criteria. One respondent did not work in the field, and three methods were excluded because they did not meet the inclusion criteria (not related to behavior or outdoor play spaces). In these cases, remaining parts of the response (including other reported methods and vision for future measurement) were retained.

Analysis related to 'benefits and challenges'

Descriptive statistics summarized the frequency of benefits and challenges. Directed content analysis was then applied to open-ended responses. The process involved three steps: (1) reviewing all responses to the two open-ended questions where participants elaborated on selected benefits and challenges; (2) coding text segments that aligned with benefits and challenges from the predefined list and assigning new themes to segments that did not fit; and (3) examining other open-ended responses for additional mentions of benefits or challenges and categorizing them similarly according to step 1 and 2.

Analysis related to 'recommended use of methods'

Closed-ended questions were used to quantify recommendations for each method across age groups, setting (e.g., school, public space, play street), and outcome (e.g., activity intensity, type, social interaction). Proportions were defined as: Limited application (+) for 1–33% of respondents recommended use, Moderate application (++) for

34–66%, and High application (+++) for 67–100%. Directed content analysis supplemented these summaries by identifying supporting or contradicting arguments in open-ended responses (see Additional file 2 for full list of themes).

Analysis related to ‘future methods’

Suggestions for improving methods and broader visions for future measurement were derived from open-ended responses. Data were reviewed and iteratively grouped into thematic categories, with new categories developed as required.

Results

Response rate

Invitations were sent to 90 eligible researchers (78 were initially invited on November 6th, 2024, 12 were suggested by respondents and invited on December 17th, 2024). A reminder was sent to all initially invited participants on November 20th, 2024, and a personal reminder was sent to 16 of the initially invited participants on December 17th, 2024. The survey was made publicly available via LinkedIn on November 28th, 2024.

A total of 31 researchers completed the survey, reporting on 62 methods. Of these, twenty-six responses were from invited participants (four anonymous), four were from researchers accessing the public link, and one anonymous response could not be classified.

Participant characteristics and method usage

Of the 31 researchers who completed the survey, 20 reported on wearables (accelerometers $n=12$; and GPS units $n=8$), 29 reported on systematic observations (group-level observations $n=13$; individual-level observations $n=5$; responses informed by both group- and individual-level $n=1$; behavioral mapping $n=4$; and camera observations $n=6$), and 13 reported on surveys. Camera-based observations ($n=6$) consisted of collecting and storing video data, followed by systematic observation of the recordings or the application of computer vision models (Table 1). One respondent reported on proximity sensors; however, the method was not applied in outdoor spaces, and the response was excluded from further analyses. Specific tools were not systematically reported; however, 25 of the 62 method responses referred to a particular tool or study. Reported examples included ActiGraph GT3X+ and activPAL accelerometers, QStarz GPS devices, the TOPO behavioral mapping protocol, SOPARC, SOPLAY, MOHAWK, SOFIT and OSRAC-P for systematic observations, and the British Children’s Play Survey (including CPS, REPS and TRiPS scale), and self-developed questionnaires. As can be seen in Table 1, participant numbers varied across categories, however the total number of participants in each category is relatively small.

Within wearables and systematic observations, most participants identified as experienced users (defined as having extensive experience using the method across multiple studies over many years). For surveys, respondents were evenly distributed across regular users (defined as having moderate experience using the method in more than one study), experienced users, and expert users (defined as having contributed to the development of the method and/or its analysis).

Table 1 Participants characteristics and method usage when measuring children and adolescent behavior in outdoor play spaces

	Wearables(n=20)	Systematic Observation(n=29)	Surveys(n=13)
Years in the field			
1–2	1 (5%)	4 (14%)	1 (8%)
3–4	.	1 (3%)	3 (23%)
5–10	4 (20%)	4 (14%)	2 (15%)
>10	15 (75%)	20 (69%)	7 (54%)
Experience with the method			
Expert user	5 (25%)	7 (24%)	4 (31%)
Experienced user	9 (45%)	10 (34%)	4 (31%)
Regular user	4 (20%)	7 (24%)	4 (31%)
Novice user	2 (10%)	5 (17%)	1 (8%)
Role in projects using this method			
Primary investigator	19 (95%)	27 (93%)	10 (77%)
Project planning	15 (75%)	18 (62%)	7 (54%)
Data collection	16 (80%)	19 (66%)	8 (62%)
Data analysis	13 (65%)	19 (66%)	6 (46%)

Participants reported A) number of years working in the field of children and adolescent behavior in outdoor play spaces. B) level of experience related to a specific method (Expert user: Contributed to development of the method and/or analysis, Experienced user: Extensive experience using this method across multiple studies over many years, Regular user: Moderate experience using this method in more than one study, Beginning user: Limited experience using this method in one study. C) What part(s) of projects using a specific method, they were involved with

Table 2 Reported benefits and challenges associated with each method

	Wearables (n=20)		Systematic observations (n=29)		Surveys (n=13)	
	Benefit	Challenge	Benefit	Challenge	Benefit	Challenge
Recruitment	1 (5%)	8 (40%)	11 (38%)	1 (3%)	3 (23%)	5 (38%)
Cost	5 (25%)	7 (35%)	4 (14%)	5 (17%)	.	1 (8%)
Use of tool/instrument	1 (5%)	8 (40%)	2 (7%)	3 (10%)	8 (62%)	.
Adapt to weather conditions	4 (20%)	.	9 (31%)	5 (17%)	3 (23%)	2 (15%)
Use with children	6 (30%)	3 (15%)	7 (24%)	1 (3%)	.	6 (46%)
Participant burden	4 (20%)	6 (30%)	18 (62%)	.	4 (31%)	6 (46%)
Time resources (e.g. data collection or processing)	3 (15%)	13 (65%)	2 (7%)	25 (86%)	3 (23%)	3 (23%)
Scalability	2 (10%)	1 (5%)	1 (3%)	3 (10%)	6 (46%)	1 (8%)
Privacy and data protection regulations (incl. GDPR)	1 (5%)	3 (15%)	6 (21%)	7 (24%)	4 (31%)	1 (8%)
Data quality	13 (65%)	1 (5%)	11 (38%)	2 (7%)	.	5 (38%)
Reactivity	2 (10%)	2 (10%)	6 (21%)	8 (28%)	2 (15%)	2 (15%)
Other*	1 (5%)	1 (5%)	2 (7%)	5 (17%)	.	.

Participants were asked to choose the three most important challenges and benefits, therefore the number adds to more than n. *Other benefits: objectivity (wearables), range of data that can be collected (Systematic observations), can be used across a range of settings (Systematic observations). Other challenges: compliance with wear protocol (wearables), many observers are needed (systematic observations), logistics, training and generalizability challenging (systematic observation)

Benefits and challenges associated with each method

Wearables

For wearables, the benefit most frequently reported from the predefined list was ‘(high) Data quality’ (65%) see Table 2. From the directed content analysis, three additional benefits emerged: ‘validated and reliable measure’, ‘provide continuous data’ and ‘reusable’. Reusable was often linked to low costs.

The challenge most frequently reported from the predefined list was ‘Time resources’ (65%), specifically data-processing were reported as being time-consuming (60%). Additionally, ‘Equipment’ (40%) e.g. loss and

technical issues and ‘Recruitment’ (40%) were frequently reported. No additional challenges were identified from the directed content analysis.

Systematic observations

The benefit most frequently reported from the predefined list for systematic observations was ‘(low) Participant burden’ (62%), as seen in Table 2. Additionally, ‘Recruitment (was easy)’ (38%) and ‘(high) Data quality’ (38%) were frequently reported. One respondent elaborated “*(observations provide) deeper insight to children’s activities and thinking compared to many other research results with another measurement*”. Additionally, camera observations were emphasized for providing rigorous and detailed data. From the directed content analysis ‘Safety’ was identified as an additional benefit related to camera-observations, as camera-observations remove the need for physical presence in potentially unsafe environments.

The most frequently reported challenge from the predefined list was ‘Time resources’ (86%), specifically data-collection (34%), data-processing (28%) and both data collection and processing (24%) were reported as time-consuming, respondents elaborated that training of observers to a reliable level were especially time consuming, and emphasized that “*Direct observations can be challenging to do at a large scale, especially with a high level of detail and accuracy*” and “*Scalability is the number 1 issue - can be challenging to collect sufficient number of hours for power, especially when counts of observed participants is low*”. From the directed content analysis, three additional challenges emerged: ‘Sensitive to local events’ e.g. celebrations or institutional programs, ‘Safety’ e.g. drugs offered, witnessed fights, heard gunshots, bikes stolen, and ‘Generalizability’, one respondent elaborated “*since observations is a scan and only assess a limited time <...> How representative is your observation moment?*”.

Surveys

For surveys, the benefit most frequently reported from the predefined list was ‘Equipment’ (62%) e.g. easy to understand and use, see Table 2. Additionally, ‘(high) Scalability’ (46%) were frequently reported. From the directed content analysis, an additional benefit emerged: “Complements other data.”

The challenges most frequently reported from the predefined list were ‘Use with children’ (46%) and ‘(high) Participant burden’ (46%). Additionally, ‘Recruitment’ (38%) and ‘(low) Data quality’ (38%) were frequently reported. One respondent elaborated “*(It is a) balance between getting the data you need from a survey vs. it being too long and not being completed well. Checking, cleaning and recoding survey data can take considerable time*”. From the directed content analysis, ‘Biases’ (social desirability) was identified as an additional challenge.

Recommended use of methods

Wearables

Respondents using wearables expressed strong endorsement for use in age groups 6–12 years and 13–18 years. Their support was more modest in the 3–5 years age group, and limited for children aged 1–2 years (see Table 3). GPS were mostly recommended for the age 6–18 years and accelerometers for 3–18-year-olds. Respondents noted that GPS often require some user involvement (e.g. charging or switching on/off) making it easier to use GPS with older children or alternatively require parental involvement. The body size of children aged 1–2 and 3–5 was noted as making GPS devices feel bulky. Similar experiences were reported for accelerometers, where issues with younger children wearing a thigh-worn accelerometer for more than a few hours were noted. Older children were described as less reactive to wearables, though it was pointed out that for this age-group (13–18 years) exciting research devices are seen as uncool in comparison to watches that most people already wear. Detailed feasibility work was recommended for accelerometer use regardless of age-group: “[...] this should

Table 3 Contexts for recommended use of methods

	Wearables(n=20)		Systematic Observation (n=29)		Surveys(n=12)	
Age groups						
1–2	2 (10%)	+	11 (38%)	++	6 (46%)	++
3–5	10 (50%)	++	24 (83%)	+++	7 (54%)	++
6–12	19 (95%)	+++	25 (86%)	+++	9 (69%)	+++
13–18	18 (90%)	+++	19 (66%)	++	9 (69%)	+++
Do not recommend using this method with children and adolescents	1 (5%)	+	1 (3%)	+	.	.
Settings						
Public open space (POS)	15 (75%)	+++	22 (76%)	+++	10 (77%)	+++
School	16 (80%)	+++	22 (76%)	+++	10 (77%)	+++
Early Childhood Education and Care (ECEC)	15 (75%)	+++	24 (83%)	+++	8 (62%)	++
Housing associations*	10 (50%)	++	9 (31%)	+	4 (31%)	+
Play streets	11 (55%)	++	15(52%)	++	8 (62%)	++
Healthcare settings	8 (40%)	++	8 (28%)	+	7 (54%)	++
Other (Sports clubs)	1 (5%)	+	.	.	1 (8%)	+
Other (Nature environments)	1 (5%)	+	1 (3%)	+	.	.
Do not recommend using this method in any of these settings	2 (10%)	+	1 (3%)	+	.	.
Outcomes						
Physical activity intensity	13 (65%)	++	19 (66%)	++	3 (23%)	+
Activity type/behaviour	6 (30%)	+	24 (83%)	+++	10 (77%)	+++
Play volume	12 (60%)	++	19 (66%)	++	7 (54%)	++
Frequency of play	9 (45%)	++	13 (45%)	++	11 (77%)	+++
Time spent in the outdoor play space	8 (40%)	++	13 (45%)	++	8 (62%)	++
Number of users/visitors	3 (15%)	+	22 (76%)	+++	3 (23%)	+
Number of UNIQUE users/visitors	1 (5%)	+	4 (14%)	+	2 (15%)	+
Social interaction	4 (20%)	+	21 (72%)	+++	9 (69%)	+++
Other (Interaction with environment and objects)	.	.	2 (7%)	+	.	.
Do not recommend this method for measuring any quantitative outcomes	1 (5%)	+	.	.	.	.

Participants could choose more categories, therefore the number in each category adds to more than n. N represents the number of users recommending a specific method for each context. Low recommendation (+). Moderate recommendation (++). High recommendation (+++). *providers of affordable housing often with shared outdoor areas and playgrounds

include evaluating the uncertainties in research design, acceptability of a device for the specific age group, contextual factors that might facilitate or hinder engagement by a participant, and exploration of factors that may increase/decrease burden of wearing protocol”.

Respondents reported strong support for the use of wearables in Public Open Space (POS), school, and Early Childhood Education and Care (ECEC); moderate support in housing associations, play streets, and healthcare; and limited support in sports club and nature environments. GPS were most frequently recommended for use in POS and accelerometers for use in school and ECEC settings, though, wearables were generally noted as participant-bound (usable anywhere), ideally for 24-hour measurements across all settings a child is exposed to. However, with limited resources, use could focus on specific exposures. GPS was noted as useful for detecting and gathering data in less controlled settings, where activities are not always expected or planned for, though it was mentioned that “*there might be issues with signaling close to buildings, which should be considered*”.

Recommendations for outcomes differed between accelerometer and GPS measures. Respondents reported strong support for accelerometers assessing physical activity (PA) and play volume, moderate support for frequency, and limited support for activity type and time spent in the outdoor play space. In contrast, for GPS strong support was reported for measuring time spent in the outdoor play space, moderate support for play volume, frequency, number of users/visitors, and social interaction, and limited support for PA, activity type, and number of unique users/visitors. Accelerometers were noted to be well validated for assessing

physical activity intensity; however, consideration should be given to the ongoing discussion regarding appropriate cut points to classify physical activity intensity.

Respondents emphasized the complementary value of combining accelerometers (for PA intensity) and GPS (for location, time spent in each setting). It was further suggested that integrating these wearables with other data sources (e.g. diaries) may enhance the capture of contextual information and activity type.

Systematic observations

Systematic observations were most strongly recommended for the age groups 3–5 years and 6–12 years, and moderate recommendations for the age groups 1–2 years and 13–18 years (Table 3). Respondents noted that group-level observations are most suitable from around age 3 onwards, when behaviors are more observable and self-directed (e.g., *“it’s easier to understand what behaviors are occurring when observing these age groups”*), whereas individual-level observations may provide greater insight into younger children’s more varied and imaginative play (e.g., *“Young children use imagination <...> it is the best way to learn about children’s behavior in different contexts”*). Individual-level approaches were considered less suitable for adolescents due to potential reactivity. Camera-based observations were viewed as applicable across age groups, although privacy considerations and increased awareness of being filmed—particularly among older children—were noted as potentially influencing behavior: *“older children might be more aware of the filming process”*.

Respondents reported strong support for the use of systematic observations in POS, school, and ECEC settings, with moderate support for play streets and limited support for housing associations and natural environments. Respondents emphasized that both group- and individual-level approaches are best suited to clearly defined or contained settings with distinct activity zones: *“[...] best in closed spaces with distinct play areas, but it can really be used in almost any space as long as the specific target areas are well defined”* and *“I would consider using systematic observation group level in studies where there are clear areas/zones where different behaviors may occur”*. Individual-level approaches were further noted to work best in settings with relatively stable populations: *“observations on an individual level work well in situations where people will be in a space (e.g., playground) for a given time and there isn’t much fluctuation in terms of people entering/leaving the space”*. Camera-based observations were considered feasible across settings but raised privacy and consent challenges, particularly in more open environments such as POS.

Systematic observations were strongly recommended for measuring activity type, number of users, and social interaction; moderate for PA intensity, play volume, frequency, and time spent in outdoor play spaces; and had limited support for capturing unique users and interactions with the environment. Suitability varied by observational method: group-level observations were effective for activity type and user counts but limited for duration-based measures (e.g., *“[...] generally just a measure of moment in time so it’s hard to gather frequency or total time spent”*); behavioral mapping was viewed as particularly suited for assessing activity type, play volume, social interaction, PA intensity, and frequency but was also constrained by its momentary design: (e.g., *“Behavior mapping is a cross-sectional/momentary observation method that does not allow to measure activity duration”*); and individual-level observations were considered good for capturing activity type, social interaction and play volume, but were less effective for capturing the number of unique users, particularly social interaction were highlighted: *“[...]you can get a range of additional outcomes using individual-level observations compared to group-level observations. Things like social interactions are easier to observe at the individual level”*. Camera-based approaches enabled more detailed and repeatable analysis, with emphasis put on user counts and social interaction: *“At the moment cameras are best for number of users and social interaction (person proximity)”*.

Surveys

Respondents using surveys expressed strong support for use in age groups 6–12 years and 13–18 years, and moderate for the age groups 1–2 years and 3–5 years (Table 3). Respondents agreed that surveys are most eligible for

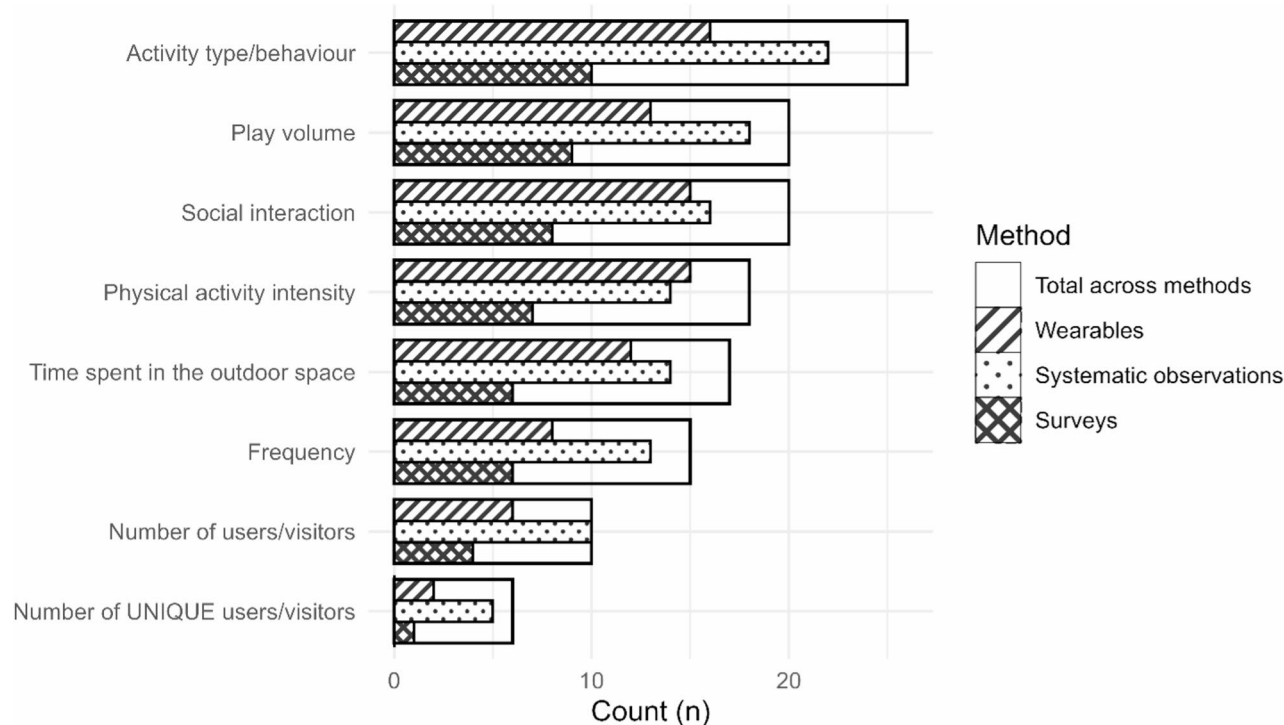


Fig. 1 Outcomes respondents were most interested in capturing in future studies. Participants could choose as many they wanted. Shows the overall number of participants ($n=31$) who are interested in each outcome and what methods they have reported on. E.g. 26 respondents chose 'activity type' as one of the outcomes they are most interested in being able to capture in future studies. Of the 26 respondents, 16 had reported on wearables, 22 on systematic observations and 10 on surveys

older children and that younger children should be assisted by parents or relevant personnel. It was noted that because the behavior of the youngest children occurs in short bouts and varies over short periods, it can be challenging for parents to capture and recall activity accurately.

Respondents reported strong support for the use of surveys in POS and school settings; moderate for ECEC, play streets and healthcare settings; and reported limited support for the use in housing associations and sports clubs. Respondents emphasized that the applicability of surveys depends less on the setting itself and more on respondent characteristics and the availability of assistance for younger age groups, e.g. school settings, where teachers can help. One respondent mentioned that for self-reporting older children (6–18 years), it is advantageous to clearly define the area of interest, e.g. school setting.

Strong support was reported for activity type, frequency, and social interaction; moderate for play volume and time spent in outdoor play space; and limited for PA intensity, number of users/visitors, and number of unique users/visitors. Respondents recommended using surveys to provide supplementary data for any other data collection method. Additionally, it was suggested to follow basic guidelines: using established reliable and valid items, conducting psychometric testing of new items, and getting the balance right between the data you need and the length of survey.

Method development needs

In future studies respondents were most interested in being able to capture activity type/behaviour followed by play volume and social interaction, as seen in Fig. 1. The same distribution was evident when looking separately at respondents reporting on systematic observations and surveys. For wearables, most respondents expressed an interest in capturing activity type/behaviour, followed by physical activity intensity and social interaction.

Suggestions and visions for method development

Respondents had the opportunity to suggest both specific improvements to existing methods and broader visions for future method development. The broader visions clustered into three themes: 24-hour wearable monitoring ($n=7$), automatic monitoring of spaces ($n=11$), and multi-source data collection ($n=8$). As these themes aligned closely with the main method categories examined in this study, they are presented alongside method-specific development needs.

For wearables respondents highlighted the need for smaller, lighter, and less expensive devices with improved battery life and storage capacity. Aesthetic appeal was considered important for increasing acceptability among children, with designs resembling contemporary smartwatches. For GPS devices, improved precision and more accessible protocols for data processing were suggested, while for accelerometers, respondents emphasized the need to better capture the complex movement patterns characteristic of children's play, alongside user-friendly interfaces inspired by commercial platforms, consensus regarding accelerometer cut-points and analytical standards. Reducing participant and researcher burden was a recurring theme, including automatic data retrieval and upload procedures, and the development of an integrated child-friendly device combining accelerometry and GPS tracking for at least seven consecutive days. These suggestions aligned with the broader vision of 24-hour wearable monitoring. Respondents envisioned wearable devices capable of continuously monitoring PA intensity, play and activity types, including complex movement patterns such as balance- and strength-based activities, while simultaneously linking these behaviours to environmental exposures. Future devices were also envisioned to incorporate physiological indicators such as heart rate to capture emotional responses such as fear or anxiety. In addition, devices should be low-cost, low-burden, unobtrusive (e.g., in-ear, shoe-mounted, wristband), easy to use, and capable of detecting social indicators and group interactions through connectivity with nearby devices.

For systematic observations, key suggestions for enhancement included improved observer training through standardized protocols and online video-based training modules. Respondents also emphasized streamlining data collection through mobile applications, camera-assisted observations, and technologies capable of capturing both physical and verbal behaviors, thereby reducing the need for researchers to travel to observation sites. Advances in camera technology, onboard processing, and machine-learning models were viewed as important opportunities for enhancement and potential pathway towards scalability, although ethical and acceptability concerns, particularly in child-focused research, were highlighted. These suggestions reflected the broader vision of automatic monitoring of spaces. Respondents imagined systems capable of unobtrusive, continuous observation within defined environments such as playgrounds and schoolyards. Such systems would integrate cameras, sensors, and onboard processing to automatically identify play and activity types, PA intensity, social interactions, engagement with playground equipment, and should distinguish repeat and new users as well as their total time in the space. The system should be able to analyze data as it goes alerting researchers to trends and interesting variations in data.

Few enhancements were suggested for surveys. Respondents suggested establishing repositories of validated and reliable survey instruments, practical guidance for assessing validity and reliability within specific populations, and time- and context-specific approaches, such as Ecological Momentary Assessment (EMA) to enable real-time data collection in natural settings. These suggestions point towards the broader vision of multi-source data collection. Respondents emphasized the potential of combining accelerometer, GPS, video, and contextual information (e.g., environmental attributes, weather conditions) to provide a comprehensive understanding of play and activity types, PA intensity, frequency, and social interactions. Such systems, for example apps, should enable richer insights into behavior patterns across diverse settings.

Across all themes and methods general design principles emphasized low participant and researcher burden, ease of use, reliability, cost-effectiveness, and adherence to ethical requirements.

Discussion

Summary of findings

This study aimed to (1) identify benefits and challenges of common quantitative methods for measuring children and adolescents' behavior in outdoor play spaces, (2) describe contexts where these methods are recommended, and (3) explore needs for methodological development.

Overall, wearables valued for high data quality and continuous, validated measurement, but were limited by participant burden, recruitment challenges, and data processing demands. Systematic observations provided rich contextual detail with minimal participant burden but were time-intensive hindering scalability. Surveys offered scalability and complemented other methods, although concerns were raised regarding child usability and data quality.

Recommendations were strongest in structured and familiar settings (e.g., schools, ECEC, POS), for children aged 6–12 years, and varied by outcome, depending on method. In contrast, gaps were identified for younger children (1–2 years) and in less structured or sporadic contexts (e.g., housing associations, play streets, and healthcare settings).

Across methods, key areas for development included improving scalability and reducing burden, and being able to capture activity type, play volume and social interaction. Three broader directions for future development were identified: 24 h wearable monitoring, automated monitoring of spaces, and multi-source data integration.

Benefits and challenges associated with each method

Wearables provide high-quality, objective data, but are associated with time-intensive processing and challenges in participant recruitment, reflecting well-established logistical barriers in accelerometer and GPS studies. In contrast, systematic observations capture only snapshots in time but generally require less individual participant recruitment and impose minimal participant burden, although access permissions, recruitment of sites, schools, or other institutions, and informing users about the observation are still required. These findings highlight the inherent trade-off between data depth and feasibility in measuring outdoor play behavior.

Scalability emerged as a key limitation of systematic observations. Observing large numbers of users often requires trade-offs between detail and accuracy, and substantial observation time is needed to achieve adequate statistical power, particularly when user numbers are low. Additional constraints—including the need for trained observers, logistical complexity, and time-intensive data collection—further limit scalability. These challenges may help explain the limited number of large-scale observational studies identified in the review by Schipperijn et al. [32].

Recommended use of methods

No method was highly recommended for the youngest children (1–2 years), and open-ended responses highlighted feasibility challenges requiring parental involvement up to around 5 years of age. Unpredictable movement patterns in young children further complicate measurement. This highlights a need for methods that reduce parental burden (e.g. more automated, low-involvement) while effectively capturing the unique, unpredictable movement patterns of children.

Gaps were also identified in settings where use is sporadic and difficult to anticipate (e.g., housing associations, healthcare environments, and play streets). A scoping review suggests that the majority of intervention studies related to children's play on playgrounds were conducted in structured settings, such as schools, ECEC and POS [32], which likely contributes to higher recommendations for these settings. As a result, it remains unclear whether lower recommendations in less structured settings reflect methodological limitations or limited

prior application. Nonetheless, these findings highlight a need for cost-effective, flexible methods suitable for unscheduled and variable contexts.

Several of the observed differences in recommendations may be explained by core methodological characteristics. Wearables provide continuous, objective, individual-level data, which likely contributed to the strong recommendations of accelerometers for PA intensity and GPS for time spent in outdoor play spaces. Their individual-based nature may also explain their broad applicability across settings, whereas requirements for wearing and managing devices likely contributed to stronger recommendations for older children, particularly for GPS. In contrast, systematic observations capture behavior within its environmental context and assess the use of space, which may explain their strong recommendations for activity type, social interaction, and user counts, as well as their suitability for schools, ECEC settings, and public open spaces with clearly defined areas for observation. Their momentary design may also explain the lower suitability for duration-based outcomes. Surveys rely on subjective self- or proxy-report and were strongly recommended for activity type, frequency, and social interaction, outcomes that may be difficult to fully capture through objective, momentary measures alone. Their reliance on recall likely contributed to stronger recommendations for older children and as a complementary method alongside wearables and observations.

Method development needs

Respondents prioritized activity type, play volume, and social interaction for future methods—outcomes often scoring moderate/limited recommendations in current methods (namely, activity type and social interaction when measured using wearables, and play volume across all methods). This highlights a research gap: existing methods excel at PA intensity (accelerometers) or user counts (observations) but lag in nuanced, multifaceted aspects of play, driving calls for innovation. 24 h wearable devices, automatic monitoring of spaces and multicomponent data collection should be prioritized. This aligns with the review by Bates et al., which calls for combining accelerometry, GPS, and survey measures to better capture the multidimensional nature of play [25]. Examples of such multicomponent approaches include the Multidimensional Toolkit for the Assessment of Play in Schools (M-TAPS), developed by Dodd et al., which combines scan- and focal-level systematic observations with child self-report surveys [34], and an approach developed by Hwang et al., which integrates accelerometer, GPS, and time-use diary data to assess active outdoor play in preschool-aged children [35]. Recent studies have found the SENS Motion Accelerometer to be promising for classifying posture and movement patterns (lying/sitting, standing, walking, and running) in children [36, 37]. Being a low-cost, 24 h wearable device with an easy-to-use interface, longer battery life and a build-in system reduce data loss, SENS Motion is a promising new method [28]. Though to fully meet the visions for 24 h wearable devices there is still room for innovation in relation to capturing social interaction and more complex movement patterns; and linking to the context where the behavior is happening. Similarly there is an increasing interest for automatic monitoring of spaces, for example, Carlsen et al. tested the validity of EVIP, a video-based computer vision algorithm, for automated assessment of physical activity in parks and schoolyards, they found EVIP to be a promising tool for ongoing monitoring, but emphasized that further work is needed to develop a generalizable algorithm, and that currently EVIP is not usable without computer vision knowledge [30].

Methodological considerations

The survey approach in this study offered a practical method for collecting quantifiable data while allowing respondents to elaborate on their experiences and perspectives alongside structured responses. This was chosen over a review to gain a better understanding of actual experience and feasibility. We considered this information difficult to extract from articles for a review, as not all articles include a strength and limitations section, and those that do often prioritize overall scope and choices. The survey was sent out to 90 eligible

researchers, 31 responded, reporting on 62 methods. Accordingly, this study is not intended as a comprehensive mapping of the field, but rather to provide insight into the concrete experiences and recommendations of a subset of researchers. Respondents were distributed across all levels of experience with methods. Most respondents had been involved in all parts of a project, had over 10 years' experience within the field, and used more than one method in their research. Level of experience with the methods was reported to address potential bias among participants with prior involvement in developing specific methods.

The survey was not based on a validated instrument but was developed specifically for this study. To compensate for this limitation, the survey was pilot tested with other researchers familiar with the methods and adjusted for clarity. However, questions on recommendations seemed to be interpreted differently by respondents, as elaborations indicate that some respondents based their answer on contexts where they had previously applied the method successfully. As a result, a low score either indicates limited applicability or simply that respondents have not used it there. Elaborations were optional, and respondents tended to provide more detailed comments on wearables and systematic observation methods than on surveys. This uneven distribution of qualitative data may have introduced an imbalance in the analysis and results sections.

For the scope of this survey, methods were grouped into the overall categories' systematic observations, wearables and surveys, and no distinction was made between e.g. different observation schemes, types of surveys, or specific accelerometers. We recognize that tools differ in important ways and therefore refer readers to validation studies, and best-practice reporting guidelines for more tool-specific information. Age categories were intentionally broad to align with the categories of toddlers, preschool children, school-aged children, and adolescents. However, substantial differences are likely to exist within the 6–12 years age group, particularly regarding the feasibility of self-report measures and the acceptance and suitability of technology-based measurement tools. Recommendations for this age group should therefore be interpreted with this consideration in mind. Furthermore, the survey assessed whether data collection and processing were perceived as time-consuming but did not collect information on their actual duration. Consequently, direct comparisons of time requirements across methods were not possible, and findings related to time burden should be interpreted as relative rather than absolute.

Conclusion

No method is without limitations, and selecting an approach involves trade-offs between data quality, resource requirements, and scalability.

Wearables are well suited for capturing individual-level behavior over extended periods but require further development to move beyond physical activity intensity toward capturing activity type, context, and social interaction. Systematic observations remain valuable for understanding how spaces are used but face challenges in scalability, for which automated approaches offer promising solutions, provided that privacy and data protection requirements are met.

Future development should prioritize approaches that are feasible in less structured, unpredictable environments, and suitable for use with younger children. Advances in technology, particularly in wearable devices and automated monitoring systems, offer considerable potential to improve the measurement of children's and adolescents' behavior in outdoor play spaces.

Abbreviations

CPS	Children's Play Scale
ECEC	Early Childhood Education and Care
EVIP	Ecological Video Identification of Physical Activity
GDPR	General data protection regulation

GPS	Global Positioning Systems
MOHAWK	Method for Observing Physical Activity and Wellbeing
OSRAC-P	Observational System for Recording Physical Activity in Children – Preschool Version
PA	Physical Activity
POS	Public Open Space
REPS	Risk Engagement and Protection Survey
SOFIT	System for Observing Fitness Instruction Time
SOPARC	System for Observing Play and Recreation in Communities
SOPLAY	System for Observing Play and Leisure Activity in Youth
TRiPS	Tolerance of Risk in Play Scale
TOPO	Tool for Observing Play Outdoors

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

Declarations

Ethics approval and consent to participate Not applicable. The study focused on research methods rather than individuals. Although researchers participated as respondents, no personal or sensitive data was collected. The only identifying information requested was name and/or email address, this was entirely optional and collected only for the purpose of acknowledging contributors. Participation was voluntary, and informed consent was obtained. Participants were informed in the invitation email and on the first page of the survey that anonymized data would be shared with other researchers.

Consent for publication Participation was voluntary, and informed consent was obtained. By answering the survey participants agreed to anonymized data being included in a publication.

Competing interests JS is a member of the Editorial Board of International Journal of Behavioral Nutrition and Physical Activity. TS is Associate Editor of the International Journal of Behavioral Nutrition and Physical Activity. JS and TS was not involved in the journal's peer review process of, or decisions related to, this manuscript.

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