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Report card grades on physical activity for children and adolescents from 18 Asian countries: Patterns, trends, gaps, and future recommendations

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ABSTRACT

Background/Objective: Physical inactivity is a persistent and worsening population health concern in Asia. Led by the Active Healthy Kids Global Alliance, Global Matrix (GM) initiative provides an opportunity to explore how regional and cultural differences across 18 Asian countries relate to physical activity (PA) participation among children and adolescents. The purpose of study was to synthesize evidence from the GM2.0 to GM4.0 (2016–2022) in Asian countries.
Methods: Report Card grades on behavioral/individual and sources of influence indicators were reported from 18 Asian countries. Letter grades were converted into numerical values for quantitative analyses. Based on this, cross-sectional and longitudinal analyses were conducted to investigate patterns and trends. Qualitative evidence synthesis was performed based on Report Card grades and published papers to identify gaps and suggest future recommendations.
Results: In total, 18 countries provided grades for at least one round of GM, 12 countries provided grades for at least two rounds, and seven countries provided grades for all three GMs. Of possible grades, 72.8%,

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69.2%, and 76.9% of the grades were assigned from GM 2.0 to GM 4.0, respectively. In terms of the Report Card grades, there was a slight decrease in behavioral/individual indicators from "D+" in GM 2.0 to "D-" in GM 3.0 but this reverted to "D" in GM 4.0. For the sources of influence, a "C" grade was given in all three rounds of GM. Longitudinal observation of seven Asian countries that provided grades in all three rounds of GM revealed that grades are generally stable for all indicators with some country-specific fluctuations. In future GM initiatives and research, considerations should be made to provide more accurate and rich data and to better understand contextual challenges in evaluating certain indicators such as Active Transportation, Active Play, and Physical Fitness in particular. Further, macro level factors such as socioeconomic/cultural disparities and gender-specific barriers, ideology, or climate change should also be proactively considered in future research as these factors are becoming increasingly relevant to indicators of GM and United Nation's Sustainable Development Goals.

Conclusions: Participation from Asian countries in GM has increased over the years, which demonstrates the region's enthusiasm, capacity, and support for global PA promotion efforts. The efforts to promote a physically active lifestyle among children and adolescents should be a collective interest and priority of the Asia region based on the gaps identified in this paper.

1. Introduction

Globally, physical inactivity is a pervasive critical health concern and is the fourth leading cause of non-communicable disease-related mortality.[1,2] Physical inactivity is defined as not meeting the recommended level of physical activity (PA) among children and adolescents aged 5–17 years (≥60 min of moderate-to vigorous-intensity PA daily). A recent pooled analysis of 298 school-based surveys from 146 countries found that 81% of adolescents aged 11–17 years did not meet the PA recommendation, and the highest physical inactivity prevalence was reported in the high-income Asia Pacific region consisting of Singapore and South Korea (92.2% overall).[3] Regional average of physical inactivity based on 2016 data was also higher in Central, East, and Southeast Asian countries, but not South Asian countries (i.e., Afghanistan, Bangladesh, Bhutan, India, Nepal, and Pakistan) compared to European, Western, Oceanian, Latin American and Caribbean, and Sub-Saharan African countries.[3]

With physical inactivity emerges as a major public health concern, so does the emphasis on research and capacity building. An important area of research that has consistently been mentioned is global surveillance of PA.[4,5] In response, the first Global Matrix (GM) was created by Active Healthy Kids Global Alliance (AHKGA, www.activehealthykids.org) to better understand the variations of PA for children and adolescents across the world. Led by AHKGA, Report Cards produced by 15 countries reported the evaluation of behavioral indicators and sources of influence indicators of PA.[6] These findings were subsequently shared at the Global Summit on the PA of Children in 2014.[6] Following the global impact of the first GM, 38, 49, and 57 countries/jurisdictions participated in GM 2.0 in 2016, 3.0 in 2018, and 4.0 in 2022, respectively.[6–8] The creation of four GMs produced insightful global data and PA trends that allow for the combination and comparison of PA evaluation from each country/jurisdiction. The results from the Report Cards showed that not one country is leading or lagging in all indicators, providing an opportunity for knowledge exchange between the participating countries/jurisdictions.[6]

The GM provides a unique opportunity to explore how regional and cultural differences of each country relate to PA participation among children and adolescents. As part of such effort, nine Asian countries participated in GM 2.0, which included China, Hong Kong, India, Japan, Malaysia, Qatar, South Korea, Thailand, and United Arab Emirates (UAE).[6] Participation increased to 12 countries for GM 3.0, which included the countries participated in GM 2.0 except for Malaysia, and Bangladesh, Lebanon, Nepal, and Taiwan.[7] For GM 4.0, a total of 16 countries participated with Indonesia, Israel, Philippines, Singapore, and Vietnam newly joined to the effort.[8] The increase in participating Asian countries in GM is encouraging and provides more insight into the differences in PA prevalence within and across the regions of the world.

Previous rounds of GMs[6,7,9] to date revealed that there are variations in grades across indicators primarily based on spatial and climatic factors, sociocultural factors, as well as countries' economic developmental stages. For instance, extreme heat is known to reduce opportunities for active transportation among children in Southeast and Middle Eastern Asian regions.[7,10] Thus, closely investigating the variations in the trends of PA related indicators across different countries in Asia and identifying unique and common barriers may help better understand region- and context-specific challenges for children and adolescents to stay active. In addition, on-going collaborations between countries are also important for information sharing and capacity building in the Asia region. To better facilitate this process, Huang and colleagues reported the combined outcome of Report Card grades from 15 Asian countries participated in GM 4.0. [11] Furthermore, Reilly and colleagues examined secular trends in child and adolescent PA and sedentary behavior using the data from four rounds of GMs.[12] In supplement of these efforts, the objectives of this study were to examine the within-country and Asia-wide patterns and trends of Report Card grades on the PA of children and adolescents from Asian countries that participated in at least one of the past three AHKGA's GMs and offer recommendations for future research, policy, and advocacy work to aid PA promotion efforts in the Asia region.

2. Methods

2.1. Global Matrix involvement

Each participating country has developed a Report Card on PA for Children and Youth (Adolescents for GM 4.0) based on the best available evidence and through a harmonized process. Asian countries participated in 2016 (n = 9), 2018 (n = 12), and 2022 (n = 16) GMs were identified for data collection and author recruitment. Global Matrix of Report Cards for 2020 was delayed to 2022 due to the COVID-19 pandemic. Countries participated in each round, main data sources, age group included, and the availability of the stratified data by varying indicators of social determinants of health (SoDH) are described in Table 1. Detailed information about

the process of Report Card development in each participating country is described elsewhere.[8]

2.2. Common indicators in the three rounds of Global Matrix

Common indicators for GM 2.0 included five behavioral indicators (i.e., *Overall* PA, *Organized Sport Participation, Active Play, Active Transportation, and Sedentary Behavior*) and four sources of influence (i.e., *Family and Peers, School, Community and the Built Environment, Government*). For GM 3.0 and GM 4.0, Physical Fitness was also added as a common indicator, resulting in a total of 10 indicators to evaluate. In addition, *Organized Sport Participation* was re-labeled to *Organized Sport and* PA, *Community and the Built Environment* to *Community and Environment*, and *Government Strategies and Investment* to *Government*. In this paper, we used the latest name for each indicator consistently. Detailed information about these indicators are provided in previous publications.[5–7]

2.3. Evaluation of indicators in the three rounds of Global Matrix

Each participating country have followed a harmonized process which included common grading framework and benchmarks, each presented in Additional File A, Supplementary Table 1 and Table 2, respectively. As with the labeling of indicators, grading framework and benchmarks were slightly different between GM 2.0 and GM 3.0/4.0. For instance, in GM 2.0, grades available for assignment included letter grades only (e.g., A, B) while "+" and "-" signs were used to indicate the high or low end of the grade or absence or presence of disparities by factors such as gender, geographical location, ethnicity, or socioeconomic status. However, a more specific grading rubric was given to each country for GM 3.0/4.0 to make data across countries more comparable (Additional File A, Supplementary Table 1). For example, "A+" indicated that 94%–100% reaching a defined benchmark(s), "A" indicated that 87%–93% reaching a defined benchmark(s), while "A-" indicating 80%–86% have met a defined benchmark(s). Benchmarks used to guide grading assignment were also more specific, comprehensive, yet flexible for GM 3.0/4.0. For example, to evaluate *Overall* PA, one more benchmark was provided in addition to the framework from GM 2.0 to allow countries with no average-per-week data to grade the indicator. More detailed information about the development process of GMs are described in previous work.[6–8]

3. Data collection and extraction process

Data were collected from GM and Report Card papers published in the *Journal of Physical Activity and Health* as well as AHKGA's webpage (www.activehealthykids.org) for GM 2.0 and GM 3.0. Data for GM 4.0 were received from AHKGA head office upon the approval of the members of the executive committee. Data from GM 2.0 and GM 3.0 were extracted by two undergraduate research assistants (AS, MC) by GM rounds and indicators graded/ungraded using the Excel form that the principal investigator (E-YL) created. Extracted data for indicators graded for 2016 Report Cards (GM 2.0) and 2018 Report Cards (GM 3.0), respectively, included country, indicator graded, grade assigned, primary data source type (i.e., national data, grey literature, independent studies, other), data source year, data source reference, sample size, sample age used, data source, sociodemographic difference mentioned, main measure used in primary data source, issues/challenges mentioned for grade assignment, other issues/challenges mentioned, key findings/recommendations, and limitations. Extracted data for indicators ungraded for 2016 RCs (GM 2.0) and 2018 RCs (GM 3.0), respectively, included country, number of indicators unassigned, indicators unassigned, reasons for unassigned grades, issues/challenges mentioned for data collection, issues/challenges mentioned for grade assignment, and other issues/challenges mentioned. The extracted data were verified by a graduate research assistant (Y-BK) (complete data extraction sheet is available upon request). Data from GM 4.0 only included Report Card grades, received from the AHKGA's head office.

3.1. Evidence synthesis

Final grades from each country for each GM round were collated for both quantitative and qualitative analyses within and across

Table 1
Countries participated from Global Matrix 2.0 to Global Matrix 4.0 (N = 18).

Countries	Global Matrix 2.0				Global Matrix 3.0				Global Matrix 4.0			
	n = 9	Data source[a]	Age included[b]	SoDH[c]	n = 12	Data source[a]	Age included[b]	SoDH[c]	n = 16	Data source[a]	Age included[b]	SoDH[c]
Bangladesh	NP				X	1,2,3	3	2	NP			
China*	X	1	2,3	1,2	X	1,2	2,3	1,2,4	X	1	2,3	1,2
Hong Kong*	X	1,2,3	1,2,3	1,2	X	2,3	2,3	1,2	X	1,2,3	2,3	1,2
India*	X	2,3	1,2,3	1,2,4	X	2,3	1,2,3	2,3,4	X	2,3	2,3	2,4
Indonesia	NP				NP				X	1	2,3	1,2
Israel	NP				NP				X	NA	NA	NA
Japan*	X	1	1,2,3	1,2	X	1	2,3	1,2	X	1	2,3	1,2
Lebanon*	NP				X	1,3	2,3	1	X	1,3	3	1,2
Malaysia*	X	1,3	2,3	–	NP				X	1,3	2,3	–
Nepal*	NP				X	2,3	3	2,4	X	1,2,3	1,2,3	1,2,4
Philippines	NP				NP				X	1,3	2,3	–
Qatar*	X	1	3	–	X	2,3	2,3	1,2	NP			
Singapore	NP				NP				X	1,2	2,3	–
South Korea*	X	1,2,3	1,2,3	1, 2	X	1,3	2,3	1,2	X	1,3	2,3	1,2
Taiwan*	NP				X	1,3	2,3	1,2	X	1,3	2,3	1,2
Thailand*	X	1, 3	2,3	1, 2	X	1,3	2,3	1,2	X	1,3	2,3	1,2
UAE*	X	1, 3	2,3	1,2,3,4,5	X	2,3	3	1,2	X	1,3	2,3	1,2,5
Vietnam	NP				NP				X	2	2,3	–

Abbreviation/acronym: SoDH = Social Determinants of Health; UAE = United Arab Emirates; NA = Not available (information was not available at the time of data collection of this manuscript). n = number of participated countries; X = countries participated in respective Global Matrix; NP = countries not participated in respective Global Matrix
*Countries that have participated in at least two rounds of Global Matrix.
[a] Data source: 1. Nationally representative data; 2. Systematic review, independent studies; 3. Grey literature (Government/provincial/regional/school reports).
[b] Age included: 1. 0–5 yrs; 2. 6–11 yrs; 3. 12–18 yrs.
[c] SoDH: 1. Age; 2. Sex/gender; 3. Socioeconomic status (including income, wealth, parental education); 4. Areas of residence (urban vs. rural); 5. Ethnicity/nationality.

Table 2
Report Card grades[a] from Global Matrix 2.0 to Global Matrix 4.0.

Country	GM round	Overall PA	Organized Sport & PA	Active Play	Active Transportation	Sedentary Behavior	Physical Fitness	Family and Peers	School	Community and the Environment	Government
Bangladesh	3.0	C-	INC	INC	C-	A-	INC	INC	INC	INC	C-
China*	2.0	F	F	D-	C-	F	–	B	B+	D+	D
	3.0	F	D-	D+	C+	F	D	D+	D+	F	F
	4.0	C	F	C-	C	D+	INC	C-	D	D-	D
Hong Kong*	2.0	D	C-	INC	B	C	–	D	C	B	INC
	3.0	C-	C	INC	B+	C-	D	D-	C	B	C
	4.0	D-[b]	B-	D	B+	D	D	INC	B	B	C+
India*	2.0	C-	INC	INC	C	C	INC	INC	INC	INC	D
	3.0	D	INC	C-	B-	C-	F	D	INC	D	D
	4.0	C	INC	INC	B-	D-	INC	INC	C	D	C+
Indonesia	4.0	F	F	F	D-	B	F	F	F	D+	B-
Israel	4.0	D-	D	INC	C-	C+	INC	D-	C+	C-	C
Japan*	2.0	INC	C	INC	B	C	C	D	B	D	B
	3.0	INC	B-	INC	A-	C-	A	C	B+	B-	B
	4.0	B-	B-	INC	A-	C-	B	C-	B+	B	B
Lebanon*	3.0	D	F	INC	D	C-	INC	INC	D	INC	C+
	4.0	D-	INC	INC	D+	C	INC	INC	D	INC	D
Malaysia*	2.0	D	INC	INC	D	D	–	INC	B	INC	B
	4.0	D-	INC	INC	D-	C	B	INC	A-	INC	B
Nepal*	3.0	D+	INC	INC	A-	B+	INC	A	INC	C-	INC
	4.0	D+	C-	C+	C	C	INC	A+	C	C	F
Philippines	4.0	F	INC	INC	D	B	INC	INC	C-	INC	B
Qatar*	2.0	F	D	INC	INC	D	–	D	INC	INC	B
	3.0	D	D+	INC	N/A	D+	INC	INC	C	INC	B+
Singapore	4.0	C-	B-	C-	C	C-	INC	C-	INC	A+	B
South Korea*	2.0	D-	C-	INC	C+	F	–	INC	D	INC	C
	3.0	F	C	INC	B+	D	D+	INC	D+	INC	D
	4.0	D-	INC	INC	B+	D	INC	C-	A	B-	A*
Taiwan*	3.0	F	D-	INC	C-	C-	B-	INC	B+	B+	B+
	4.0	F	D-	F	C-	D+	INC	D-	A-	A-	B+
Thailand*	2.0	D-	C	F	B	D-	–	B	C	C	C
	3.0	D-	C-	F	C	D-	INC	B	B	B-	B+
	4.0	D	D+	F	C+	F	D-	A-	B-	C-	B
UAE*	2.0	D-/F-	INC	INC	D-/F-	C-	–	C-	D	INC	B+
	3.0	F	INC	INC	INC	C-	INC	INC	D-	INC	B+
	4.0	F	INC	INC	F	D-	INC	D-	A-	INC	B+
Vietnam	4.0	F	INC	INC	D+	C-	INC	C	A	C	B-

Abbreviation/acronym: GM = Global Matrix; PA = Physical activity; UAE: United Arab Emirates; INC: Incomplete.
Refer to Additional File A, Supplementary Tables 1, 2 and 3 for grading rubric and benchmarks used and additional indicator(s) graded for each round of GMs.
*Countries that have participated in at least two rounds of Global Matrix.
[a] The grade for each indicator is based on the percentage of reaching a defined benchmark (see Supplementary Table 1 for details).
[b] Based on device-based data only.

countries. For three rounds of cross-sectional GM evidence, a total number of indicators graded and ungraded were calculated (i.e., completeness of the grades). Also, all grades were converted into numerical values to obtain the overall grade of all indicators by country and across all participating countries as well as the overall grade of all participating countries by indicator (see Additional File A, Supplementary Table 1). To calculate the average grade per round, weighted average for overall grades were calculated via ([Sum of the number of countries graded each indicator*overall grade of each indicator]/sum of grades for all indicators). Weighted average grades were also calculated for behavioral indicators and sources of influence indicators separately. Furthermore, the number of countries with the absence/presence of national data and the main method of measurements were also reported. If sociodemographic differences were reported, the information was further synthesized using quantitative and qualitative evidence provided from the data collected.

For longitudinal evidence that involved ≥ two rounds of GM data per country, changes in grades for each indicator were described in four categories: "+ (improved grade)", "- (worsened grade)", "0 (no changes)", and "Not applicable". "(+)" is assigned when the baseline data is not available due to incomplete data, but follow-up data is provided while "(−)" is assigned when the baseline data is available, but follow-up data is not provided due to incomplete data. "Not applicable" was assigned when both baseline and follow-up had incomplete data. Changes were also interpreted by the magnitude of change. Specifically, all letter grades were converted to numerical values for analysis.[7] For the absolute changes (Δ), earlier GM served as the baseline data and baseline scores were subtracted from the corresponding score at follow-up. For instance, if a country provided data for GM 2.0 then GM 4.0, GM 2.0 served as the baseline data while GM 4.0 served as the follow-up data. For absolute change (Δ), "0" indicated no changes and either positive (improved) or negative (worsened) changes were divided into three groups based on the score to indicate the magnitude of absolute change: large (±7–9), medium (±4–6), and small (±1–3). Relative change (ΔR) was also calculated to describe the size of the absolute change in comparison to the baseline score using the following equation: ΔR (% increase or decrease) = (Absolute change (Δ)/baseline score) x 100. For quantitative synthesis and chart creation, IBM SPSS Statistics v.29 was used.

4. Results

Grades for each indicator by the GM round and country are presented in Table 2. In total, nine Asian countries in GM 2.0, 12 Asian countries in GM 3.0, and 16 Asian countries in GM 4.0 provided cross-sectional evidence while 12 Asian countries provided

longitudinal evidence. Of those, seven countries provided Report Card grades for all three rounds of GM. Table 3 describes the number of countries that participated in each GM, number of countries that provided a grade for each indicator, and the overall grade for each indicator as well as the weighted average of the total grade per GM round.

In cross-sectional analysis (Table 3), the completeness of the grades from GM 2.0 to GM 4.0 was 72.8%, 69.2%, and 76.3%, respectively. The weighted average grade for behavioral/individual indicators was "D", "D-", and D, respectively for each round of the GM, while the corresponding grades for the sources of influence were "C-" and "C" for GM 2.0 and GM 3.0/4.0. Grades by indicator and GM round are presented in Table 3. Participating countries were encouraged to evaluate indicators relevant to PA in their country but not part of the common GM indicators. Information on additional indicators graded is presented in Additional File A, Supplementary Table 3.

Table 4 presents the temporal changes on the Report Card grades among countries that participated in at least two rounds of GMs (n = 12). In total, 50 positive, 31 negative, and 18 no changes were observed, with 21 "NA" due to incomplete data at both baseline and follow-up. Japan was the country with the most improvement with seven positive changes followed by Nepal that showed six positive changes. Lebanon, Malaysia, and UAE showed four "NA"s. When absolute changes were observed by indicator, small, positive changes were observed for School (n = 9, Δ = +2.1), Active Play (n = 2, Δ = +1.5), Government (n = 11, Δ = +1.0), Organized Sport and PA (n = 7, Δ = +0.7), Community and the Environment (n = 7, Δ = +0.7), and Overall PA (n = 11, Δ = +0.6). Small, negative changes were observed for Sedentary Behavior (n = 12, Δ = −0.5) and Family and Peers (n = 6, Δ = −0.5) while Active Transportation (n = 11, Δ = 0) showed no changes.

When the changes were examined by country (Table 2, Fig. 1), China and Thailand provided the most complete data in all rounds of GM, having only one indicator with the incomplete grade out of 29 possible grades (completeness of the grade = 96.6%). The most significant improvement for Behavioral/individual indicators was observed in China (ΔR = 589.3%), followed by South Korea (ΔR = 197.6%). Malaysia (ΔR = 60.0%), Qatar (ΔR = 40.0%), Japan (ΔR = 20.6%), and Lebanon (ΔR = 14.3%) also showed smaller improvements for Behavioral/individual indicators. The countries with worsened Behavioral/individual indicators were the UAE (ΔR = −109.5%), Nepal (ΔR = −71.8%), Thailand (ΔR = −68.2%), Taiwan (ΔR = −14.3%), India (ΔR = −10.7%), and Hong Kong (ΔR = −5.6%). As for the sources of influence, South Korea showed the most improvement (ΔR = 255.0%), followed by Japan (ΔR = 169.1%), UAE (ΔR = 117.1%), India (ΔR = 80.0%), Thailand (ΔR = 68.2%), Hong Kong (ΔR = 30.0%), Nepal (ΔR = 21.4%), Malaysia (ΔR = 18.2%), and Qatar (ΔR = 9.1%). China (ΔR = −128.0%) and Lebanon (ΔR = −44.5%) were the two countries that showed worsened scores for the sources of influence.

The patterns and temporal changes of Report Card grades among seven countries that participated in all three rounds of GM are provided in Fig. 2 (Behavioral/individual indicators) and Fig. 3 (Sources of influence). Out of 126 possible grades, 69 grades were provided (54.8%) on behavioral/individual indicators in all three rounds of GM from seven Asian countries (Fig. 2). In general, Overall PA (Fig. 2a) remained low across the three rounds of GM in almost all countries; however, China has shown a marked increase from "F" in GM 2.0 and GM 3.0 to "C" in GM 4.0. Japan showed the highest score (10.0, B-) in GM 4.0; however, grades were not assigned in the previous rounds of GM. For Organized Sport and PA (Fig. 2b), Thailand has shown a decrease across the three rounds of GM from "C" to "D+". China showed consistently low scores in all rounds of GM in this indicator compared to other countries. Japan, Hong Kong, and South Korea have shown the highest scores and a slight increase over time; however, data were limited to two rounds for Hong Kong and South Korea. China and Thailand provided complete data on this indicator. China has shown an increase from "D-" to "C-" while the grade for Thailand remained at a F grade over time. Japan maintained the best grade of all seven countries in Active Transportation (Fig. 2d) over the three rounds of GM (B+ to A-). Most Asian countries maintained above "C-" grades over three rounds of GM with country-specific fluctuations, except for UAE, which showed the lowest grades (D-/F). Sedentary Behavior (Fig. 2e) grade was generally lower in seven Asian countries (below "C" grades). An increase in the grade was only observed in China ("F" to "D+") and South Korea ("F" to "D"). Japan was the only country that provided data on all three rounds of GM and has shown an increase over time ("C" to "B"). In general, incompleteness of data was most severe for Active Play (61.9%) and Physical Fitness (57.1%).

Out of 84 possible grades for the sources of influence, 69 grades were provided (82.1%) in all three rounds of GM from seven Asian countries (Fig. 3). By indicator, more variations existed within and between countries for the sources of indicators. For Family and Peers (Fig. 3a), China, Japan, and Thailand provided grades, as well as the highest grades across all three rounds of GM, and Thailand

Table 3
Overall grades from the Asian countries participated from Global Matrix 2.0 to Global Matrix 4.0.

	Global Matrix 2.0 (n = 9)		Global Matrix 3.0 (n = 12)		Global Matrix 4.0 (n = 16)	
Indicator	Indicators graded, n	Overall grade[a]	Indicator[a] graded, n	Overall grade[a]	Indicator[a] graded, n	Overall grade[a]
Overall P[a]	8	4 (D-)	11	4 (D-)	16	4 (D-)
Organized Sport & PA	6	6 (D+)	8	6 (D+)	9	6 (D+)
Active Play	2	3 (D-/F)	3	5 (D)	7	4 (D-)
Active Transportation	8	8 (C)	10	9 (C+)	16	7 (C-)
Sedentary Behavior	9	5 (D)	12	7 (C-)	16	6 (D+)
Physical Fitness[b]	–	–	6	8 ([b])	4	6 (D+)
Family and Peers	6	7 (C-)	6	8 (C)	11	7 (C-)
School	7	8 (C)	9	8 (C)	15	9 (C+)
Community/Environment	4	7 (C-)	7	8 (C)	12	8 (C)
Government	8	8 (C)	11	8 (C)	16	9 (C+)
Weighted average[c]	59	6.5 (D+)	83	7.1 (C-)	122	6.8 (D+)

Abbreviation/acronym: PA = Physical activity.
Refer to Additional File A, Supplementary Tables 1 and 2 for grading rubric and grading benchmarks used for each round of GMs.
[a] Overall grade ranged between 2 (F; lowest) and 15 (A+; highest) (see Supplementary Table 1 for details).
[b] Physical Fitness was not a common indicator in Global Matrix 2.0.
[c] Weighted averaged was calculated by ([Sum of the number of countries graded each indicator*overall grade of each indicator]/sum of grades for all indicators).

Table 4
Temporal Changes in the Report Card grades on common indicators between at least two rounds of Global Matrix from Global Matrix 2.0 to Global Matrix 4.0.

	China	Hong Kong	India	Japan	Lebanon	Malaysia	Nepal	Qatar	South Korea	Taiwan	Thailand	UAE
Overall PA	+	−	+	(+)	−	−	0	+	0	0	+	0
Organized Sport & PA	0	+	NA	+	(−)	NA	(+)	+	(−)	0	−	NA
Active Play	+	(+)	(−)	NA	NA	NA	(+)	NA	NA	(+)	0	NA
Active Transportation	+	0	+	+	+	−	−	NA	+	0	−	0
Sedentary Behavior	+	−	−	−	+	+	−	+	+	−	−	−
Physical Fitness	NA	0	(−)	+	NA	(+)	NA	NA	(−)	(−)	(+)	NA
Family and Peers	−	−	(−)	+	NA	NA	+	(−)	(+)	(+)	+	−
School	−	+	(−)	+	0	+	(+)	(+)	+	+	+	+
Community/Environment	−	0	0	+	NA	NA	+	NA	(+)	+	−	NA
Government	0	+	+	0	−	0	(+)	+	+	0	+	0
Completeness of the grades (%)	96.6	86.2	58.6	82.8	55.0	57.9	70.0	63.2	69.0	85.0	96.6	55.2

Abbreviation/acronym: PA = Physical activity; NA = Not applicable due to incomplete grades in all available GMs; UAE = United Arab Emirates.
"+": Grade improved; "-": Grade worsened; "0": Grade not changed; "(+)": Changes unable to determine due to incomplete data at baseline but follow-up data are provided; "(−)": Changes unable to determine due to incomplete data at follow-up.

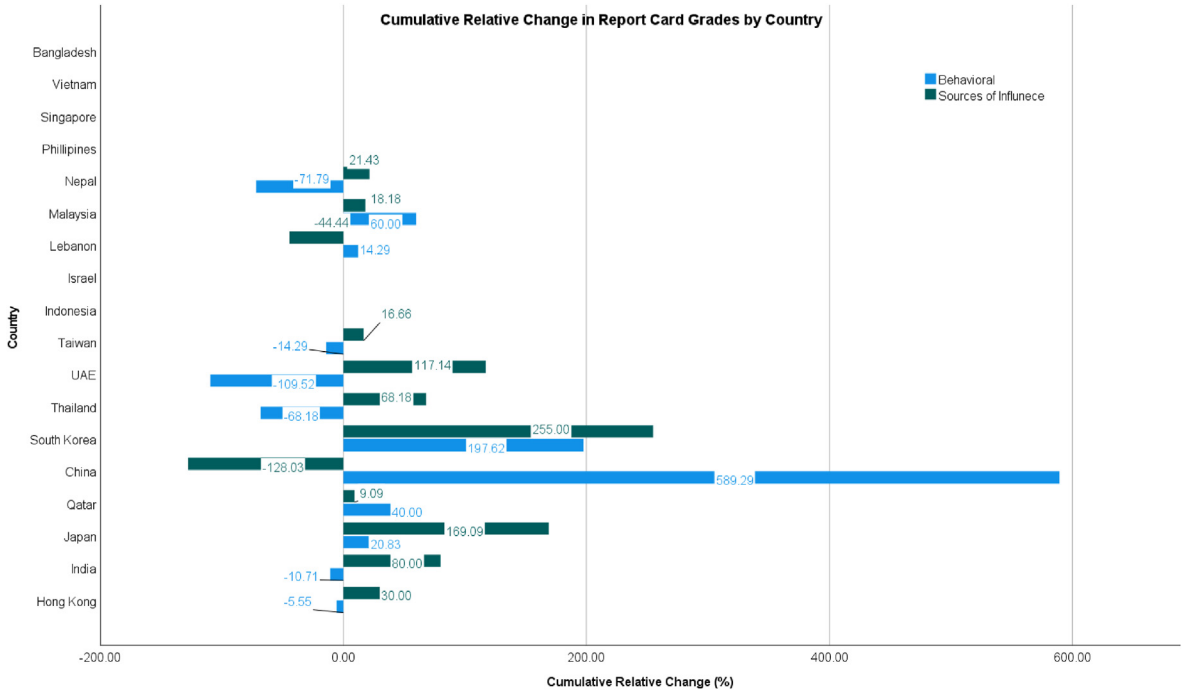

Fig. 1. Relative changes in Report Card grades by country and cumulative by behavioral/sources of influence indicators between at least two rounds of Global Matrix from Global Matrix 2.0 to Global Matrix 4.0.

("B" to "A-") and Japan ("D" to "C-") exhibited a slight increase over time. For the School indicator (Fig. 3b), an increase was observed in most countries over three rounds of the GM, however with an overall drop in GM 3.0 and bouncing back up in GM 4.0, except for China ("B+" to "D"). For Community and the Environment (Fig. 3c), Japan showed a marked increase from GM 2.0 to GM 3.0/4.0 ("D" to "B"). No changes were observed in terms of the rank among the countries (Japan, Hong Kong, Thailand, India, China) over time except for Japan in GM 2.0. UAE did not provide any data while South Korea provided a relatively high grade ("B-") in GM 4.0 only. Lastly, the Government indicator (Fig. 3d) was stable over time in Japan and UAE ("B" range), also showing best grades over time, while an eventual increase was observed in India ("D" to "C+"), South Korea ("C" to "A"), and Thailand ("C" to "B"). China also showed stable, but the lowest grades ("D" and "F") over time.

5. Discussion

This study investigated the cross-sectional patterns and longitudinal trends of the Report Card grades on PA among children and adolescents in Asian countries that participated in AHKGA's GM initiatives. Participation in GMs from Asian countries have consistently been increasing over the years, which demonstrates the collective efforts from the Asia region to promote PA among children and adolescents. Overall, the completeness of the grades has slightly improved from GM 2.0 (73%) to GM 4.0 (76%). In terms of the Report Card grades, the average grade for behavioral/individual indicators was in the "D" range while for the sources of influence, the grades across the three rounds of GM were in the "C" range.

5.1. Cross-sectional patterns

Cross sectional data have shown that, overall, the grades are lower for behavioral/individual indicators ("D" range), except for Active Transportation ("B/C" range) compared to the sources of influence grades ("C" range). This may be relevant to the built environment commonly observed in East Asian countries that is

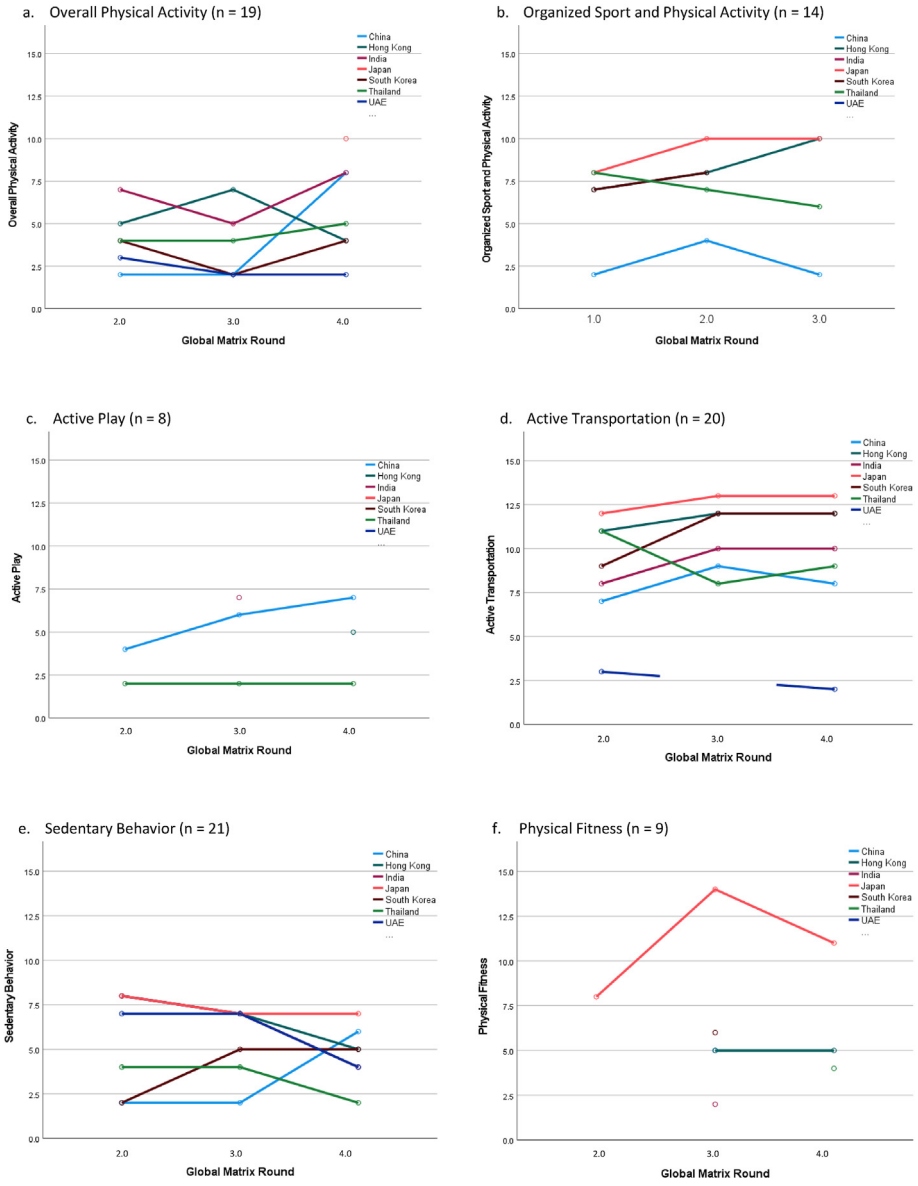

Fig. 2. Temporal trends of Report Card grades on behavioral/individual indicators from Global Matrix 2.0 to Global Matrix 4.0 in seven Asian countries.

conducive to using active modes of transport. For instance, in South Korea[13] and Hong Kong,[14] it is reported that most children walk to school due to proximity from their home. Similarly, in Nepal[15] and India,[16] most children, particularly in rural areas, walk to school due to inadequate road infrastructure and transportation facilities. However, evidence from Malaysia[17] and Lebanon[18] also suggested that school's academic reputation is a more important determinant of choosing school for parents than proximity from home. All sources of influence grades in three rounds of GMs were in the "C" range, indicating that the region is succeeding at 40–59% in terms of providing adequate micro-, meso-, and exo-level support for children and adolescents to be physically active. This is slightly better than the behavioral/individual indicators that the average grades remained in the "D" range across GMs.

With the continuing countries that participated in at least two rounds of GMs, the addition of the five new countries in GM 4.0 – Indonesia, Israel, Philippines, Singapore, and Vietnam – contributes to furthering the effort to promote PA among children and adolescents in the Asia region. Given that three countries (i.e., Indonesia, Philippines, Vietnam) graded Overall PA an "F", more efforts should be made to improve the indicator in future initiatives. In particular, Indonesia provided complete grades on all indicators; however, six out of 10 indicators were given an "F" grade. Perhaps PA promotion is not considered as important in low-to-middle income countries (e.g., Indonesia, Philippines) in the Asia region similar to that of the global trend.[7,8] In the Philippines, Government was graded "B" but Overall PA was "F". One possible reason for this gap might be because existing policies have not been translated into long-term, measurable programs that will eventually lead to increases in PA and decreases in sedentary behavior at the population level.

A total of 12 countries that participated in at least two rounds of GM and half of the grades showed improvement over time. This is a positive change observed from Asian countries; however, 31% of negative changes and 19% of no changes should be of focus in future efforts to promote PA among children and adolescents in the Asia region. Seven out of 12 countries showed reduced scores for Sedentary Behavior, indicating that sedentary behavior among

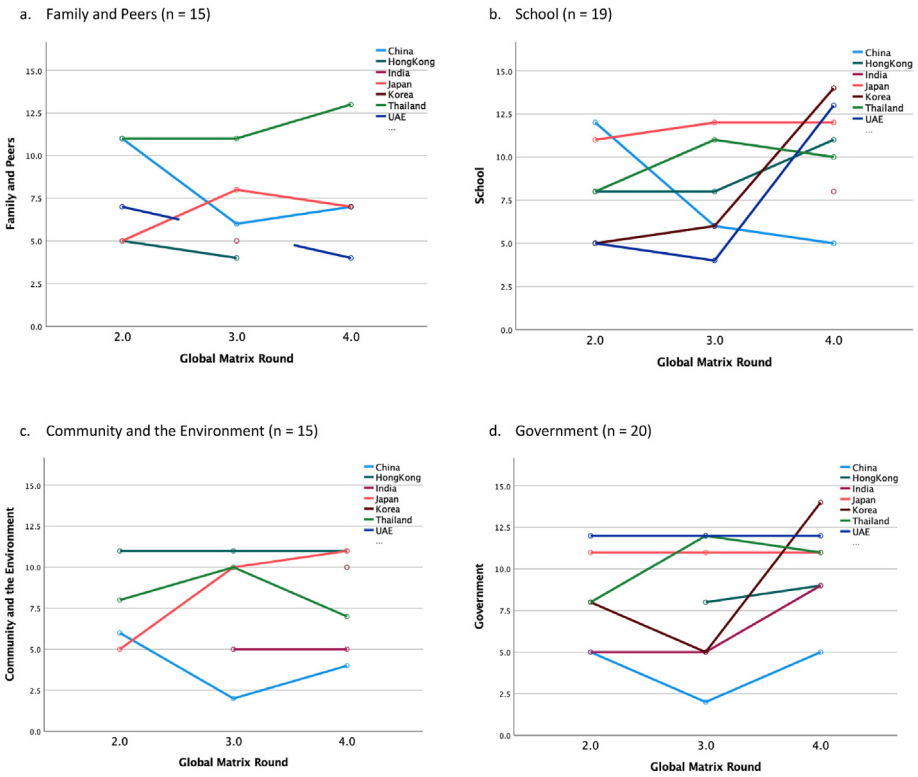

Fig. 3. Temporal trends of Report Card grades on the sources of influence indicators from Global Matrix 2.0 to Global Matrix 4.0 in seven Asian countries.

children and adolescents in these countries is increasing. This trend is observed in other recent studies and inevitable given technological advancement and accessibility[19]; nevertheless, efforts should be made to reverse this trend by providing alternative leisure activities for children and adolescents in the Asia region. For instance, providing more opportunities and social support for organized sports and active play could be good alternatives that could also improve Overall PA grades. However, it is important to note that increases in Overall PA did not translate into positive changes in Sedentary Behavior in most Asian countries included in this analysis. For instance, positive or no changes in Overall PA were observed in India, Nepal, Taiwan, and UAE; however, the changes in Sedentary Behavior were negative.

As highlighted in the 24-h movement paradigm,[20,21] a more holistic approach should be taken to improve grades in both Overall PA and Sedentary Behavior simultaneously as shown in China, Qatar, and, partially, South Korea. Between GM 2.0 and GM 4.0, cumulative relative changes in both behavioral and sources of influence indicators have improved in South Korea (255% increase for the sources of influence and 198% increase for the behavioral indicators). Such positive change may reflect that PA promotion efforts and actual behavioral profile of children and adolescents go hand in hand in South Korea; however, these results should be interpreted with caution particularly the sources of influence. Specifically, different evaluation tools were used between GM 2.0/GM 3.0 and GM 4.0 in evaluating School and Government indicators, resulting in an increase in the grades for these indicators for South Korea. Qatar also showed a similar pattern but at a much smaller scale (9% increase for the sources of influence and 40% increase for the behavioral indicators) as well as Japan (169% increase for the sources of influence and 21% increase for the behavioral indicators). However, this was not the case for China where a 589% increase in behavioral indicators and 128% decrease in the sources of influence were observed. Such counterintuitive patterns were also observed in most Asian countries included in this work. Therefore such "lost in translation" should be further investigated in Asian countries.

5.2. Longitudinal trends

Longitudinal observation of seven Asian countries that provided grades in all three rounds of GM revealed that grades are generally stable for behavioral indicators with some country-specific fluctuations. Overall, Japan appears to maintain higher grades in all indicators compared to other six countries, while UAE and Thailand appear to be lagging for behavioral/individual indicators and China appears to be lagging for sources of influence. The apparent fluctuation was observed in GM 3.0 in most countries particularly for indicators that had changes in the grading benchmarks. Other than the changes due to the actual change in the respective indicator within-country, there are potential reasons inherent to the methodology used for Report Card grades. Specifically, countries with Report Card grade changes between GM 2.0 and GM 4.0 may be consequential of benchmark modification instead of situational changes (see Additional File A, Supplementary Table 2).[6–8] Also, the changes could be due to the data used to inform the Report Card grads. For example, China participated in all three rounds of GM, GM 2.0 only evaluated data from Shanghai, whereas the subsequent GMs were informed by nationally representative data.[22,23] Finally, the previous GMs indicated a lack of evidence among children aged 0–4 years and, as a result, the ages included for Report Card grading were limited to school-age children (5–17 years old) for GM 3.0 [7]. Changes in the age range directly influence the sources of evidence included for review and the Report Card grades. This was the case for Japan, where there was a marked change in the grades for the School indicator from 2016 to 2018 due to the changes in the target age.[24] Furthermore, in Hong Kong, Overall PA received "C-" in GM 3.0 and "D-" in GM 4.0, and such decrease may be because of the

use of device-based measures of PA data only to assign a grade in GM 4.0.

6. Gaps and future recommendations

Based on the observations from three rounds of GM, the following gaps and future recommendations are identified in Asian countries:

1. Challenges with data availability and quality: Lack of nationally representative data or inconsistency of data to the benchmarks were commonly mentioned as challenges in Asian countries. For instance, even with the presence of nationally representative data, due to the inconsistency in the national vs. internationally accepted recommendations or because the country-specific survey items that measure PA and sedentary behavior do not allow researchers to manipulate data based on the benchmarks, the accuracy of grades were reported to be uncertain in some countries.[10,13,18,25–29] Issues of lack of consistency have been partially resolved as modification was made for GM 4.0 [8] (also see Additional File A, Supplementary Table 2), data that allow making clear distinctions between different types of sedentary behavior is warranted. In addition to lack or inconsistency of data, when data exist, accuracy of data appears to be another challenge. In several countries, it was observed that data can be present and consistent but have poor validity, reliability, and representativeness.[30] For instance, from our data, Hong Kong used device-determined PA only in GM 4.0 to assign a grade for Overall PA, which has resulted in a decrease of grade from "C-" in GM 3.0 to "D-". Non-reliable, -valid, and -representative data can be misleading and confuse global PA surveillance efforts and policy making. A study of Aubert and colleagues[31] highlighted that the harmonized methods used in developing Report Cards for GM 3.0 may have contributed to producing globally comparable information related to PA, inconsistencies in the types of data used for evaluation by each country (e.g., device-based, self- or proxy reported, grey literature, expert opinion) cannot be overridden.
2. Indicator-specific challenges: Some countries have reported potentially under/over-reporting issues related to evaluating Active Transportation. For example, South Korea (metropolitan areas) and Hong Kong reported that because schools are conveniently located within districts, the commute is short in duration.[25,32] In addition, UAE reported that active transport is not prevalent in their country perhaps due to the infrastructure (e.g., urban planning, traffic, safety).[33] Japan reported that there are laws related to the distance between home and school as, typically, 4 km buffer for primary school children and 6 km buffer for junior high schoolers considered as acceptable.[34] On the other hand, Nepal reported that Active Transportation may be underestimated because, in rural areas, many children and adolescents likely commute by foot as motorized vehicle ownership is low.[10] In case of Malaysia, walkability is improved due to recent urban development; however, environmental factors such as hot weather and heavy rainfall throughout the year in addition to broken segments along the walkaway may hinder children and adolescents to walk/bike.[35] Lastly, Qatar reported that evaluating Active Transportation is not realistic as commuting to school is considered as hazardous due to unsafe road conditions and extreme heat.[10] Along with Qatar, Thailand also expressed the importance of safety in the community, including traffic and crime, for encouraging outdoor play among children and adolescents.[28]
3. Indicators with unassigned grades: Active Play and Physical Fitness were identified as the indicators with unassigned grades over three rounds of GM. Reasons for not being able to assign a grade for Active Play was because the behavior itself is inherently difficult to quantify due to its spontaneous and sporadic nature,[13] absence of valid survey or representative data,[10,16,36,37] and/or no recommendations available for actively play or outdoor activity; therefore, it is difficult to evaluate.[10,38] Efforts have been made to better facilitate the evaluation of Active Play by AHKGA and a higher proportion of Asian countries were able to assign a grade on this indicator in GM 4.0 (44% assigned) compared to GM 2.0 (22% assigned) and GM 3.0 (25% assigned); however, it remains as a difficult indicator to evaluate with persisting issues of measurement. Recently, a clear definition of active play is provided based on international efforts.[39] Developing a valid and reliable measure that is applicable to Asian countries and including such measure to national surveys would allow more countries to evaluate Active Play in future GM initiatives. Physical Fitness was another indicator that many Asian countries were unable to assign a grade mainly due to lack of valid, reliable, and/or comparable data across different schools/countries. The countries that assigned a grade on this indicator had nationally representative data based on nation-wide, school-based government initiatives.[13,34,40,41] Therefore, it may be important to advocate for mandated, regular school-based physical fitness testing for children and adolescents to be able to grade this indicator.
4. Rising concerns-disparities, ideology, and climate change: Disparities by social determinants of health were reported consistently and persistently over three rounds of GM in the Asia region. In particular a gender gap has been identified as a key factor that is associated with behavioral indicators.[13,16,25,34,40,42,43] In particular, India's 2018 Report Card reported that girls in the lowest socioeconomic status show the greatest disadvantage in PA participation due to cultural and safety perceptions.[16] This indicates that the future disparity analysis may benefit from considering multiple social identities simultaneously rather than considering one SoDH at a time by adopting the intersectionality framework.[44,45] Intersectionality allows researchers to identify population groups that require most attention in future interventions, thus, informing effective resource allocation at national and regional levels. In addition to 2018 India's Report Card,[16] a few recent studies have found that intersectionality is a useful framework in investigating disparities and inequalities beyond sex/gender in behavior research.[46–48]

Rooted in the Confucian ideology, a strong emphasis is placed on academic activities rather than PA, which directly impacts the time children and adolescents could spend in physical education (PE) classes, particularly in East Asian countries.[25,49,50] As well, the heavy workload and pressure for academic pursuits may also impact the amount of time spent sedentary or in other indicators, such as active play.[13,40,51] PE classes provide opportunities for students to engage in different types of PA, but they are still neglected in many Asian countries.[7] At the regional level, providing more mandated PE classes by shifting values on education and health held by policy makers, parents, and stakeholders may be of priority in this region. Japan, one of the East Asian countries but have received relatively a better grade in three rounds of GM for behavioral/individual indicators as well as the School indicator compared to other countries testify that the school PA policies and environment are important.

Finally, though it was not clearly mentioned in previous two rounds of GM, indicators related to climate change are a rising concern. In GM 2.0[6] and GM 3.0[7], as well as independent studies from Asian counties, accumulating evidence suggests that factors like extreme weather events, traffic noise, urbanization, and air

pollution are a rising threat to PA in the general population.[52,53] For instance, active transportation or active (outdoor) play is not feasible in countries with longer extreme heat days (e.g., India, Malaysia, Qatar, Taiwan, Thailand, UAE) or increased ambient air pollutant levels (e.g., China, Hong Kong, India, South Korea). Furthermore, school disruptions due to typhoons and heavy tropical rains may also limit active transportation or active (outdoor) play in countries like the Philippines, at least before the pandemic. In relation to these concerns and based on the results from GM 4.0, neoliberal capitalist ideology, climate culpability, and PA were investigated simultaneously in a recent study[54] and found that country-specific economic ideology and responsibility for climate change, together, influence PA inequitably. Therefore, future studies should further explore the interactions between ideology-climate change factors and how they influence Report Card grades to inform global policies for PA promotion of the Asia region.

6.1. Strengths and limitations

The major strength of this study is that it provides a comprehensive overview of the patterns and temporal trends of the Report Card grades from Asian countries for three rounds of GM that cover the year between 2016 and 2022. Providing regional-specific gaps and future recommendations based on the GM data is another strength, which will inform future country- and regional-level health promotion policies. Also, this work included Report Card leaders from previous and current GMs as co-authors for their validation and contribution; therefore, appropriate reflection in presenting and interpreting data is highly likely.

Nonetheless, some limitations can be noted. Longitudinal analyses can provide reliable interpretation of the trends (e.g., magnitude of change); however, this was not possible due to a small number of countries included in this manuscript. Therefore, evidence was synthesized qualitatively rather than quantitatively. Furthermore, Report Card grades in GM 4.0 were based on pre- and post-pandemic data (stratified or together) in almost half of the Asian countries participated (i.e., China, Hong Kong, Indonesia, South Korea, Taiwan, Thailand, UAE). Due to heterogeneity of the data provided, results were not interpreted based on COVID-19 specific data but only overall grades (pre- and post-COVID-19 pandemic average) were considered in this work. However, some decreases in the behavioral/individual grades may be indeed due to the pandemic. Thailand's 2022 reported that the reduction in the proportion of children who met the behavioral guidelines and used active transportation in the GM 4.0 (compared to GM 2.0) was likely due to the public health restrictions and school closure due to the pandemic.[42] It is also important to note that Thailand had higher grades in behavioral indicators compared to other countries in GM 2.0. It would be interesting to examine pre- and post-COVID-19 Report Card grades with all 57 countries participated in GM 4.0. Lastly, it is important to note that by using aggregated scores (e.g., behavioral indicators and the sources of influence), detailed contextual interpretation for each country may have been missed. For instance, India showed worsened behavioral indicators between GM 2.0 and GM 3.0 overall; however, this was mainly driven by Sedentary Behavior. In fact, PA and Active Transportation grades improved over time.

7. Conclusion

Through international collaboration and capacity building in Asian countries that participated in the GM initiative, this study provided patterns and temporal trends of Report Card grades from Asian countries. Also, this study offers recommendations for future GM initiatives and research based on gaps identified. It is hopeful that participation from Asian countries in GM has increased over the years, which demonstrates the region's enthusiasm, capacity, and support in part of global PA promotion efforts. Cross-national comparisons were made to provide contextual information by the countries participated in GM; nevertheless, the efforts to promote a physically active lifestyle among children and adolescents should be a collective interest and priority of the Asia region. In future GM initiatives and research, considerations should be made to provide more accurate and rich data and to better understand contextual challenges in evaluating certain indicators such as Active Transportation, Active Play, and Physical Fitness in particular. Further, macro level factors such as disparities, ideology, or climate change should also be proactively considered in future research as these factors are becoming increasingly relevant to indicators of GM and for the promotion of PA more broadly.

Author statements

Eun-Young Lee: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data Curation, Writing – Original Draft, Writing – Review & Editing, Visualization, Supervision, An-Chi Shih, Maia Collins, Yeong-Bae Kim: Validation, Formal analysis, Investigation, Data Curation, Patrick Abi Nader, Jasmin Bhawra, Tarun Reddy Katapally, Chiaki Tanaka, Pairoj Saonuam, Piyawat Katewongsa, Dyah Anantalia Widyastari, Wendy Y. Huang, Stephen H. Wong, Asaduzzaman Khan, Narayan Subedi, Susan Paudel, Chen-Kang Chang, Ching-Lin Wu, Justin Y. Jeon, Yeon Soo Kim, Tom Loney, Falk Müller-Riemenschneider, Bozhi Chen, Jonathan Y. Cagas, Jyh Eiin Wong, Mohd Razif Shahril, Agus Mahendra, Mark S. Tremblay: Validation, Writing – Review & Editing.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jesf.2022.10.008.

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