Developing International Consensus on Key Indicators for a 24-Hour Movement Behaviour Report Card in Early Childhood: A Twin-Panel Delphi Study

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Citation:

Developing International Consensus on Key Indicators for a 24-Hour Movement Behaviour Report Card in Early Childhood: A Twin-Panel Delphi Study

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Abstract

Background The World Health Organization has established recommendations for 24-h movement behaviours in children under 5 years. Building on the successful knowledge translation model of *Active Healthy Kids Global Alliance Report Cards*, this study aimed to develop a similar framework for the early years.

Methods Using a three-round twin-panel Delphi survey (conducted via an online survey between 28 November 2024 and 11 March 2025), expert consensus was sought on indicators and benchmarks for the first dedicated report card on 24-h movement behaviours for the early years. The experts were identified through a three-step selection process, which included recognised international projects and networks as well as literature search. In Round 1, participants evaluated the applicability of 15 initial indicators. In Rounds 2 and 3, they rated the importance of each indicator, with results from their own panel (Round 2) and the other panel (Round 3) provided to inform their decisions. Qualitative feedback on definitions and benchmarks was systematically reviewed and incorporated. Consensus was predefined as ≥ 75% agreement, with stability across rounds considered.

Results Of 175 invited experts, 72 (41.1% recruitment rate) from 15 regions participated in Round 1, with 61 (84.7% response rate) and 56 (77.8% response rate) completing Rounds 2 and 3, respectively. Consensus was achieved for 12 indicators, with definitions and benchmarks refined based on expert inputs. Notably, *Weight Status* and *Motor Proficiency* were excluded due to lower agreement.

Conclusions The finalised set of indicators, definitions, and benchmarks provides a robust foundation for creating a standardised report card for early childhood. The finalised results serve as a critical advocacy instrument to raise awareness, improve surveillance, facilitate cross-jurisdictional comparisons, and inform policy and public health initiatives, ultimately supporting the health and well-being of young children globally.

Key points

- Global experts from 15 world regions collaborated to create the first standardised indicators and their benchmarks for inclusion in dedicated report cards on 24-hour movement behaviours for young children through a structured consensus process.

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Background

There is ample evidence showing that combinations of movement behaviours, including physical activity, sedentary behaviour, and sleep, are essential for health and development in the early years [1–3]. The World Health Organization (WHO) have provided age-specific recommendations on combinations of these movement behaviours in a 24-h day for children under 5 years [4]. Similar recommendations have been developed and employed by a few countries in recent years [5–8]. However, low compliance with the guidelines have been reported worldwide [9–11].

To address the global epidemic of physical inactivity, the WHO advocates a systems-based approach that engages stakeholders from all relevant sectors to work together to drive changes in systems, environments, and policies [12]. A prominent global initiative in this effort is the development of *Active Healthy Kids Report Cards on Physical Activity*, a well-established knowledge translation model led by the Active Healthy Kids Global Alliance (AHKGA) [13, 14]. The Report Cards synthesise the best available evidence across ten common indicators, including physical activity, its sub-components, and factors that influence it, to assess a jurisdiction's performance by assigning a letter grade anchored to a harmonised benchmark to each indicator [15]. Over the past decade, this model has been successfully replicated in more than 70 jurisdictions worldwide [16–19]. Its demonstrated impacts include advancing knowledge, capacity building, network formulation, identification of knowledge gaps, establishment of partnerships, community advocacy, and informing policy changes [13, 14].

The *Active Healthy Kids Report Cards* have historically targeted children aged 5–17 years, with primary focus on physical activity-related indicators. While this model has successfully fostered cross-sector collaboration for school-aged populations, the 2019 WHO guidelines on 24-h movement behaviours for children under 5 years [4] create new imperatives for early childhood monitoring. The Report Card model is uniquely positioned to address this need, providing the practical implementation structure required to achieve the intended impact of the WHO guidelines [20]. Recently published evaluations of the *AHKGA Global Matrix 4.0* explicitly identified the desire to extend this framework to younger children [21]. However, there has been neither consensus on core indicators nor evidence-based benchmarks tailored to this age group defined. This standardisation gap limits global comparability and weakens advocacy efforts. To address this gap, our Delphi survey study aimed to systematically gather expert input and achieve consensus on indicators and benchmarks for the first dedicated report card on 24-h movement behaviours for children at their early years. By synthesising input from geographically and professionally diverse experts, this study could produce a resulting framework that balances scientific rigor with contextual adaptability. The finalised results aim to serve as both benchmarks for surveillance and a catalyst for policy change, empowering stakeholders to drive measurable improvements in early childhood health and development globally.

Methods

Study Design

The Delphi method is deemed appropriate for establishing expert consensus and plays a critical role in developing evidence-based guidelines for best practices [22]. The Delphi approach has been widely used to achieve consensus on research priorities in physical activity [23], physical fitness [24], and specific fitness test batteries [25]. Accordingly, our study employed this approach and adhered to the Guidance on Conducting and Reporting Delphi Studies (CREDES) [22]. Although a single-panel Delphi approach is efficient to manage and reduces logistical complexity, it may introduce bias and increase the risk of groupthink [26]. Therefore, a twin-panel approach was adopted in this study, as it enables cross-validation of findings between independent panels [24], reduces group bias, and enhances the robustness of consensus, particularly when addressing international topics. The modified Delphi approach was selected because the initial indicators and benchmarks were informed by preliminary formative work and presented to the panel in the first round. The study was designed to include multiple rounds of opinion gathering, with stop criteria defined as achievement of consensus taking into consideration a minimum degree of stability among the responses reached [27]. Respondents were identifiable to the research team via email addresses but anonymous to each other. An overview of the Delphi process is illustrated in
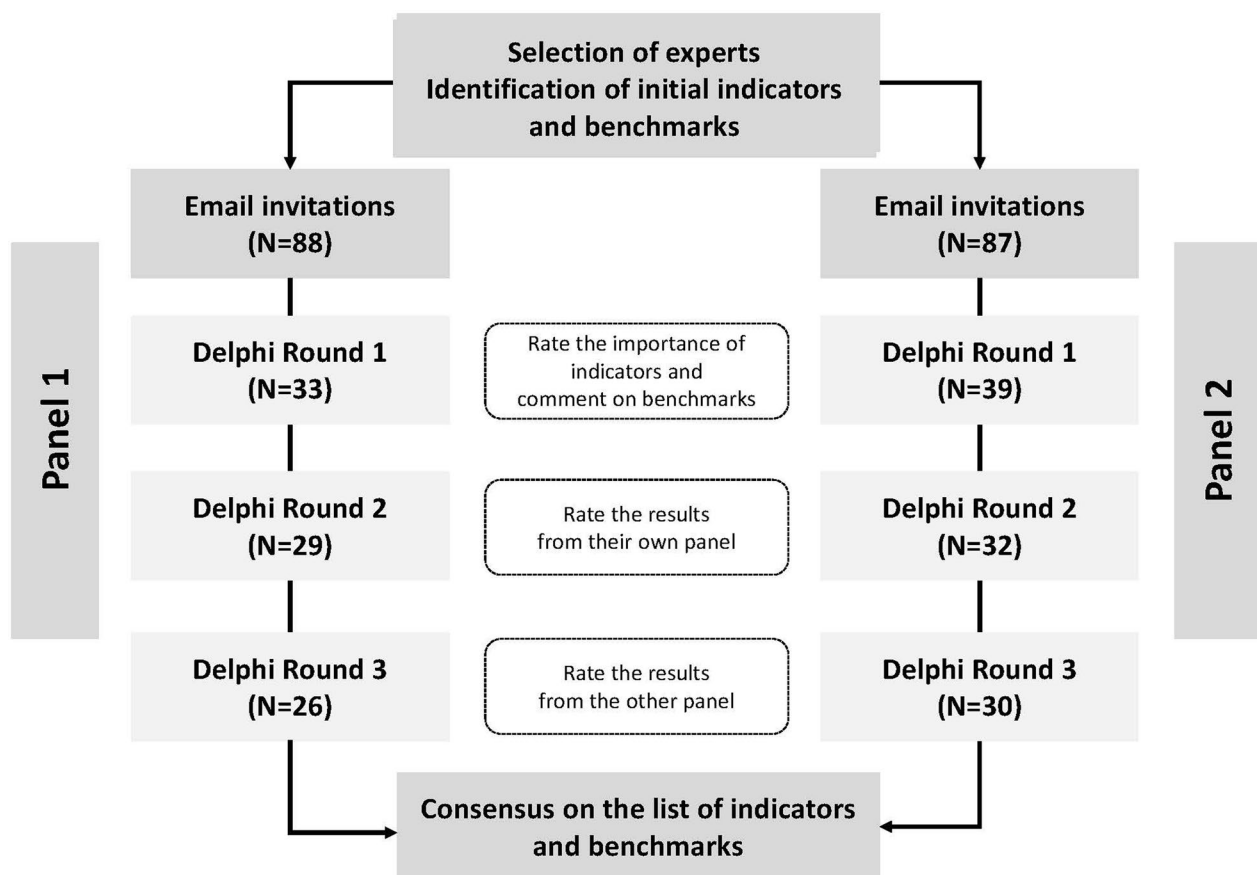
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Fig. 1 Flow diagram of twin-panel Delphi process

Fig. 1 and the completed CREDES Checklist is shown in Additional File 2.

Panel Selection and Recruitment

The experts who have experience in relevant fields were identified through recognised international projects/networks and literature searches.

International Network/Projects

Core team members (or leadership group) from two international research projects, the Sleep and Activity Database for the Early Years (SADEY) [28] and the International Study of Movement Behaviours in the Early Years (SUNRISE) [29] that focus on physical activity, sedentary behaviour, and sleep for children under 5 years of age, were manually searched. The AHKGA Global Matrices 1.0 to 4.0 were also screened for potential participants. Country/region leaders and co-leaders from participating jurisdictions that have evaluated evidence on the early years were included, resulting in 62 experts from 35 jurisdictions identified.

Literature Searching

This study linked two strings of search terms: #1: age range: "early year*" OR "early child*" OR "preschool*" OR "infant*" OR "young child*" OR "toddler*" OR "age*0-year*" OR "age*-1-year*" OR "age*-2-year*" OR "age*-3-year*" OR "age*-4-year*" OR "kids", and #2: outcomes: "physical activity" OR sedentary OR screen OR sleep OR play OR exercise OR "movement behavio*" OR "movement guideline*". The literature search was implemented in Web of Science to identify highly cited researchers, with the following filters applied: Preprint Citation Index (excluded – database), Article (document types), publication in the past ten years (till the search date: July 31, 2024). Papers were eligible for inclusion if they included at least one of the 24-h movement behaviours in healthy children under 5 years old, as indicated in the title or abstract. Conference abstracts, commentaries or studies involving only children with disabilities or illnesses were excluded. A total of 5,356 documents were retrieved. Based on citation metrics, the top 500 highly cited publications were selected and imported into VOSviewer [30] for analysis. Co-author selection in VOSviewer identified

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authors with a minimum of five publications. A total of 27 authors were identified, with 85.2% originating from the United States, Australia, and Canada.

To account for cultural and contextual differences (e.g., policy, education) across countries [31], two additional search strategies were employed to enhance the representation of researchers from other regions. First, an additional search in Web of Science was conducted using the same search terms (#1 and #2) but excluding publications from these three countries, yielding 2,499 documents. Second, the China National Knowledge (CNKI) database, the largest and most comprehensive Chinese-language literature database, was searched using a similar set of key terms translated into Chinese. This search retrieved 35 publications. From these, 869 corresponding authors from 830 publications were identified, and 82 of them, who had published three or more articles with at least one publication within the last 3 years, were selected.

After deduplication, the two search strategies yielded 172 experts. Four additional experts were included through referrals during the first round and one expert was eventually excluded due to undeliverable email address. A total of 175 experts were invited to participate in the first-round survey. These experts were randomly allocated to two panels, stratified by career status. The flowchart illustrating the expert selection process is presented in Additional File 3.

Initial Indicators and Benchmarks

The initial indicators and the benchmarks were determined using two approaches. First, we extracted the indicators and benchmarks that have been developed for children in the early years in the country/region report cards (n = 35) included in Global Matrices 1.0 to 4.0 (https://www.activehealthykids.org/). Eleven indicators were considered as "core indicators" if they were reported in at least three countries/regions report cards. These included six behavioural indicators (*Overall Physical Activity*, *Organised Sport and Physical Activity*, *Active Play*, *Active Transportation*, *Sedentary Screen Time*, and *Sleep*), four sources of influence (*Family and Peers*, *School/Early Childhood Education*, *Community and Environment*, and *Government*), and an individual indicator (*Obesity/Weight Status*). Although this report card targets 24-h movement behaviours and their influencing factors, *Obesity* was initially included given its frequent reporting in report cards for school-aged children and adolescents. Two indicators (*24-Hour Movement Behaviours* and *Motor Proficiency*) that were reported once were also considered. The benchmarks of these indicators were extracted from the report card details.

Second, the WHO Guidelines were searched and identified two additional indicators, *Restrained Time* (regarding sedentary time) and *Tummy Time* (physical activity for infants) [4]. In addition, local government policies related to 24-h movement behaviours in early childhood were also referred to when developing the benchmarks for the four sources of influence indicators. The initial indicators, definitions, and benchmarks that were presented to the panels in Round 1 are provided in Additional File 4.

Delphi Surveys

The surveys were developed and administered using QuestionPro (www.questionpro.com). To evaluate the clarity and comprehensibility of the questions, a pilot study was conducted among five project team members and two external scholars who did not participate in the main study. No major revisions were required following the pilot. The three survey rounds were conducted between 28 November 2024 and 11 March 2025, with intervals of 4–6 weeks between each round. Respondents were given up to four weeks to complete the survey, which was distributed via email. Two mass reminder emails were sent after one and two weeks, respectively, followed by a personalised email reminder to non-respondents after three weeks. All participants who consented in Round 1 were invited to participate in subsequent rounds. Respondents were not informed of the existence of other panel until the start of Round 3.

In the first round, participants were provided with background information on the project, along with descriptions of the initial indicators, including their definitions and benchmarks. They were asked to respond to two key questions: (1) "In your opinion, are these indicators applicable to children aged under 5 years (i.e., should be included in the report card on 24-h movement behaviours for this age group)?" and (2) "In your opinion, what are the additional indicators for the early years that should be considered but not included above?" Participants were also invited to provide comments and suggestions on the initial indicators and benchmarks, if applicable. For any additional indicators and benchmarks proposed, an explanatory rationale was requested. Additionally, participants completed a demographic questionnaire covering age, gender, country of residence, education, occupation, and years of professional experience. Two authors reviewed the feedback and compiled a list of indicators, incorporating any additional indicators suggested by at least two experts. Qualitative feedback on the benchmarks was reviewed and discussed by the project team to inform necessary revisions.

In the second round, the respondents were presented with the revised indicators and benchmarks, updated based on feedback from their respective panel in Round 1. They were asked to rate the importance of

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each indicator using a 5-point Likert scale (ranging from '1 = unimportant' to '5 = very important'). Participants were also given opportunities to provide further comments on the revised benchmarks. The project team reviewed and discussed the qualitative feedback to determine whether additional modifications to the definitions and benchmarks were required.

In Round 3, participants received a cover letter informing them of the other panel's responses and a summary of Round 2 results, including results [mean, median, standard deviation (SD), interquartile range, percentage of respondents rating the indicator as 'important' or 'very important'] alongside anonymised qualitative comments. With this knowledge, they were asked to re-rate the importance of each indicator using the same 5-point Likert scale (ranging from '1 = unimportant' to '5 = very important'). Additionally, given the significant update to the benchmark for *Motor Proficiency* following Round 2,

an extra question related to this indicator was included in Round 3: "Taking into consideration the lack of currently available benchmarks, do you agree on including 'Motor Proficiency or Gross Motor Skills' in the report card?" Responses were collected using a 5-point Likert scale, ranging from '1 = strongly disagree' to '5 = strongly agree'. Consensus was predefined as 75% agreement of respondents rating an indicator as '4 = important' or '5 = very important' [22, 32].

Data Analysis

The demographic characteristics of respondents in each round were summarised using means and standard deviations (SDs) for continuous variables and frequencies (numbers and percentages) for categorical variables. Quantitative results and qualitative feedback were reported for each round. To evaluate differences between the two panels in Round 3, the Mann–Whitney U and

Table 1 Characteristics of the participants

	Round 1 (n=72)		Round 2 (n=61)		Round 3 (n=56)	
	Panel 1 (n=33)	Panel 2 (n=39)	Panel 1 (n=29)	Panel 2 (n=32)	Panel 1 (n=26)	Panel 2 (n=30)
Age, years, median (range)	48 (33,70)	45 (34,77)	48 (33,70)	44 (34,77)	48.5 (33,64)	45.0 (35,77)
Gender, female	17 (51.5%)	21 (53.8%)	15 (51.7%)	17 (53.1%)	14 (53.8%)	13 (43.3%)
Country of residence						
North America	3 (9.1%)	5 (12.8%)	2 (6.9%)	4 (12.5%)	2 (7.7%)	4 (13.3%)
South America	2 (6.1%)	3 (7.7%)	1 (3.4%)	2 (6.3%)	1 (3.8%)	2 (6.7%)
Europe	13 (39.4%)	18 (46.2%)	11 (37.9%)	14 (43.8%)	11 (42.3%)	13 (43.3%)
Africa	4 (12.1%)	2 (5.1%)	4 (13.8%)	1 (3.1%)	2 (7.7%)	1 (3.3%)
Asia	10 (30.3%)	7 (17.9%)	10 (34.5%)	7 (21.9%)	9 (34.6%)	6 (20.0%)
Oceania	1 (3.0%)	4 (10.3%)	1 (3.4%)	4 (12.5%)	1 (3.8%)	4 (13.3%)
SES of the country of residence						
High-income	22 (66.7%)	27 (69.2%)	18 (62.1%)	22 (68.8%)	18 (69.2%)	21 (70.0%)
Middle-income	7 (21.2%)	12 (30.8%)	7 (24.1%)	10 (31.3%)	7 (26.9%)	9 (20.0%)
Low-income	4 (12.1%)	0	4 (13.8%)	0	1 (3.8%)	0
Highest Degree						
PhD	31 (91.2%)	39 (97.5%)	26 (89.7%)	32 (100.0%)	23 (88.5%)	29 (96.7%)
Masters	3 (8.8%)	1 (2.5%)	3 (10.3%)	0	3 (11.5%)	1 (3.3%)
Current occupation*						
Clinical/health care provider	3	4	3	2	2	2
Scientist/researcher	32	36	28	31	25	29
Research manager/research assistant	1	0	1	0	1	0
Year of working experience						
≤ 5	2 (6.1%)	4 (10.3%)	2 (6.9%)	4 (12.5%)	2 (7.7%)	4 (13.3%)
6–10	4 (12.1%)	5 (12.8%)	4 (13.8%)	5 (15.6%)	3 (11.5%)	2 (6.7%)
11–20	18 (54.5%)	16 (41.0%)	15 (51.7%)	12 (37.5%)	13 (50.0%)	13 (43.3%)
21 +	9 (27.3%)	14 (35.9%)	8 (27.6%)	11 (34.4%)	8 (30.8%)	11 (36.7%)

Data are n (%) unless specified

* Non-single-choice question. SES: Socioeconomic status

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the Kolmogorov–Smirnov (K-S) Z tests were conducted. The changes in expert opinions across the two rounds were assessed by comparing the percentage of agreement between Round 2 and Round 3, supplemented by Wilcoxon signed-rank tests to analyse shifts in rating distributions.

Results

Participants' Characteristics

Among the 175 experts invited via email, 72 agreed to participate (41.1% recruitment rate). The participant flow is illustrated in Fig. 1. In Round 2, 61 experts completed the survey (84.7% response rate), and in Round 3, 56 experts participated (77.8% response rate). A total of 50 experts (Panel 1: n=24; Panel 2: n=26) completed all rounds of the survey. Table 1 summarizes the demographic and professional characteristics of the respondents in each round. Slightly more than half of the participants were female at recruitment. Respondents were geographically diverse, representing 79% regions (15 out of 19) as defined by the United Nations geoscheme, with the majority residing in Europe and Asia. Over 60% of participants were employed in high-income countries, and the majority were affiliated with academic institutions. While the two panels were generally comparable, Panel 2 included a higher proportion of experts with over 20 years of professional experience compared to Panel 1 (35.9% vs 27.3%).

Delphi Results

In Round 1, 71 respondents provided feedback on the applicability of the 15 initial indicators for the early years and their recommended inclusion in the report cards (see Additional File 4). *Weight status* (73.2% agreement) was the only indicator that did not meet the 75% threshold for inclusion. Inter-panel agreement was high for most indicators, except for *Restrained Time* and *Motor Proficiency*; however, both indicators still achieved over 75% agreement for inclusion (details provided in Additional File 5). Based on qualitative feedback, three major adjustments were made: (1) *Overall Physical Activity* and *Tummy Time* were consolidated into a single indicator, (2) *Organised Sport and Physical Activity* was renamed to *Structured Physical Activity*, and (3) the age range was revised to include children under 5 years, in alignment with the WHO guidelines, despite the recognition that 5- and 6-year-olds are considered preschoolers in several countries. In addition, definitions and benchmarks for the indicators were refined to enhance consistency and clarity, incorporating expert suggestions. Notable revisions include: (1) the addition of a benchmark requiring 30 min of moderate-to-vigorous physical activity for children aged 1–2 years under the *Overall Physical Activity*

indicator, (2) the removal of the phrase "competitive and contest-based" from the *Structured Physical Activity* definition, (3) clarification of definition for *Restrained Time*, (4) the inclusion of a peer support-related benchmark for *Family and Peers*, (5) the recommendation to use the Health-Enhancing Physical Activity (HEPA) Policy Audit Tool Version 2 [33] for grading the *Government* indicator, and (6) revision of the *Motor Proficiency* benchmarks to reflect the potential use of normative values for motor skills among 3-to-4-year-olds, which are currently under development by an international project [29].

In the second round, 61 responses were received. The ratings between the two panels were consistent across all indicators (Additional File 6). While all indicators achieved over 80% agreement across the entire sample, *Structured Physical Activity* and *Restrained Time* received comparatively lower rating scores; agreement for these two indicators in Panel 2 fell slightly below 80%. Qualitative feedback was carefully reviewed by the project team to further refine the definitions and benchmarks. As a result, the requirements of 30 min of moderate-to-vigorous physical activity for children aged 1–2 years was removed from the *Overall Physical Activity* indicator. Additionally, it was recommended that a simple average approach be used for indicators with multiple benchmarks. Where appropriate, country-specific examples were incorporated into the definitions of certain indicators (e.g., *Structured Physical Activity*) to accommodate cultural differences. Feedback from the international project [29] indicated that normative values for motor skills would not be available in time for the development of the report cards in the near future. As a result, the lack of well-established benchmarks for *Motor Proficiency* was explicitly acknowledged and clearly stated in the revised benchmarks following Round 2.

In the third round, all indicators met the 75% agreement threshold for inclusion, except for *Motor Proficiency* (Table 2 and Additional File 7). Given the lack of well-established benchmarks for this age group, less than 75% of the respondents (65.3% of panel 1 and 73.3% of panel 2) agreed or strongly agreed to recommend *Motor Proficiency* in the early years report cards. The median and rating distributions between the two panels were not significantly different; however, agreement for *Structured Physical Activity* and *Restrained Time* as 'important' or above fell slightly below 75% in panel 1 (73.1%) and panel 2 (73.3%), respectively. Ratings remained stable between Round 2 and Round 3 for all indicators except *Motor Proficiency*, for which agreement was 72%, and the proportion of experts rating this indicator as 'important' or above declined from 90% in Round 2 to 74% in Round 3 (Table 3). After reviewing the qualitative feedback, the project team decided to exclude *Motor Proficiency*.

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Table 2 Comparisons of ratings between two panels in Round 3 (n = 56)

Indicators	Median (IQR)			% Very important + Important	
	Panel 1 (n = 26)	Panel 2 (n = 30)	*p* value	Panel 1 (n = 26)	Panel 2 (n = 30)
Overall Physical Activity	5 (0)	5 (0)	0.193	100.0	100.0
Structured Physical Activity	4 (2)	4 (1)	0.142	73.1	90.0
Active Play	5 (0.25)	5 (0)	0.782	100.0	100.0
Active Transportation	4 (1)	4.5 (1)	0.695	92.3	90.0
Sedentary Screen Time	5 (0)	5 (0)	0.519	96.2	100.0
Restrained Time	4 (1)	4 (2)	0.673	80.8	73.3
Sleep	5 (0)	5 (0)	0.804	100.0	100.0
Family and Peers	5 (1)	5 (1)	0.828	92.3	96.7
School / Early Childhood Education	5 (1)	5 (1)	0.649	96.2	100.0
Community and Environment	5 (1)	4 (1)	0.253	96.2	83.3
Government	5 (1)	4 (1)	0.512	92.3	86.7
24-Hour Movement Behaviours	5 (0.25)	5 (1)	0.362	96.2	90.0
Motor Proficiency					
Importance level	4 (2)	4 (2)	0.868	73.1	70.0
Agreement level[#]	4 (1.25)	4 (1.25)	0.498	65.4	73.3

IQR: interquartile range. *p* values are based on Mann–Whitney U tests

Note: Participants rated the importance level for each indicator to be included in the report card using a 5-point Likert scale (1 = not important, 2 = of little importance, 3 = moderately important, 4 = important, 5 = very important)

[#] given the significant update to the benchmark for this indicator following round 2, an extra question was asked in Round 3 – "Taking into consideration lack of available benchmarks, do you agree on including 'Motor Proficiency or Gross Motor Skills' in the report card?" A 5-point Likert scale was employed (1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree)

Table 3 Stability of ratings between Round 2 and Round 3

Indicator	Exact agreement (%)	Within one point (%)	% Very important + Important		Median (IQR)		
			Round 2	Round 3	Round 2	Round 3	*p* value
Overall Physical Activity	96	98	96	100	5 (0)	5 (0)	0.197
Structured Physical Activity	84	94	80	84	4 (1)	4 (1)	0.932
Active Play	92	96	92	100	5 (1)	5 (0)	0.087
Active Transportation	90	94	88	90	4 (1)	4 (1)	0.369
Sedentary Screen Time	98	98	96	98	5 (0)	5 (0)	0.190
Restrained Time	86	98	82	76	4 (1)	4 (1)	0.221
Sleep	98	100	98	100	5 (0)	5 (0)	1.000
Family and Peers	92	96	98	94	5 (1)	5 (1)	0.519
School / Early Childhood Education	94	100	96	98	5 (1)	5 (1)	0.637
Community and Environment	92	96	98	90	5 (1)	5 (1)	0.060
Government	88	96	94	90	5 (1)	4.5 (1)	0.694
24-Hour Movement Behaviours	90	94	94	92	5 (0)	5 (1)	0.672
Motor Proficiency	72	90	90	74	4 (1)	4 (2)	0.099

Based on data from participants who completed both Round 2 and Round 3 (n = 53)

IQR: interquartile range. *p* values are based on Wilcoxon Signed-Rank Tests

Consequently, 12 indicators were finalised for inclusion in the report card on 24-h movement behaviours for children under 5 years. The finalised indicators, along with their definitions and benchmarks, are presented in Additional Files.

Discussion

Main Findings

This study represents the first global attempt to develop a harmonised set of indicators, definitions, and benchmarks for the first dedicated report card on 24-h movement behaviours in children under 5 years. By employing

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a rigorous twin-panel Delphi survey, expert consensus was achieved on 12 relevant indicators, providing a standardised framework that can be adapted across diverse cultural and geographical contexts. The novelty of this work lies in its global perspective, addressing the need for a unified approach to monitoring and promoting healthy movement behaviours in early years children.

The findings demonstrate strong expert agreement on including 24-h movement behaviours or its subcomponents—including *Overall Physical Activity, Active Play, Active Transportation, Sedentary Screen Time*, and *Sleep*—reflecting their well-established importance in the literature and alignment with the WHO guidelines [4]. Moreover, all sources of influence factors—including *Family and Peers, School/Early Childhood Education, Community and Environment*, and *Government*—consistently achieved high agreement for inclusion. These results reinforce the social ecological model's emphasis on multifaceted influences shaping young children's movement behaviours [34–36]. This structure is also consistent with the well-established Global Matrix Report Card format used by the AHKGA in more than 70 countries [14]. The broad consensus of experts from around the world underscores these indicators' global relevance and practical applicability of this set of indicators for population-level monitoring.

However, experts highlighted important contextual considerations regarding specific operationalisations, examples, and age-range applicability of some indicators across different countries. Two indicators—*Structured Physical Activity* and *Restrained Time*—while meeting the 75% inclusion threshold, generated substantial debate in qualitative feedback. For *Structured Physical Activity*, some experts questioned its developmental appropriateness for young children and advocating sport instead of active play. Yet in countries with established traditions of organised physical activity programs for preschoolers (e.g., Canada, Japan), this indicator was deemed highly relevant [37, 38]. In low- and middle-income countries, however, its relevancy was questioned. Evidence supporting benefits of both structured and unstructured moderate-to-vigorous physical activity for physical and mental health for the early years [39, 40] justified retaining this indicator while acknowledging the need for culturally appropriate interpretations. Similarly, *Restrained Time* provoked discussion due to limited direct evidence supporting its health impacts [41], despite WHO guidelines recommending that children under 5 years should not be restrained for more than one hour at a time [4]. Studies examining adherence to early years' 24-h movement guidelines have generally not included this recommendation [42–44]. Nevertheless, to align with the WHO guidelines, this indicator was retained. Future research

should strengthen operational definitions and investigate its associations with health outcomes in the early years to better inform indicator utility.

Notably, *Weight Status* and *Motor Proficiency* were excluded due to insufficient agreement. While *Weight Status* was the second most frequently included additional indicator in Global Matrix 4.0 report cards [18], its benchmarks vary significantly across jurisdictions. In our study, experts expressed divergent views on assessment parameters (e.g., normal weight, stature, underweight) and benchmark determination. A prominent concern was the potential for obesity-focused metrics to overshadow the behaviour and influence indicators, ultimately leading to this indicator's removal after the first round. Regarding *Motor Proficiency*, while experts acknowledged the well-documented importance of motor competence for young children [45, 46], consensus was hindered by inconsistent terminology in the literature (e.g., motor competence, motor ability, or fundamental movement skills) and conceptual ambiguity [47]. Motor competence encompasses multifaceted constructs like postural stability, locomotion, and object manipulation [48], with recent frameworks proposing four distinct, interconnected domains measurable through both process- and product-oriented assessments [49]. This complexity complicates standardised assessment development. Although tools like the Test of Gross Motor Development-2 (TGMD-2) [50] and the NIH Toolbox [29] exist and have been employed in previous studies, benchmarks selection remains contentious. Modelled after approaches for school-aged children and adolescents [51, 52], normative values from an international preschool study [29] were proposed for consideration in the Round 2 survey. However, this proposal faced two key challenges: (1) the absence of normative data in many countries which has also been reported in the literature (e.g., Ireland's physical education curriculum lacks explicit motor competence benchmarks [48]), and (2) concerns that norms derived from contemporary young populations may not represent optimal motor competence levels necessary for health and development. Given these unresolved challenges in definition, assessment, and benchmarking, the decision to exclude *Motor Proficiency* at this stage was justified to maintain the report card's clarity and feasibility for global implementation. This decision does not diminish the importance of motor proficiency in early childhood. In the future, once appropriate benchmarks are established, this indicator should be seriously considered for inclusion in report cards.

Implications of the Findings

This study addresses a critical translational gap by establishing the first standardised, consensus-driven

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framework for monitoring and reporting 24-h movement behaviours in early childhood. The findings have significant implications across surveillance, research, and policy domains. First, the harmonised indicators and adaptable benchmarks enable immediate development of dedicated national/jurisdictional report cards for the early years, creating robust monitoring systems essential for tracking progress toward WHO guideline targets [20] and making inter-jurisdictional comparisons. Second, the identified evidence gaps, particularly regarding restrained time and motor competence, underscore the need for coordinated multinational studies using these standardised indicators to establish global prevalence data and refine benchmarks. Third, the framework's socioecological structure provides policymakers an actionable template through two critical features: (1) culturally adaptable benchmarks that emerged as a critical need from expert feedback, and (2) modular components that can be tailored to local contexts. These features are particularly vital for low- and middle-income countries, where the framework's flexibility helps overcome infrastructure and resource limitations without compromising global data comparability. Finally, the framework's synergy with the established AHKGA Global Matrix report cards for school-aged children and adolescents [13] creates an unprecedented life-course monitoring system, allowing jurisdictions to consistently track behavioural trajectories across developmental stages and identify critical transition periods.

Strengths and Limitations

This study has several strengths, including the participation of experts with an approximately equal gender distribution and representation from diverse geographic regions, socioeconomic backgrounds, and professional experiences. The use of a twin-panel design enhanced cross-validation, while predefined criteria for agreement, including stability across rounds [32], strengthened the robustness of the findings. However, several limitations must also be acknowledged. Despite a recruitment rate comparable to previous studies [24, 53], about 60% of the invited experts did not participate. The findings cannot represent the views of the non-respondents. Additionally, the selection of panel members may have introduced potential bias due to the possible over-representation of perspectives from high-income countries. However, the respondents in this study represented 79% of the geographic regions as defined by the United Nations, indicating a reasonable degree of geographical diversity. Furthermore, the proportion of respondents from low- and

middle-income countries (~30%) was higher than that reported in previous Delphi surveys [24, 53]. Furthermore, the study primarily relied on expert opinions and did not include the opinions of key stakeholders such as parents, teachers, and caregivers, whose insights are critical for enhancing the practical applicability and cultural relevance of the report card indicators. Qualitative feedback occasionally revealed discrepancies within and between panels, highlighting the challenges of achieving universal consensus on benchmarks. This was particularly evident for *Motor Proficiency*, where the lack of established benchmarks and significant modifications of the benchmarks following the first two rounds may have influenced experts' agreement. Future research should explore the implementation of report cards in different countries and regions, incorporate feedback from various stakeholders, and assess its practicality and impact.

Conclusion

Through a three-round twin-panel Delphi survey, expert consensus was achieved on 12 relevant indicators for inclusion in a dedicated report card on 24-h movement behaviours for children under 5 years. The harmonised definitions and benchmarks developed in this study provide a robust foundation for creating a standardised report card. This tool will serve as a critical advocacy instrument to raise awareness, improve surveillance, facilitate cross-country comparisons, and inform policy and public health initiatives, ultimately supporting the health and well-being of young children globally.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s40798-025-00905-x.

> Supplementary file1

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Author Contributions
WYH conceived the study, with ongoing development of study design supported by MST, MCSW, CHPS, SWSW, DKCC, and SHSW. WYH and DQZ designed the surveys, collected and analysed data. All authors helped synthesise the qualitative feedback and were involved in discussion and interpretation of survey results. WYH drafted the manuscript. All authors critically revised the manuscript and approved the final version.

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Availability of Data and Materials
The anonymised dataset from the three-round survey is available from the corresponding author on reasonable request.

Declarations

Ethics Approval and Consent to Participate
The study was approved by the Research Ethics Committee of Hong Kong Baptist University (#REC/22–23/0318). All participants gave electronic informed written consent by submitting their responses to the online survey.

Consent for Publication
Not applicable.

Competing interests
The authors declare that they have no conflicts of interest relevant to the content of this research study.

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References
1. Kuzik N, Poitras VJ, Tremblay MS, et al. Systematic review of the relationships between combinations of movement behaviours and health indicators in the early years (0–4 years). BMC Public Health. 2017;17(Suppl 5): 849. https://doi.org/10.1186/s12889-017-4851-1.
2. Kuzik N, Spence JC, Arkko K, et al. Associations between meeting the Canadian 24-hour movement guidelines and physical, cognitive, social-emotional, and overall development in early childhood. J Act Sedent Sleep Behav. 2022;1(1):2. https://doi.org/10.1186/s44167-022-00002-4.
3. Taylor RW, Haszard JJ, Healey D, et al. Adherence to 24-h movement behavior guidelines and psychosocial functioning in young children: a longitudinal analysis. Int J Behav Nutr Phys Act. 2021;18(1):110. https://doi.org/10.1186/s12966-021-01185-w.
4. Willumsen J, Bull F. Development of WHO guidelines on physical activity, sedentary behavior, and sleep for children less than 5 years of age. J Phys Act Health. 2020;17(1):96–100. https://doi.org/10.1123/jpah.2019-0457.
5. Okely AD, Ghersi D, Hesketh KD, et al. A collaborative approach to adopting/adapting guidelines - The Australian 24-hour movement guidelines for the early years (birth to 5 years): an integration of physical activity, sedentary behavior, and sleep. BMC Public Health. 2017;17(Suppl 5): 869. https://doi.org/10.1186/s12889-017-4867-6.
6. Reilly JJ, Hughes AR, Janssen X, et al. GRADE-ADOLOPMENT process to develop 24-hour movement behavior recommendations and physical activity guidelines for the under 5s in the United Kingdom, 2019. J Phys Act Health. 2020;17(1):101–8. https://doi.org/10.1123/jpah.2019-0139.
7. Tremblay MS, Chaput JP, Adamo KB, et al. Canadian 24-hour movement guidelines for the early years (0–4 years): an integration of physical activity, sedentary behaviour, and sleep. BMC Public Health. 2017;17(Suppl 5): 874. https://doi.org/10.1186/s12889-017-4859-6.
8. Draper CE, Tomaz SA, Biersteker L, et al. The South African 24-hour movement guidelines for birth to 5 years: an integration of physical activity, sitting behavior, screen time, and sleep. J Phys Act Health. 2020;17(1):109–19. https://doi.org/10.1123/jpah.2019-0187.
9. Feng J, Zheng C, Sit CH, et al. Associations between meeting 24-hour movement guidelines and health in the early years: a systematic review and meta-analysis. J Sports Sci. 2021;39:2545–57. https://doi.org/10.1080/02640414.2021.1945183.
10. Chong KH, Suesse T, Cross PL, et al. Pooled analysis of physical activity, sedentary behavior, and sleep among children from 33 countries. JAMA Pediatr. 2024;178(11):1199–207. https://doi.org/10.1001/jamapediatrics.2024.3330.
11. Bourke M, Haddara A, Loh A, et al. Adherence to the World Health Organization's physical activity recommendation in preschool-aged children: a systematic review and meta-analysis of accelerometer

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studies. Int J Behav Nutr Phys Act. 2023;20(1):52. https://doi.org/10.1186/s12966-023-01450-0.

12. World Health Organization. Global action plan on physical activity 2018–2030: more active people for a healthier world. Geneva: World Health Organization; 2018.

13. Tremblay MS, Barnes JD. Active healthy kids global alliance global matrix 4.0-a resource for physical activity researchers. J Phys Act Health. 2022;19(11):693–9. https://doi.org/10.1123/jpah.2022-0257.

14. Aubert S, Barnes JD, Forse ML, et al. The international impact of the Active Healthy Kids Global Alliance physical activity report cards for children and youth. J Phys Act Health. 2019;16(9):679–97. https://doi.org/10.1123/jpah.2019-0244.

15. Tremblay MS, Gray CE, Akinroye K, et al. Physical activity of children: a global matrix of grades comparing 15 countries. J Phys Act Health. 2014;11(Suppl 1):S113-125. https://doi.org/10.1123/jpah.2014-0177.

16. Tremblay MS, Barnes JD, González SA, et al. Global matrix 2.0: report card grades on the physical activity of children and youth comparing 38 countries. J Phys Act Health. 2016;13:S343–66. https://doi.org/10.1123/jpah.2016-0594.

17. Aubert S, Barnes JD, Abdeta C, et al. Global matrix 3.0 physical activity report card grades for children and youth: results and analysis from 49 countries. J Phys Act Health. 2018;15(S2):S251–73. https://doi.org/10.1123/jpah.2018-0472.

18. Aubert S, Barnes JD, Demchenko I, et al. Global matrix 4.0 physical activity report card grades for children and adolescents: results and analyses from 57 countries. J Phys Act Health. 2022;19(11):700–28. https://doi.org/10.1123/jpah.2022-0456.

19. Vanderloo LM, Bruijns BA, Kuzik N, et al. Impact of the ParticipACTION report card on physical activity for children and youth in Canada: 2015–2024. J Exerc Sci Fit. 2025;23(2):102–11. https://doi.org/10.1016/j.jesf.2025.01.005.

20. De Craemer M, Veldman SLC, Azevedo LB, et al. Practical steps needed to achieve impact of the WHO 2019 movement behaviour guidelines for children under the age of 5: the SUNRISE Study Europe Group evaluation. Lancet Reg Health Eur. 2024;39: 100869. https://doi.org/10.1016/j.lanepe.2024.100869.

21. Demchenko I, Aubert S. Global matrix 4.0 on physical activity for children and adolescents: project evolution, process evaluation, and future recommendations. J Phys Act Health. 2025;22(4):457–69. https://doi.org/10.1123/jpah.2024-0513.

22. Jünger S, Payne SA, Brine J, et al. Guidance on conducting and reporting DElphi studies (CREDES) in palliative care: recommendations based on a methodological systematic review. Palliat Med. 2017;31(8):684–706. https://doi.org/10.1177/0269216317690685.

23. Gillis L, Tomkinson G, Olds T, et al. Research priorities for child and adolescent physical activity and sedentary behaviours: an international perspective using a twin-panel Delphi procedure. Int J Behav Nutr Phys Act. 2013;10:112. https://doi.org/10.1186/1479-5868-10-112.

24. Lang JJ, Zhang K, Agostinis-Sobrinho C, et al. Top 10 international priorities for physical fitness research and surveillance among children and adolescents: a twin-panel Delphi study. Sports Med. 2023;53(2):549–64. https://doi.org/10.1007/s40279-022-01752-6.

25. Ortega FB, Zhang K, Cadenas-Sanchez C, et al. The Youth Fitness International Test (YFIT) battery for monitoring and surveillance among children and adolescents: a modified Delphi consensus project with 169 experts from 50 countries and territories. J Sport Health Sci. 2024;14: 101012. https://doi.org/10.1016/j.jshs.2024.101012.

26. Drumm S, Bradley C, Moriarty F. 'More of an art than a science'? The development, design and mechanics of the Delphi Technique. Res Soc Admin Pharm. 2022;18:2230–6. https://doi.org/10.1016/j.sapharm.2021.06.027.

27. von der Gracht HA. Consensus measurement in Delphi studies: review and implications for future quality assurance. Technol Forecast Soc Change. 2012;79(8):1525–36. https://doi.org/10.1016/j.techfore.2012.04.013.

28. Cliff DP, Antczak D, Draper CE, et al. The sleep and activity database for the early years (SADEY) study: design and methods. J Activity Sedent Sleep Behav. 2024;3(1): 15. https://doi.org/10.1186/s44167-024-00054-8.

29. Okely T, Reilly JJ, Tremblay MS, et al. Cross-sectional examination of 24-hour movement behaviours among 3- and 4-year-old children in urban and rural settings in low-income, middle-income and high-income countries: the SUNRISE study protocol. BMJ Open. 2021;11(10): e049267. https://doi.org/10.1136/bmjopen-2021-049267.

30. van Eck NJ, Waltman L. Software survey: VOSviewer, a computer program for bibliometric mapping. Scientometrics. 2010;84(2):523–38. https://doi.org/10.1007/s11192-009-0146-3.

31. Harris A, Jones M. Why context matters: a comparative perspective on education reform and policy implementation. Educ Res Policy Pract. 2018;17(3):195–207. https://doi.org/10.1007/s10671-018-9231-9.

32. Barrios M, Guilera G, Nuño L, et al. Consensus in the delphi method: what makes a decision change? Technol Forecast Soc Change. 2021;163: 120484. https://doi.org/10.1016/j.techfore.2020.120484.

33. Ward MR, Tyler R, Edwards LC, et al. The AHK-wales report card 2018: Policy measures - Is it possible to 'score' qualitative data? Health Promot Int. 2021;36:1151–9. https://doi.org/10.1093/heapro/daaa118.

34. Altenburg TM, Gubbels JS, Arts J, et al. 24-hour movement behaviours in the early years, potential behavioural determinants and prospective associations with growth, motor and social-emotional development: the My Little Moves study protocol. BMJ Open. 2024;14(10): e081836. https://doi.org/10.1136/bmjopen-2023-081836.

35. Arts J, Drotos E. Correlates of physical activity in 0- to 5-year-olds: a systematic umbrella review and consultation of international researchers. Sports Med. 2023;53(1):215–40. https://doi.org/10.1007/s40279-022-01761-5.

36. Veldman SLC, Altenburg TM, Chinapaw MJM, et al. Correlates of screen time in the early years (0–5 years): a systematic review. Prev Med Rep. 2023;33: 102214. https://doi.org/10.1016/j.pmedr.2023.102214.

37. Tanaka C, Tanaka S, Inoue S, et al. Results from the Japan's 2018 report card on physical activity for children and youth. J Exerc Sci Fit. 2019;17(1):20–5. https://doi.org/10.1016/j.jesf.2018.10.001.

38. Harlow M, Fraser-Thomas J. Describing early years sport: take-up, pathways, and engagement patterns amongst preschoolers in a major Canadian city. Sport Soc. 2024;27(1):68–90. https://doi.org/10.1080/17430437.2023.2234306.

39. Chen D, Zhao G, Fu J, et al. Structured-unstructured activity behaviours on preschoolers' mental and physical health: a compositional and isotemporal reallocation analysis. Sci Rep. 2024;14(1):24219. https://doi.org/10.1038/s41598-024-74882-8.

40. Pate RR, Brown WH, Pfeiffer KA, et al. An intervention to increase physical activity in children: a randomized controlled trial with 4-year-olds in preschools. Am J Prev Med. 2016;51(1):12–22. https://doi.org/10.1016/j.amepre.2015.12.003.

41. Bianconi A, Fiore M, Zauli E, et al. How strong is the evidence supporting the WHO guidelines on physical activity, sedentary behaviour and sleep in early childhood? Eur J Clin Invest. 2024;54(12): e14294. https://doi.org/10.1111/eci.14294.

42. Cliff DP, McNeill J, Vella SA, et al. Adherence to 24-hour movement guidelines for the early years and associations with social-cognitive development among Australian preschool children. BMC Public Health. 2017;17(Suppl 5): 857. https://doi.org/10.1186/s12889-017-4858-7.

43. Santos R, Zhang Z, Pereira JR, et al. Compliance with the Australian 24-hour movement guidelines for the early years: associations with weight status. BMC Public Health. 2017;17(Suppl 5): 867. https://doi.org/10.1186/s12889-017-4857-8.

44. Feng J, Huang WY, Reilly JJ, et al. Compliance with the WHO 24-h movement guidelines and associations with body weight status among preschool children in Hong Kong. Appl Physiol Nutr Metab. 2021;46(10):1273–8. https://doi.org/10.1139/apnm-2020-1035.

45. Brian A, Pennell A, Taunton S, et al. Motor competence levels and developmental delay in early childhood: a multicenter cross-sectional study conducted in the USA. Sports Med. 2019;49(10):1609–18. https://doi.org/10.1007/s40279-019-01150-5.

46. Martins C, Valentini NC, Sääkslahti A, et al. Motor competence as key to support healthy development of 3- to 5-year-old children: an expert statement on behalf of the international motor development research consortium. J Motor Learn Dev. 2024;12(3):437–54. https://doi.org/10.1123/jmld.2023-0055.

47. Logan SW, Ross SM, Chee K, et al. Fundamental motor skills: a systematic review of terminology. J Sports Sci. 2018;36(7):781–96. https://doi.org/10.1080/02640414.2017.1340660.

Huang *et al. Sports Medicine - Open* (2025) 11:92

Page 12 of 12

48. Duncan M, Foweather L, Bardid F, et al. Motor competence among children in the United Kingdom and Ireland: an expert statement on behalf of the international motor development research consortium. J Motor Learn Dev. 2022. https://doi.org/10.1123/jmld.2021-0047.

49. Bandeira PFR, Lemos LF, Estevan I, et al. Are we assessing motor competence? Evidence-informed constructs for motor competence in preschoolers through an exploratory graph analysis. J Sports Sci. 2025;43(1):109–16. https://doi.org/10.1080/02640414.2024.2414361.

50. Bolger LE, Bolger A, Cian ON, et al. Global levels of fundamental motor skills in children: a systematic review. J Sports Sci. 2021;39(7):717–53. https://doi.org/10.1080/02640414.2020.1841405.

51. Tomkinson GR, Carver KD, Atkinson F, et al. European normative values for physical fitness in children and adolescents aged 9–17 years: results from 2 779 165 Eurofit performances representing 30 countries. Br J Sports Med. 2018;52(22):1445–14563. https://doi.org/10.1136/bjsports-2017-098253.

52. Tomkinson GR, Lang JJ, Tremblay MS, et al. International normative 20 m shuttle run values from 1 142 026 children and youth representing 50 countries. Br J Sports Med. 2017;51(21):1545–54. https://doi.org/10.1136/bjsports-2016-095987.

53. Prince SA, Lang JJ, de Groh M, et al. Prioritizing a research agenda on built environments and physical activity: a twin panel Delphi consensus process with researchers and knowledge users. Int J Behav Nutr Phys Act. 2023;20(1):144. https://doi.org/10.1186/s12966-023-01533-y.

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