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Global Matrix 3.0 Physical Activity Report Card Grades for Children and Youth: Results and Analysis from 49 Countries

Original Research

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Abstract

Background

Accumulating sufficient moderate to vigorous physical activity (MVPA) is recognised as a key determinant of physical, physiological, developmental, mental, cognitive, and social health among children and youth (5-17 years). The Global Matrix 3.0 of Report Card grades on physical activity was developed to achieve a better understanding of the global variation in child and youth physical activity and associated supports.

Methods

Work Groups from 49 countries followed harmonized procedures to develop their Report Cards by grading 10 common indicators using the best available data. The participating countries were divided into three categories using the United Nations' Human Development Index (HDI) classification (low or medium, high, and very high HDI).

Results

A total of 490 grades, including 369 letter grades and 121 "INC" grades, were assigned by the 49 Work Groups. Overall, an average grade of "C-", "D+", and "C-" was obtained for the low and medium HDI countries, high HDI countries, and very high HDI countries, respectively.

Conclusions

The present study provides rich new evidence showing that the situation regarding the physical activity of children and youth is a concern worldwide. Strategic public investments to implement effective interventions to increase physical activity opportunities are needed.

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Introduction

Physical inactivity, defined as engaging in insufficient levels of physical activity and not meeting the current physical activity recommendations,[1] has been identified as the fourth leading risk factor of premature mortality in adulthood.[2] In contrast, accumulating sufficient moderate to vigorous physical activity (MVPA) is recognised as a key determinant of physical, mental, social and environmental health.[3,4] Among children and youth (5-17 years), several systematic reviews have reported physical activity benefits on physical, physiological, developmental, mental, cognitive, and social health as well as academic achievement.[5–10] Despite these benefits, it has been estimated that 80% of youth (11-17 years old) worldwide do not reach the minimum recommendation of 60 minutes of MVPA per day.[11] This is alarming given that physical inactivity among school-aged children and youth has been found to be associated with adverse physical, mental, social and cognitive health outcomes[5,8,12,13], lower physical fitness,[14] and lower physical activity levels in later life.[15]

To achieve a better understanding of the global variation in child and youth physical activity and its correlates, the Global Matrix of Report Card grades on physical activity was launched for the first time in 2014.[16] Physical activity Report Cards were developed based on the Canadian Report Card model,[17] using a harmonized process for data gathering, assessing, and assigning grades to indicators. For over a decade, the Canadian Report Card has been successful in raising awareness and influencing policies for childhood physical activity promotion. However these efforts have not yet translated into improving the physical activity levels of Canadian children and youth.[18] Fifteen countries in 2014 (Global Matrix 1.0), and 38 countries in 2016 (Global Matrix 2.0), developed and launched Report Cards presenting grades for nine physical activity indicators, allowing for international comparisons and offering insights from global data.[16,19] The first two Global Matrices enabled the identification of several gaps in surveillance and research practice. Also, a paradox of higher physical activity and lower sedentary behavior in countries

220 reporting poorer infrastructure, and lower physical activity and higher sedentary behavior in countries
221 reporting better infrastructure was highlighted.[16,19] While participation in the Global Matrices 1.0 and 2.0
222 facilitated capacity building, professional networking, research collaborations, and international
223 comparisons, the Global Matrix framework still needs to be continuously expanded, improved, replicated
224 and widely disseminated.[19]

225

226 The Global Matrix initiative is led by the Active Healthy Kids Global Alliance (AHKGA), which is an
227 incorporated not-for-profit organization consisting of researchers, health professionals and stakeholders
228 who collaborate to advance physical activity in children and youth from around the world.[20] In 2017, the
229 AHKGA invited previous participating countries and called for new countries to register for the Global
230 Matrix 3.0. As a result, work groups from 49 countries completed the full registration process and
231 followed the harmonized procedures to develop their Report Cards by grading 10 common indicators
232 (Overall Physical Activity, Organized Sport and Physical Activity, Active Play, Active Transportation,
233 Sedentary Behaviors, Physical Fitness, Family and Peers, School, Community and Environment, and
234 Government) using the best available data.

235

236 Countries in different development stages may have different challenges and priorities to inform
237 strategies to improve physical activity among children and youth. Countries involved in the Global Matrix
238 3.0 were classified within three categories using the Human Development Index (HDI): low and medium
239 HDI (<0.70), high HDI (≥0.70 to <0.80), and very high HDI (≥0.80). The HDI, ranging from zero to one,
240 is a composite index calculated using data on education, life expectancy, and income per capita,[21] and was
241 created by the United Nations Development Programme to rank countries on a scale of human
242 development conceptualized in terms of capabilities of humans within the countries to function.[22] Nine of
243 the participating countries were classified as low or medium HDI (Bangladesh, Botswana, Ethiopia,

Ghana, India, Nepal, Nigeria, South Africa, and Zimbabwe), 10 as high HDI (Brazil, Bulgaria, China, Colombia, Ecuador, Lebanon, Mexico, Thailand, Uruguay, and Venezuela), and 30 countries and territories as very high HDI (Australia, Belgium [Flanders], Canada, Chile, Chinese Taipei [Taiwan], Czech Republic, Denmark, England, Estonia, Finland, France, Germany, Guernsey, Hong Kong, Japan, Jersey, Lithuania, Netherlands, New Zealand, Poland, Portugal, Qatar, Scotland, Slovenia, South Korea, Spain, Sweden, United Arab Emirates, United States, and Wales).

This special issue of the *Journal of Physical Activity and Health* includes 49 extended abstracts documenting the main Report Card findings from each participating country. A manuscript presenting the international impact of the Report Cards and the Global Matrices on the international scientific community, on raising awareness among general population and stakeholders, and on powering the movement to get kids moving closes this special issue.[23] In addition, three papers were developed to present and discuss results from the Report Cards by pre-determined HDI categories as follows:

- "The Indicators of Physical Activity among Children and Youth in Nine Countries with Low and Medium Human Development Indices: A Global Matrix 3.0 Paper";[24]
- "Report Card Grades on the Physical Activity of Children and Youth from 10 Countries with High Human Development Index – Global Matrix 3.0";[25]
- "Report Card Grades on the Physical Activity of Children and Youth Comparing 30 Very High Human Development Index Countries".[26]

The aim of this integrated article is to combine and compare the findings from each of the HDI (low and medium; high; and very high) papers and present, compare, and discuss further analyses of the results from the 49 countries participating in the Global Matrix 3.0.

Methods

Creating the Global Matrix 3.0

In April 2017, the AHKGA invited interested countries to participate in, and register for the Global Matrix 3.0 through an open call that was distributed via established networks. Between April 2017 and January 2018, 49 countries from six different continents (Africa, Asia, Europe, North America, Oceania, and South America) registered and paid a registration fee based on their HDI classification to cover costs associated with the Global Matrix 3.0 initiative. Three different tiers of registration fees ($500 USD for the low HDI countries, $750 USD for the medium HDI countries, $1,000 USD for the high HDI countries, and $1,500 USD for the very high HDI countries) were offered to encourage equitable participation from around the world. Individuals who registered on behalf of their country were responsible for leading the effort to form a multidisciplinary Report Card work group of national physical activity experts and stakeholders. Furthermore, one to three Report Card leaders/co-leaders per country were designated officially to manage the national Report Card development, and to ensure effective communication between the AHKGA Executive Committee and the Report Card work group.

A mentoring system was developed for the Global Matrix 3.0. New Report Card leaders and teams were paired with an experienced Report Card leader from a country who participated in the Global Matrix 2.0. In addition, six members of the Executive Committee of AHKGA were assigned to be regional mentors for each involved continent to provide help and guidance to the countries when needed and report their progress to the AHKGA Executive Committee. Finally, the AHKGA Executive Committee served as the coordinating center of the Global Matrix development, and provided information including background papers, previous Report Cards and Report Card papers, fundraising suggestions, and a theoretical framework to support the preparation of grant proposals, scholarship and funding applications. The

AHKGA Executive Committee also provided guidance through monthly e-blasts by sharing milestones, and upcoming deadlines.

Harmonised Report Card Development

An updated list of indicators (to which grades would be assigned) and corresponding benchmarks were created based on the previous Global Matrix methods,[19] and feedback received during a workshop after the Global Matrix 2.0 launch in Bangkok, Thailand (November, 2016). A new indicator, Physical Fitness, and its corresponding benchmarks were added to the list. The benchmark for Overall Physical Activity was modified in accordance with the new Canadian 24-Hour Movement Guidelines for Children and Youth,[27] where "at least 60 minutes of MVPA per day" was changed to "at least 60 minutes of MVPA per day *on average*". Further modifications to the benchmarks were made during the development of the Global Matrix 3.0 to address several issues that were reported by Report Card leaders to the AHKGA Executive Committee. The final version of the benchmarks for the 10 indicators is presented in Table 1. A more detailed grading scheme using positive (+) and negative (-) mathematical symbols, was also developed (Table 2). In some countries, because of the modifications of the benchmarks from previous Global Matrices, grades for some indicators have changed while in fact, the situation was relatively the same. Consequently, while the Report Card work groups reported grades based on the revised benchmarks for the Global Matrix 3.0, some countries reported different grades in their national Report Grades (i.e., to be consistent with their previous methods). For example, in Colombia, with the new benchmark, a "D+" was assigned to Overall Physical Activity for the Global Matrix 3.0, while a "D-" is reported in the Colombian country Report Card, based on the previous benchmark.[28]

Each country work group identified and complemented the list of indicators to be graded (i.e., the 10 common indicators and potentially additional ones that would be included in their national Report Card

but not in the Global Matrix 3.0) and gathered the highest quality of published and unpublished evidence, or in some cases collected data prospectively. Due to the lack of data concerning physical activity among children in the early years (0 - 4 years) observed in the previous Global Matrices, consensus was reached among the AHKGA Executive Committee that the 10 indicator grades should only be informed by data from school-aged children and youth (~5-17 years-old) for the Global Matrix 3.0 to ensure consistency across countries. Where possible, countries were also advised to consider and synthesize the best available evidence from approximately the past five years for each indicator. Through a harmonized and transparent Report Card development process, each country's work group collected and collated the best available evidence from local, national or international studies, national surveys, official reports, and normative documents, and then synthesized findings and reached consensus for the grading of each indicator. A draft of each country Report Card grades were submitted along with their rationale by Report Card leaders and were audited by members of the AHKGA Executive Committee to ensure that the grades were consistent with the harmonized benchmarks and grading scheme. This audit process led to minor changes of the grades or rationale for most of the countries.

Data Analysis

For analysis purposes, the 49 participating countries and regions were divided into three categories using the United Nations' HDI classification (low or medium, high, and very high HDI) described above. Sociodemographic data that are available online were compiled to identify the characteristics of the participating countries. Descriptive statistics (average grade and standard deviation) were calculated after converting categorical variables (letter grades) to interval variables (see corresponding numbers in Table 2), and the incomplete grades (INC) were converted into "No Grade" which was treated as a missing value. Averages were calculated by country, indicator, and category of HDI from the interval values and the floor (the number rounded down) was converted back to a letter grade. Three scores were generated

for the analysis: 1) Overall score computed as the sum of interval values for all indicators, 2) Behavioral score (the sum of Overall Physical Activity, Organized Sport and Physical Activity, Active Play, Active Transportation, and Sedentary Behaviors interval values), and 3) Sources of influence score (the sum of Family and Peers, School, Community and Environment, and Government interval values). "INC" grades were removed, and the scores were re-weighted accordingly (i.e., the missing grade was replaced by the sum of the interval values divided by the number of letter grades included in the score). Categorical variables (letter grades) were grouped into four ("A-B", "C", "D-F", and "No Grade") based on the overall score. These categories were then used to rank countries by the letter grade/score and category level in scatter plots. Correlational analyses between the 10 common indicators and sociodemographic indicators were performed using Spearman's rank correlation coefficients. Only significant moderate to strong correlations were considered for the discussion in this analysis ($r \geq 0.30$ or $r \leq -0.30$, $p<0.05$).[29] Pairwise deletion was used to treat missing data (INC grades) in order to minimize the number of cases excluded from the analysis. All statistical analyses were performed, and maps were created in R version 3.4.1 (The R Foundation for Statistical Computing, Vienna, Austria). Several packages were loaded to extend base R including corrplot,[30] ggplot2,[31] UpSetR,[32] and VIM.[33]

Results

A total of 52 countries responded to the AHKGA and showed interest in participation in the Global Matrix 3.0, but only 51 fully registered on time, and later on two countries withdrew. Sociodemographic characteristics of the 49 countries participating in the Global Matrix 3.0 are presented in Table 3. The HDI scores ranged from 0.448 (Ethiopia) to 0.985 (Jersey). Ethiopia also scored the lowest for the following: Growth National Income per Capita ($1,523 USD), mean years of schooling (2.6 years), Global Food Security Index (33.3), urban population percentage (17.2%), and prevalence of people using improved drinking water sources (44%). Qatar scored highest in the Growth National Income per Capita

($129,916 USD) and the Gender Inequality Index (0.542). Public health expenditure in percentage of Growth Domestic Product was the highest in Sweden (10.0%) and the lowest in Venezuela (1.5%). Life expectancy at birth ranged from 53.1 years in Nigeria to 84.2 years in Hong Kong. Hong Kong also had the highest urban population percentage (100%) and the highest population density (6,987 people/km^2 of land area). The lowest Gini index (least income inequality) was observed in Slovenia (25.4) and the highest (greatest income inequality) in Botswana (60.5).

The physical activity grades for the 10 common indicators are organized by country in alphabetical order (Table 4). A total of 490 grades, including 369 letter grades and 121 "INC" grades, were assigned by the 49 Report Card work groups. A "Not Applicable" grade was assigned to Active Transportation by Qatar's Report Card work group because of unsafe road conditions and a hot climate during most of the year.[34] The grade count, number of "INC" grades, mean number grade, standard deviation, and mean letter grade by indicator and group of indicators are presented in Table 5. The indicators with the lowest number of "INC" grades were Overall Physical Activity and Active Transportation (n = 2), while the indicator with the highest number of "INC" grades was Active Play (n = 29), followed by Physical Fitness (n = 27), and Family and Peers (n = 22). The mean letter grades ranged from "D" for Overall Physical Activity to "C" for Organized Sport and Physical Activity, Active Transportation, School, Community and Environment, and Government. An average grade of "C-" was obtained for the behavioral indicators combined, "C" for the sources of influence indicators combined, and "C-" was the overall average grade for the 369 letter grades. The average letter grades by indicator and group of indicators for the low and medium, high, and very high HDI countries are presented in Table 6. For the low and medium HDI countries, an average of "C" was obtained for the behavioral indicators combined and "D+" for the source of influence indicators combined, while for the very high HDI countries, an average of "D+" was obtained for the behavioral indicators combined and "C+" for the sources of influence indicators combined. For the high HDI countries, an average of "D+" was obtained for the behavioral indicators combined and for the sources of

influence indicators combined. Overall, an average grade of "C-", "D+", and "C-" was obtained for the low and medium HDI countries, high HDI countries, and very high HDI countries, respectively.

A plot for the estimated overall score of each country from the 10 indicators is presented in Figure 1 and the behavioral and sources of influence scores are shown in Figure 2 and Figure 3, respectively. Slovenia ranked first while China ranked 49th for the overall score (full rankings are shown in Figure 1); Nepal ranked first, and Estonia ranked last for the behavioral score (complete rankings are shown in Figure 2); and Slovenia ranked first while Venezuela ranked last for the source of influence score (see all country rankings in Figure 3). The Online Supplementary File S1 presents the correlation coefficients and their associated p-values between and within the 10 core physical activity indicators and the sociodemographic indicators. It showed that there were no statistically significant relationships between the Overall Physical Activity grade and the other core indicator grades with the exception of Sedentary Behaviors for which a statistically significant positive weak correlation was observed ($r = 0.39$, $p<0.05$). Finally, presented in the Online Supplementary File S2 is the distribution of the grades ("A-B", "C", "D-F", or "INC" grades) for the 10 common indicators and the average grades per country. Slovenia was the only country out of 49 with a very high grade for Overall Physical Activity ("A-") while most of the other countries had "D-F" ($n = 38$). A greater variability in grades was observed for Sedentary Behaviors, but poor grades ("D-F") were observed in most of the very high HDI countries.

Discussion

As a result of the efforts of the Report Card work groups, the Global Matrix 3.0 allowed us to present physical activity-related indicators for children and youth assembled across 49 countries with varying levels of human development (nine low and medium HDI, ten high HDI, and 30 very high HDI countries). While the average grades calculated for the indicators were all between "D" and "C" (Table

411 5), a great variety of grades was observed within and across the countries (Table 4), showing that every
412 country is facing unique challenges and can learn from the successes or difficulties experienced by others.
413 However, trends and comparable challenges identified across the physical activity indicators were
414 identified within countries in the same HDI grouping despite their diverse sociodemographic, cultural,
415 and geographical contexts. A discussion of the most and the least successful countries, followed by the
416 interpretation of the findings from each indicator is presented in the following section, integrating the
417 comparison of each HDI grouping.

418

419 *Most successful countries*

420 On the overall score, the very high HDI countries ranked generally higher than the low and medium, and
421 high HDI countries (Figure 1), but this is not corroborated with results presented in Table 6 where the
422 overall averages were the same for the low and medium HDI countries and the very high HDI countries.
423 Slovenia obtained the best grade on average ("B"), followed by two other very high HDI countries (Japan
424 and Denmark) that both obtained an average grade of "B-". The specifics of childhood physical activity in
425 these three countries has already been discussed in the paper presenting the findings from the very high
426 HDI countries.[26] These three countries were also leading the ranking based on the sources of influence
427 score (Figure 3). The ranking of the behavioral score was dominated by two low HDI countries (Nepal
428 and Zimbabwe) and Japan (Figure 2). These rankings should be interpreted with caution given the large
429 number of "INC" grades in their country Report Cards (two in Japan, three in Denmark, five in Nepal,
430 and two in Zimbabwe).

431 Nepal lacked data to inform five of the 10 indicators that were assigned an "INC" grade (Organized Sport
432 and Physical Activity, Active Play, Physical Fitness, School, and Government). A "D+" was assigned to
433 Overall Physical Activity based on a study that found that only 39.8% of children and youth accumulated
434 at least 60 minutes of MVPA per day. Nevertheless, Nepal shared the best grade for Active

Transportation with Japan and Zimbabwe ("A-"), obtained a high grade for Sedentary Behaviors ("B+") and also scored highest for the Family and Peers indicator ("A"). These grades were all informed by local studies focusing on adolescents.[35] Nepal's good grades in many of the indicators including Active Transportation and Sedentary Behavior may be associated with low automobile dependency (e.g., 7.12 vehicles for 1,000 people in 2011),[36] and minimal opportunities and access to screen-based recreational sedentary pursuits such as television- and computer-time, and time spent using the internet. Nepal had 5.30 televisions per 1,000 people (as of 2003); 4.37 computer (as of 2004), and 4.51 internet subscribers (as of 2012) for 1,000 people.[37] Due to the concurrent economic development in recent years in Nepal, the number of motorized vehicles is increasing rapidly with the expansion of road networks in rural areas,[38] and potentially more people have access to screen devices. These findings should be interpreted with caution, but they do suggest that the situation can potentially be positive in Nepal in terms of child and youth's active transportation and sedentary behaviors at present. Yet, these favorable behaviors might be threatened by the economic growth and development and these physical activity behaviors may be more a function of poor economic development than a freely chosen physical activity. Nonetheless, more good quality research with nationally representative data is needed to obtain more reliable estimates of the physical activity of children and youth and to inform the grades with "INC" grades.

Zimbabwe had the second-best grade for Overall Physical Activity ("C+") after Slovenia, with high grades for most of the behavioral indicators ("B" for Organized Sport and Physical Activity, "A-" for Active Transportation, and "B" for Sedentary Behaviors); however, its sources of influence indicators were assigned grades between "D" and "C". In comparison with the previous Report Card in Zimbabwe, the grades for School, Community and Environment, and Government, have improved due to recent policy implementations and commitments made by the government to promote physical activity and nutritional status among Zimbabwean children and youth.[39] However, there is need for caution in interpreting these grades as they were informed by limited and mostly unpublished data and expert

opinion. Thus, more research is needed to obtain a reliable picture of the context of the physical activity level of children and youth in Zimbabwe.

Least successful countries

One low HDI country, Ethiopia, and two high HDI countries, Venezuela and China, were the least successful countries based on the overall and the source of influence score rankings (Figures 1 and 3). An average grade of "D-" was assigned to China, and an average grade of "D" was assigned to Ethiopia and Venezuela. China's Report Card work group developed a national surveillance protocol to collect nationally representative data for China's 2018 Report Card.[40] An "F" was assigned to four indicators (Overall Physical Activity, Sedentary Behaviors, Community and Environment, and Government) and the remaining indicators were assigned grades between "D-" and "C+". The small proportions of 9-17-year-old children in China meeting the physical activity guidelines (13.1%) or the sedentary behavior guidelines (7.1%) are alarming.[40] With an estimated population of 1.4 billion,[41] China is the most populated country in the world, and the low prevalence estimates observed here suggest that the majority of a large number of children and youth (approximately 160 millions of 10-19 year-olds in 2015)[41] are not engaging in sufficient amounts of MVPA to benefit their health. However, the high levels of air pollution in China represents a major threat to the promotion of physical activity,[42] and is a potential barriers stopping the Chinese children and youth from exercising. The recent support from the Chinese Ministry of Education in conducting national surveillance of children physical activity is however encouraging, and hopefully this support will be expanded to future investments in the development of interventions and policies designed to increase physical activity opportunities at community and environment levels in China.

In Ethiopia, an "F" was assigned to Sedentary Behaviors, Family and Peers, and Community and Environment, and the grades for the remaining indicators ranged between "D" and "C", with the

484 exception of Active Play that was graded "B". These findings should be interpreted with caution as the
485 grades were informed by estimates based on experts opinion when data for an indicator were
486 unavailable.[43] This method nevertheless did allow the Report Card work group to present an initial broad
487 picture of childhood physical activity in Ethiopia.

488 Venezuela is currently facing a humanitarian crisis related to its economic and socio-political situation.
489 Between 2016 and 2017, marked increases in maternal mortality (65%), infant mortality (30%), and cases
490 of malaria (76%) were observed and the estimated prevalence of severe malnutrition among children
491 under five years of age increased from 10.2% in February 2017 to 14.5% in September 2017.[44]
492 Nevertheless, a Report Card was developed, using published and unpublished national survey data, peer-
493 reviewed literature, government and nongovernment reports and online content, and meetings with
494 experts working for governmental (municipal) and non-governmental organizations.[45] The Venezuelan
495 Report Card work group assigned an "INC" grade to five indicators: Active Play, Sedentary Behaviors,
496 Physical Fitness, Family and Peers, and School. An "F" grade was assigned to the Government indicator
497 while the remaining indicators were graded "D" or "D-", with the exception of Active Transportation
498 which was graded "B-". Though there were no physical activity data available for those under 15 years of
499 age, the work group found that the majority of adolescents older than 15 years do not engage in physical
500 activity regularly. In addition, the high rates of crime were identified as a barrier to physical activity.
501 Currently, no governmental efforts to ensure safety and promote an active lifestyle in Venezuela are being
502 implemented.[45]

503

504 *Overall Physical Activity*

505 Only two countries assigned "INC" grades to the Overall Physical Activity indicator: Japan and
506 Botswana. Slovenia, where more than 80% of children and youth aged between 6 and 19 years (according
507 to subjective self-reported data), 88% of the 11 year-olds, and 66% of the 14 year-olds (according to

objective data) were meeting the physical activity guidelines, was the only country reporting a high grade for this indicator ("A-").[46] For this indicator, the grades for the remaining countries ranged from "F" (Belgium, China, Scotland, South Korea, and Taiwan) to "C+" (Zimbabwe).

The Overall Physical Activity grade was informed by various types of data across countries: objective measurement with accelerometers or pedometers, self-report or proxy-report questionnaire, and expert opinion. Even among both the subjective and objective data, the methods varied substantially in terms of instruments, analysis, age range, sample size, and representativeness of samples.[24,25,47] In addition, the available data in each country did not necessarily allow the Report Card work groups to use either of the recommended benchmarks (see Table 1) strictly when estimating the prevalence of physically active children and youth in their sample.[24,25,47] For such reasons, the comparability of these results among the countries should be interpreted with caution.

Overall Physical Activity was the indicator with the lowest average grade: "D". A distinction was observed between the low and medium HDI countries and the two other HDI groupings. The average grade for the low and medium HDI countries was "C-", whereas both the high and very high HDI countries obtained an average of "D-", which could represent a difference of 14-26% in physical activity guidelines adherence ("D-" = 20-26% vs. "C-" 40-46%). In accordance with this difference of grades, a significant low negative correlation was observed between the Overall Physical Activity indicator and several sociodemographic indicators including the HDI ($r = -0.3$, $p<0.05$) and the growth national income per capita ($r = -0.33$, $p<0.05$) (see Online Supplementary File, S1). The present study provides new evidence showing that the situation regarding the physical activity of children and youth is a universal concern worldwide. This finding is consistent with the results from the previous Global Matrices[16,19] and recent global estimates.[11] Efforts should be made globally and collectively to develop standardized physical activity surveillance systems adapted to the national context of each country. Furthermore, developing effective strategies to increase physical activity opportunities for all should be a national public health priority in all countries regardless of the HDI background.

533

534 *Organized Sport and Physical Activity*

535 An "INC" grade was assigned for this indicator in seven countries: Bangladesh, Botswana, Ecuador,
536 India, Jersey, Nepal, and United Arab Emirates. The Organized Sport and Physical Activity grades ranged
537 from "F" (Lebanon and Uruguay) to "A-" (Denmark), with an average of "C". The benchmark
538 recommended for this indicator was the "percentage of children and youth who participate in organized
539 sport and/or physical activity programs" (Table 1), meaning that this indicator did not provide any
540 information on the dose (i.e., duration, frequency, intensity) of physical activity while participating in
541 sport and organized physical activities, because few countries have such data. The grade for this indicator
542 depends on the availability of organized sport opportunities and the availability of data reporting the
543 prevalence of children and youth who have taken advantage of these opportunities. This grade was mostly
544 informed by official reports from governmental and/or public institutions as well as self-reported surveys.

545

546 Organized Sport and Physical Activity was graded "C", "D+", and "C+" on average for the low and
547 medium HDI countries, the high HDI countries, and the very high HDI countries, respectively. Among
548 the nine low and medium HDI countries, five assigned a letter grade to this indicator, which ranged from
549 "D" to "B", with an average of "C". In these countries, the organized sport opportunities corresponded
550 mostly to school-based sports or sport teams and recreational sports organized by non-governmental
551 organizations and communities. Among the high HDI countries, the grades ranged from "F" to "C+" with
552 an average of "D+". However, it is not possible to discern from the available data if these low grades
553 correspond to the limited availability of organized sport opportunities (i.e., distal correlates) or if there are
554 barriers (e.g., proximal correlates such as motivation, interest, time, or parental support) hindering
555 children from participating while organized physical activities are readily available to them. In the very
556 high HDI countries, with an average grade of "C+", Organized Sport and Physical Activity was the
557 highest graded behavioral indicator. In these countries, organized sport opportunities are available to

children and youth in various settings: sport club and federations, school-based sport teams and organized sport sessions, municipal sport programs, and sport programs offered by private businesses. In addition, significant low to moderate positive associations were observed between Organized Sport and Physical Activity and several sociodemographic indicators including HDI, life expectancy at birth, mean years of schooling, growth national income per capita, public health expenditure (% of GDP), Global Food Security index, improved drinking water coverage, and summer Olympic medal count; while significant low negative associations between this indicator and the two inequality indices (Gini index and Gender inequality index) (see Online Supplementary File, S1) were observed.

More research is needed to examine if affordable and appealing organized physical activity and sport opportunities are offered to all children and youth equally and equitably—across different age, gender, socioeconomic, ethnic, and special population groups—and to isolate the missing components of organized sports opportunities in each country. In addition, it would be interesting to add the measurement of the dose of physical activity associated with organized sports and physical activities in national physical activity surveillance systems. Filling these research and surveillance gaps is a necessary step towards the development of effective strategies to promote physical activity by increasing organized sport opportunities at the national level.

Active Play

Among the 20 countries that graded Active Play, this behavior was mostly measured by self- or proxy-report surveys, assessing the frequency or the time of active play/being active while playing,[46,48–51] unstructured/unorganized active play,[40,52–58] playing outdoors/outdoors activities/being outdoors,[39,48,56,59–61] and/or was based on expert opinion.[39,43,62,63] A definition for active play was proposed in a recent systematic review: “a form of gross motor or total body movement in which young children exert energy in a freely chosen, fun, and unstructured manner”.[64] A consensus definition, however, still needs to be

583 internationally agreed upon and acknowledged to allow the development of standardized measurement
584 tools for this indicator in varying age groups.

585 Active Play was the indicator with the most "INC" grades where 29 of 49 countries were unable to find
586 available data to grade this indicator. The grades ranged from "F" (Estonia and Thailand) to "B" (Ethiopia
587 and The Netherlands) with an average of "D+". The average grades for the low and medium HDI
588 countries, high HDI countries, and very high HDI countries were "C-", "D", and "D+", respectively.
589 Given the amount of "INC" grades and the variability of the data used to inform the grades for the Active
590 Play indicator, a valid comparison between the three HDI groupings was difficult. The low grades that
591 were reported for this indicator aligned with the previous Global Matrices findings.[16,19] Such low level of
592 engagement in active play can potentially be explained by the low detection capacity of instruments
593 utilized for its measurement. Active play during free time may be slowly disappearing in favour of screen
594 time in developed countries or is replaced with chores or work in developing countries. Perception of the
595 environment as unsafe can also be a potential barrier to this behavior. However, no relation was found
596 between Active Play and the Community and Environment indicators (Online Supplementary File, S1).
597 Further research is needed for the development of a consensus definition, measurement instruments,
598 surveillance systems, and to identify the barriers and facilitators of active play.

599

600 *Active Transportation*

601 Only two countries did not assign a letter grade to Active Transportation: Qatar (not applicable) and
602 United Arab Emirates ("INC"). The average grade for this indicator was D+ and ranged from "F" (Chile)
603 to "A-" (Japan, Nepal, Zimbabwe). The recommended benchmark for this indicator was "the percentage
604 of children and youth who use active transportation to get to and from places" (Table 1). For most of the
605 countries, the grades were informed by data reporting the prevalence of children and/or youth actively

606 commuting between home and school without information on different doses (i.e., frequency, duration,
607 intensity).

608 Active Transportation was the indicator with the highest average grade for the low and medium HDI
609 countries ("C+") and for the high HDI countries ("C"). The average grade for the very high HDI countries
610 was "C-" for this indicator. In three of the four very high HDI countries from Eastern Asia, very high
611 grades were assigned to this indicator: Japan ("A-"), Hong Kong ("B+"), and South Korea ("B+"). These
612 three countries share similar characteristics historically, culturally, and developmentally,[65] and have
613 shown a high percentage of urban population (83.3% to 100%, Table 3). A specific policy in Japan
614 (limiting the distance between the children and youth homes and the public elementary and junior high
615 schools),[66] and the high density of Hong Kong, and Japanese and South Korean cities, allow children and
616 youth to live a short trip away from their school, which can minimize the use of car or other forms of
617 motorized vehicles, and promote active travel.[26,67,68]

618

619 High to very high grades for this indicator were also reported in several developing countries: Colombia
620 ("B"), Nepal ("A-"), Nigeria ("B"), Venezuela ("B-"), and Zimbabwe ("A-"), while poor grades were
621 reported for 16 of the 30 very high HDI countries (with grades between "F" and "C-"). However, no
622 statistically significant relation was found between Active Transportation and Community and
623 Environment indicators or the HDI in the correlational analysis. These findings suggest that, for
624 developing countries, active transportation may be driven by a necessity (i.e., no access to public or
625 family/personal motorized transportation) instead of a choice,[69] notwithstanding the safety of the
626 environment or the long distance to commute. The measurement of the dose and the characteristics of
627 children's and youth's active transportation internationally are necessary to identify the contribution of
628 active transport to overall physical activity levels, as well as the facilitators and obstacles for this behavior
629 in order to develop contextually adapted, effective ways to promote it. Strategies to improve safety

conditions and to promote active transportation as a desirable mode of transport are required in order to maintain the high grades in the countries leading this indicator and to improve those that are lagging.

Sedentary Behaviors

Sedentary Behaviors is defined as "any waking behavior characterized by an energy expenditure ≤1.5 metabolic equivalents, while in a sitting, reclining, or lying posture".[1] Screen time, referring to time spent in screen-based behaviors[1], is often used as a proxy for sedentary behavior in research. Screen time can be performed while being sedentary or physically active,[1] however this behavior has been shown to be associated with a variety of negative health outcomes among children and youth.[70] This is why guidelines recommending limiting screen time to two hours daily for 5-17 year-olds were developed for the first time in Canada.[71] Further, it was also the reason why the benchmark for Sedentary Behaviors focused on screen time: "percentage of children and youth who meet the *Canadian Sedentary Behaviour Guidelines* (5- to 17-year-olds: no more than 2 hours of recreational screen time per day)" (Table 1). However, the comparisons between the countries should be interpreted with caution because of the variability of the data that were used to inform the grades for this indicator. Several Sedentary Behaviors grades were partially or totally informed by data reporting time spent sitting or doing other sedentary activities that did not involve screens, and screen time cut-off points differing from the one in the benchmark (i.e., ≤1 hour/day, <2 used hours/day, ≤3 hours/day) were also used by some countries because of available data.

Three countries assigned an "INC" grade to Sedentary Behaviors: Ghana, South Africa, and Venezuela. The grades for this indicator ranged from "F" (China, Estonia, Ethiopia, Scotland, and Wales) to "A-" (Bangladesh), with an average of "D+". These findings are consistent with international estimates reporting that at least two thirds of the children exceed 2 hours of recreational screen time per day,[72] although comparison may be limited by the heterogeneity in Sedentary Behaviors across countries. The low and medium HDI countries obtained an average of "C+" for this indicator, and only two of the eight

654 countries had a low grade: Ethiopia "F" and India "C-". The grades for the six remaining low and medium
655 HDI countries ranged from "B" to "A-". The high and the very high HDI countries obtained an average
656 grade of "D" and "D+", respectively, for Sedentary Behaviors. In 36 out of the 39 high and very high
657 HDI countries that graded this indicator, a low or very low grade (between "F" and "C-") was assigned.
658 Regardless, the Sedentary Behaviors grades were not related to HDI or to the other sociodemographic
659 indicators except the mean years of schooling ($r = 0.31$, $p<0.05$) and the summer Olympic medal count (r
660 $= -0.57$, $p<0.05$) in the correlational analysis presented in the Online Supplementary File S1.

661 The results presented here suggest that the situation concerning the childhood screen time is particularly
662 concerning in high and very high HDI countries. The moderately good grades for Sedentary Behavior in
663 the low and medium HDI countries are potentially threatened to decrease with their continuing economic
664 growth and development, which may lead to increased access to electronic devices. Several interventions
665 to reduce screen time have been developed and tested, and results from systematic reviews and meta-
666 analyses reported that interventions to reduce children's screen time can have a small but significant
667 effect.[73] More research is necessary to accumulate more evidence on the effectiveness of specific
668 interventions across different contexts and settings, but investment from public health institutions in high
669 and very high HDI countries to support the implementation of these interventions in the child and youth
670 population should become a priority.

671

672 *Physical Fitness*

673 Physical fitness represents the ability to perform daily activities with vigor, and the demonstration of
674 traits and capacities that are associated with a lower risk of the premature development of diseases
675 associated with physical inactivity.[74] Cardiorespiratory endurance, muscular endurance, muscular
676 strength, body composition, and flexibility are the health-related components of physical fitness.[75] The
677 Global Matrix 3.0 evaluated the Physical Fitness indicator for the first time, and 27 countries were unable

678 to find available data to inform the grade for this indicator in. In the remaining countries, the grade for
679 Physical Fitness ranged from "F" (India) to "A" (Japan), with an average of "C-". India was the only
680 country from the low and medium HDI countries with a letter grade for this indicator. Among the 10 high
681 HDI countries, only four had a letter grade reported for this indicator: Brazil ("D"), China ("D"),
682 Colombia ("D-"), and Uruguay ("C-"), with an average of "D". A letter grade was assigned to 17 of the
683 30 very high HDI countries, ranging from "D" (Canada, Chile, Hong Kong, and Jersey) to "A" (Japan).

684 The benchmark for this indicator corresponded to the average percentile achieved on certain health-
685 related physical fitness components based on the normative values published by Tomkinson et al (Table
686 1).[76] However, many differences in the data informing the grades for this indicator were observed across
687 countries in terms of number fitness indicators reported, normative value used, age range and sample size.
688 Given the amount of "INC" grades and variability in the data informing the grades for this indicator, the
689 comparison between HDI groupings is difficult. Cardiorespiratory fitness (measured with the 20-meter
690 shuttle run test) was found to be associated with favourable indicators of adiposity and some indicators of
691 cardiometabolic, cognitive, and psychosocial health in boys and girls from 32 countries in a recent
692 systematic review.[77] Therefore, cardiorespiratory fitness is an important indicator of current and future
693 health among school-aged children and youth, and can be used as a holistic indicator of population health
694 in this age group.[78] These findings highlight that global surveillance of physical fitness, which represents
695 a simple and cost-effective assessment[79] that could be integrated in physical education classes, should be
696 a priority in all countries.

697

698 *Family and Peers*

699 The average grade for Family and Peers was the same among the three HDI groupings: "D+". An "INC"
700 grade was assigned in 22 countries: four from the low and medium HDI group, six from the high HDI
701 group, and 12 from the very high HDI group. The grades ranged from "F" (Chile, Ecuador, Ethiopia,

Ghana) to "A" (Nepal). This amount of "INC" grades and the letter grades reported are consistent with the previous Global Matrices.[16,19]

Support from parents and peers is recognized as a correlate of physical activity in children and youth;[80] however, the nature of this interaction is complex and no valid and internationally recognized instrument exists to measure the influence of family and friends on children and youth's physical activity at present. This is why several benchmarks were proposed to capture a picture of the influence of Family and Peers (Table 1), and variability in the data used to inform the letter grades for this indicator was observed. The number of "INC" grades and the measurement variation for this indicator limit the comparison and the interpretation of the letter grades reported. However, these findings highlight the need for the development of standardized methods for the surveillance of this indicator in various settings and contexts.

School

Given the potentially significant amount of time that children and youth spend at school, this environment is a strategically important setting for the promotion of physical activity. Physical activity opportunities can be provided to children and youth in the school environment through physical education, lunch and recess breaks, in-class physical activities, and in intramural competitive and non-competitive activities before or after school.[81] However, school physical activity policies, if they exist at all, differ from one country to another, and are not always mandatory.

The average grade for the School indicator was "C", and Report Card work groups in eight countries could not assign a letter grade to this indicator (Bangladesh, Ecuador, Guernsey, India, Nepal, Scotland, Venezuela, Wales). This indicator ranged from "D-" (South Africa, United Arab Emirates, United States) to "A" (Finland, Portugal, Slovenia). The average grade for this indicator was "D+" for the low and medium HDI countries. For the high HDI countries, School was the source of influence indicator that

obtained the highest average grade ("C-"). The very high HDI countries obtained an average grade of "B-", and it is worth noting that only medium to favorable grades ("C" to "A") were assigned to European countries (high and very high HDI counties included). The correlational analysis found a significant moderate association between the School indicator and six of the sociodemographic indicators: the HDI ($r = 0.53$, $p<0.001$), the mean years of schooling ($r = 0.51$, $p<0.001$), the Gini Index ($r = -0.66$, $p<0.001$), the Gender Inequality Index ($r = -0.65$, $p<0.001$), the Global Food Security Index ($r = 0.52$, $p<0.05$) and the distance to Equator ($r = 0.55$, $p<0.001$). In other words, the grades for school indicator increased as the HDI, the mean years of schooling, the food security and the distance to the equator increased, and as the Gender Inequality Index and the Gini index decreased. These findings align with the results of the Global Matrix 2.0.[19]

These findings further suggest that the quality and/or quantity of physical activity opportunities offered by the school are associated with the economic and development status of a given country. Cultural values attributed to sport and or physical activity can also be potential barriers or facilitators for this indicator. Quality school policies and programs related to physical activity for the three European countries leading this indicator (Finland, Portugal, Slovenia) have already been highlighted elsewhere.[19,26] While mandatory physical education classes is part of the school curriculum in most European countries for all school grades, it is only optional in some other countries from other parts of the world. For example, in the United States, the percentage of schools delivering mandatory physical education classes, in each grade, decrease from 97% in 6th grade to 42% in 12th grade.[82] In the United Arab Emirates, only 26% of adolescents aged 13-17 years reported participating in physical education class on three or more days each week.[83] In South Africa, 32% of children do not participate in school physical education classes, and no evidence of progress in the prioritization of physical education in the schools was found by the Report Card work group.[84] Similarly, two consecutive Report Cards from South Korea highlighted that the emphasis on important subjects (e.g., math, science) for university admission overrides the importance of physical activity in the Korean education system.[85,86] Though the new 2018 Korean national curriculum

751 requires schools to provide mandatory physical education, it is regarded as a minor subject and, with
752 progressing school grades, it is devalued and neglected.[87]

753 Evidence showed that adding more time to academic or curricular subjects by taking time away from
754 physical education programs was found not to enhance academic achievement in the corresponding
755 academic subjects and to be potentially detrimental to health.[88] Conversely, allocating more time to
756 physical activity from other subjects can improve the time children spend engaging in MVPA without the
757 risk of "hindering students' academic achievement".[88] The measure of the dose of physical activity
758 occurring in school should also be added to the national surveillance systems globally to identify the
759 needs in terms of policies and interventions aimed at promoting physical activity at school. In addition,
760 the Global Matrix 3.0 findings suggest that developing interventions or programs targeting schools in low
761 and medium HDI countries should be a priority on the international public health agenda.

762

763 *Community and Environment*

764 The Community and Environment indicator obtained an average grade of "C" and had 13 "INC" grades.
765 The grades ranged from "D-" (Venezuela) to "A" (Sweden). The low and medium HDI countries obtained
766 an average of "D", and the high HDI countries obtained a "D+". Among the very high HDI countries the
767 Community and Environment indicator was the indicator with the highest average grade ("B-"). The
768 correlational analysis (see Online Supplementary File, S1) found a positive significant moderate to strong
769 association between the Community and Environment indicator and the HDI ($r = 0.73$, $p<0.001$), the life
770 expectancy at birth ($r = 0.74$, $p<0.001$), mean years of schooling ($r = 0.64$, $p<0.001$), Growth National
771 Income per capita ($r = 0.80$, $p<0.001$), public health expenditure ($r = 0.67$, $p<0.001$), Global Food
772 Security Index ($r = 0.71$, $p<0.001$), urban population percentage ($r = 0.51$, $p<0.001$), improved drinking
773 water coverage ($r = 0.77$, $p<0.001$) and distance to Equator ($r = 0.58$, $p<0.001$); and a negative significant
774 moderate to strong association was found with the Gini Index ($r = -0.62$, $p<0.001$) and Gender Inequality

Index (r = -0.83, p<0.001). These findings aligned with the results of the previous Global Matrices[16,19] and reinforce the importance of income and gender equity for the physical activity and overall population health.

Characteristics of the built environment are recognized as a potential source of influence on the physical activity level of children and youth.[89–91] Given that a great number of characteristics could potentially influence the physical activity of children and youth, numerous benchmarks were proposed to evaluate this indicator. A great variability of data were used to inform the grades for this indicator, limiting direct comparisons between countries. Yet, the significant correlations suggest that despite the variability of data available that was used to inform the grade for this indicator, the Report Card work groups assigned a grade that was coherent with the characteristics of the environment. The available evidence from this indicator suggests that the characteristics of the built environment potentially influencing the physical activity of children and youth are already favorable in the very high HDI countries, and that an increase of the grades for this indicator is expected with the further development of low, medium, and high HDI countries.

Government

The average grade for the Government grade was "C", and an "INC" grade was assigned in eight countries. With an average of "C-", Government was the source of influence indicator with the highest average in low and medium HDI countries. The high HDI countries obtained an average of "D+", and the very high HDI countries a "C+". The highest grades for this indicator were reported in high and very high HDI countries. The correlation analysis found significant low associations between the Government indicator and the growth national income per capita (r = 0.48, p<0.005), public health expenditure (r = 0.48, p<0.005), Gini index (r = -0.45, p<0.005), Gender Inequality Index (r = -0.45, p<0.005), improved water coverage (r = 0.44, p<0.005), and distance to the equator (r = 0.31, p<0.005).

Similar to the Community and Environment indicator, a government can potentially influence the physical activity level of children and youth in multiple ways. As there is no official standardized method to evaluate this influence, the recommended benchmark for this indicator focused on evidence of leadership and commitment, allocated funds and resources, and demonstrated progress for the promotion of physical activity opportunities for all children and youth (Table 1). As a result, the grades were informed by very different types of data across countries, and the Report Card work groups did not always have access to relevant quantitative data, and therefore graded this indicator mostly based on expert opinion when required.

The low behavioral grades that were reported broadly in the Global Matrix 3.0 suggest that the government's efforts and physical activity policies are not reflected in an increase in the prevalence of MVPA among children and youth, and/or that there is an implementation gap between the strategy level (source of influence indicators) and individual level (behavioral indicators). More research is needed globally to identify the potential barriers for the engagement of children at the country and community level, in different contexts and settings.

Integrated discussion

Overall, the average grades obtained for each indicator were low, and a small variation was observed within the 10 indicators ("D" to "C"). More diversity was observed between the three HDI groupings, between the countries, and within each country. Higher behavioral grades and lower source of influence grades were generally observed in the low and medium HDI countries, while the opposite was observed for the very high HDI countries, and generally low average grades were reported for each indicator in the high HDI countries. It is important to highlight that the overall concerning levels of physical activity and sedentary behavior among children and youth may be indicative of a global crisis. Moreover, this phenomenon may get worse with the economic growth and development of low, medium and high HDI

823 countries, and very high rates of non-communicable diseases can be anticipated when the current
824 generation of children and youth reaches adulthood unless a major shift to a more active lifestyle happens
825 soon. Strategies to mitigate the projected reduction in habitual physical activity in developing countries
826 should learn from countries who have already navigated the physical activity transition.[92]

827

828 *Strengths and Limitations*

829 A major limitation of this study was the amount of missing data to inform the grades, resulting in a total
830 of 121 "INC" grades of the 490 grades in total. In addition, the great variability of the data (e.g., in terms
831 of benchmark, measurement instrument, age range, sample size, quality, quantity) that were used to
832 inform the grades was observed between the countries for each indicator, and in many cases the available
833 data did not permit the Report Card work groups to align strictly with the recommended benchmarks.
834 Furthermore, a loss of information potentially occurred when translating original prevalence data to a
835 letter grade, as letter grades provide less information than continuous variables. Consequently, all the
836 comparisons, correlations and interpretations involving the grades are limited and should be interpreted
837 with caution, as two identical grades for the same indicator can capture two very different contexts from
838 one country to another. Excluding the countries with insufficient data and imposing to assign "INC"
839 grades every time the data did not fit exactly with the benchmarks for each indicator could have been an
840 alternative strategy. But this approach would have significantly reduced the number of countries and
841 grades included in the Global Matrix 3.0 and the relevance of conducting international comparisons.
842 Despite the limitations of the underlying data, this encyclopedia of global information of the physical
843 activity of children and youth represents the richest source of such information compiled to date.

844 Another limitation of the Global Matrix 3.0 was the lack of representativeness of some areas of the world
845 and some specific child and youth populations. Indeed, the participation of a total of 49 countries or
846 nations meant that most of the countries around the world were still missing. In particular, the South

847 Pacific islands nations, where the average body mass indices for child and youth were estimated to be the
848 highest of the world,[93] are missing, as well as countries from Central Asia, and North Africa.
849 Additionally, children and youth with disabilities were not explicitly included in this analysis while the
850 Global Matrix process could help to identify and circulate best-practice strategies in terms of physical
851 activity promotion for these specific populations.[19] Furthermore, the disparities and inequities across
852 gender, socioeconomic status, or urban versus rural dwelling were mentioned in only a handful of Report
853 Card articles, thus they were not analyzed or discussed in this study.

854 The correlation analyses showed that the Overall Physical Activity grade had a low positive association
855 with Sedentary Behaviors and was not statistically related with the eight remaining indicators (Online
856 Supplementary File, S1). This can potentially be the consequence of the aforementioned limitations, but
857 another hypothesis may explain this absence of relation. The absence of statistically significant
858 correlations between Overall Physical Activity, and Organized Sport and Physical Activity, Active Play,
859 and Active Transportation, may have resulted from the fact that the physical activity dose related to these
860 indicators was not measured well. The absence of a relation between the source of influence indicators
861 and Overall Physical Activity may suggest that a favorable physical and social environment is not enough
862 to induce individual engagement in sufficient amounts of MVPA. In addition, the absence of choice (i.e.,
863 children that have no other options than using active transportation regardless of safety and any other
864 characteristics of the source of influence), child labor, and the cultural values attributed to physical
865 activity and sports were not evaluated in this study.

866 Major strengths of this work include the large number of countries who adopted the harmonized Report
867 Card development process and the quantity of data used to inform an international, comprehensive and
868 meaningful comparison of physical activity behaviors of children and youth. In addition, the AHKGA
869 facilitated and supported the development of Report Cards from 49 countries, by providing the Report
870 Card work groups from each participating country with a platform to capture, synthesize, interpret, and
871 publish the findings with autonomy. With the 49 countries participating and the 10 common indicators

872 being graded by each participating country, the Global Matrix 3.0 represents the most comprehensive and
873 meaningful comparison of the contexts of the physical activity of children and youth. In addition, the
874 identification and discussion of major trends concerning the characteristics of the physical activity of
875 children and youth among the three HDI groupings were realized for the first time.[24–26] Finally, major
876 research and surveillance gaps, including the need for the development and the international adoption of
877 standardized methods to conceptualise and measure the ten indicators, were identified and highlighted for
878 each indicator in the present paper.

879 The launch of the Global Matrix 3.0 is the result of a tremendous amount of work by the AHKGA
880 Executive Committee members and from the physical activity experts and stakeholders from all over the
881 world for the past 15 months. The 49 Report Cards were developed by supported and unsupported work
882 groups of professionals who acknowledge the importance of a healthy and active lifestyle for the present
883 and the future of the children and youth worldwide. The involvement of governmental and non-
884 governmental organizations in the development of some of the national Report Cards is a potential sign of
885 a growing interest in the childhood physical inactivity crisis; and it is hoped that this awareness will be
886 translated into support for the development of effective interventions increasing physical activity
887 opportunities for all. In addition, the development of a national Report Card of physical activity for
888 children and youth, and the participation in the Global Matrix initiative, were found to contribute to
889 raising awareness on the childhood physical inactivity issue nationally and internationally, building
890 capacity within participating countries, and potentially influencing the creation of physical activity
891 opportunities in the future.[23] It is hoped that more physical activity experts and stakeholders will rally
892 with AHKGA members to pursue and expand the Global Matrix initiative and will help filling the
893 identified gap in physical activity research and surveillance. The AHKGA, with the contribution of its
894 international network of researchers, will be available to offer guidance to the countries willing to develop
895 national surveillance of physical activity, and policies or interventions promoting physical activity among
896 children and youth.

Conclusion

A comprehensive summary of the grades, comparison and interpretation of 10 physical activity indicators among 49 countries were presented in this Global Matrix 3.0 paper. Higher behavioral grades and lower source of influence grades were generally observed in the low and medium HDI countries, while lower behavioral grades and higher source of influence grades were observed for the very high HDI countries, and generally low average grades for each indicator in the high HDI countries. International research and surveillance gaps were also identified by the Global Matrix 3.0 and the Report Card initiatives. Internationally collaborative and collective efforts are needed to redirect the persisting trend of low physical activity and high sedentary behavior among children and youth worldwide. Strategic public investments to implement effective interventions within families, communities, and schools to increase physical activity opportunities are needed. It is hoped that researchers and relevant stakeholders will collaborate internationally to address the research and surveillance gaps highlighted in this paper and expand the Global Matrix initiative to include more countries.

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1184 **Table 1: Global Matrix 3.0 indicators and benchmarks used to guide the grade assignment process**

Indicator	Benchmark
Overall Physical Activity	% of children and youth who meet the Global Recommendations on Physical Activity for Health, which recommend that children and youth accumulate at least 60 minutes of moderate- to vigorous-intensity physical activity per day on average. Or % of children and youth meeting the guidelines on at least 4 days a week (when an average cannot be estimated).
Organized Sport and Physical Activity	% of children and youth who participate in organized sport and/or physical activity programs.
Active Play	% of children and youth who engage in unstructured/unorganized active play at any intensity for more than 2 hours a day. % of children and youth who report being outdoors for more than 2 hours a day.
Active Transportation	% of children and youth who use active transportation to get to and from places (e.g., school, park, mall, friend's house).
Sedentary Behaviors	% of children and youth who meet the Canadian Sedentary Behaviour Guidelines (5- to 17-year-olds: no more than 2 hours of recreational screen time per day). Note: the Guidelines currently provide a time limit recommendation for screen-related pursuits, but not for non-screen-related pursuits.
Physical Fitness	Average percentile achieved on certain physical fitness indicators based on the normative values published by Tomkinson et al.[76]
Family and Peers	% of family members (e.g., parents, guardians) who facilitate physical activity and sport opportunities for their children (e.g., volunteering, coaching, driving, paying for membership fees and equipment). % of parents who meet the Global Recommendations on Physical Activity for Health, which recommend that adults accumulate at least 150 minutes of moderate-intensity aerobic physical activity throughout the week or do at least 75 minutes of vigorous-intensity aerobic physical activity throughout the week or an equivalent combination of moderate- and vigorous-intensity physical activity. % of family members (e.g., parents, guardians) who are physically active with their kids. % of children and youth with friends and peers who encourage and support them to be physically active. % of children and youth who encourage and support their friends and peers to be physically active.

School	% of schools with active school policies (e.g., daily PE, daily physical activity, recess, "everyone plays" approach, bike racks at school, traffic calming on school property, outdoor time). % of schools where the majority (≥ 80%) of students are taught by a PE specialist. % of schools where the majority (≥ 80%) of students are offered the mandated amount of PE (for the given state/territory/region/country). % of schools that offer physical activity opportunities (excluding PE) to the majority (> 80%) of their students. % of parents who report their children and youth have access to physical activity opportunities at school in addition to PE classes. % of schools with students who have regular access to facilities and equipment that support physical activity (e.g., gymnasium, outdoor playgrounds, sporting fields, multi-purpose space for physical activity, equipment in good condition).
Community and Environment	% of children or parents who perceive their community/municipality is doing a good job at promoting physical activity (e.g., variety, location, cost, quality). % of communities/municipalities that report they have policies promoting physical activity. % of communities/municipalities that report they have infrastructure (e.g., sidewalks, trails, paths, bike lanes) specifically geared toward promoting physical activity. % of children or parents who report having facilities, programs, parks and playgrounds available to them in their community. % of children or parents who report living in a safe neighbourhood where they can be physically active. % of children or parents who report having well-maintained facilities, parks and playgrounds in their community that are safe to use.
Government	Evidence of leadership and commitment in providing physical activity opportunities for all children and youth. Allocated funds and resources for the implementation of physical activity promotion strategies and initiatives for all children and youth. Demonstrated progress through the key stages of public policy making (i.e., policy agenda, policy formation, policy implementation, policy evaluation and decisions about the future).

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1187 **Table 2: Global Matrix 3.0 grading rubric**

Grade	Interpretation	Corresponding number for analysis
A+	94% - 100%	15
A	We are succeeding with a large majority of children and youth (87% - 93%)	14
A-	80% - 86%	13
B+	74% - 79%	12
B	We are succeeding with well over half of children and youth (67% - 73%)	11
B-	60% - 66%	10
C+	54% - 59%	9
C	We are succeeding with about half of children and youth (47% - 53%)	8
C-	40% - 46%	7
D+	34% - 39%	6
D	We are succeeding with less than half but some children and youth (27% - 33%)	5
D-	20% - 26%	4
F	We are succeeding with very few children and youth (<20%)	2
INC	Incomplete - insufficient or inadequate information to assign a grade	No Grade

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1190 **Table 3: Sociodemographic information of the 49 countries in the Global Matrix 3.0**

Country (in alphabetical order)	HDI[a]	GNI per capita (USD) [a]	Public Health Expenditure (% of GDP)[a]	GII[a]	Life expectancy at birth (years)[a]	Mean years of schooling (years)[a]	Gini index [b]	Global Food Security Index[c]	Urban Population Percentage [d]	Improved drinking water coverage (%)[d]	Population Density (people / km^2 of land area)[e]	Summer Olympic Medal Count[f]	Distance to the Equator (km)[g]
Australia	0.939	42822	6.3	0.12	82.5	13.2	34.7	83.3	89.4	100	3	497	2796
Bangladesh	0.579	3341	3.7	0.52	72	5.2	32.4	39.7	28.9	81	1252	0	2620
Belgium (Flanders)	0.896	41243	8.3	0.073	81	11.4	27.7	79.8	97.5	100	374	148	5597
Botswana	0.698	14663	5.1	0.435	71.7	11.9	60.5	59.4	62.3	96	4	1	2470
Brazil	0.754	14145	3.8	0.414	74.7	7.8	51.3	67.7	84.9	98	25	128	1574
Bulgaria	0.794	16261	4.6	0.223	74.3	10.8	37.4	62.9	73.7	100	66	218	4733
Canada	0.92	42582	7.4	0.098	82.2	13.1	34	82.2	80.8	100	4	302	6223
Chile	0.847	21665	3.9	0.322	82	9.9	47.7	74.7	89.4	96	24	13	3949
China	0.738	13345	3.1	0.164	76	7.6	42.2	63.7	51.9	91	147	546	3970
Colombia	0.727	12762	5.4	0.393	74.2	7.6	50.8	60.1	75.6	92	44	28	505
Czech Republic	0.878	28144	6.3	0.129	78.8	12.3	25.9	75.8	73.4	100	137	56	5521
Denmark	0.925	44519	9.2	0.041	80.4	12.7	28.2	80.3	87.1	100	136	194	6238
Ecuador	0.739	10536	4.5	0.391	76.1	8.3	45	55.2	68	94	66	2	202
England	0.909	37931	7.6	0.131	80.8	13.3	33.2	84.2	79.7	100	271	NA	5803
Estonia	0.865	26362	5	0.131	77	12.5	32.7	NA	69.5	98	31	34	6498
Ethiopia	0.448	1523	4.7	0.499	64.6	2.6	39.1	33.3	17.2	44	102	53	1011
Finland	0.895	38868	7.3	0.056	81	11.2	27.1	81	83.8	100	18	303	6868
France	0.897	38085	9	0.102	82.4	11.6	32.7	82.3	86.4	100	122	716	5121
Germany	0.926	45000	8.7	0.066	81.1	13.2	31.7	82.5	74.1	100	236	1346	5671
Ghana	0.579	3839	4.8	0.547	61.5	6.9	42.4	47.9	52.6	86	124	4	879
Guernsey Channel Islands*	0.975	NA	NA	NA	82.6	NA	40	NA	31.7	NA	850	NA	5481
Hong Kong	0.917	54265	NA	NA	84.2	11.6	NA	NA	100	NA	6987	3	2478
India	0.624	5663	3.9	0.53	68.3	6.3	35.1	48.9	31.6	92	445	28	2278
Japan	0.903	37268	8.6	0.116	83.7	12.5	32.1	79.5	91.9	100	348	439	4008
Jersey**	0.985	NA	NA	NA	81.9	NA	41	NA	31.7	NA	845	NA	5453
Lebanon	0.763	13312	3	0.381	79.5	8.6	31.8	NA	87.4	100	587	4	3748
Lithuania	0.848	26006	4.4	0.121	73.5	12.7	37.4	NA	67.2	92	46	25	6116
Mexico	0.762	16383	3.3	0.345	77	8.6	43.4	65.8	78.4	96	66	69	2615

Nepal	0.558	2337	5.4	0.497	70	4.1	32.8	44.5	17.3	89	202	0	3142
Netherlands	0.924	46326	9.5	0.044	81.7	11.9	29.3	82.8	83.6	100	506	285	5778
New Zealand	0.915	32870	9.1	0.158	82	12.5	NA	81	86.3	100	18	117	4530
Nigeria	0.527	5443	5.3	NA	53.1	6	43	38.4	50.3	58	204	25	1004
Poland	0.855	24117	4.5	0.137	77.6	11.9	31.8	74.1	60.8	NA	124	284	5754
Portugal	0.843	26104	6.2	0.091	81.2	8.9	35.5	79	61.6	99	113	24	4363
Qatar	0.856	129916	1.9	0.542	78.3	9.8	NA	73.3	98.9	100	221	5	2805
Scotland	0.909	37931	7.6	0.131	80.8	13.3	33.2	84.2	79.7	100	271	NA	6263
Slovenia	0.89	28664	6.6	0.053	80.6	12.1	25.4	NA	49.8	99	103	23	5113
South Africa	0.666	12087	8.5	0.394	57.7	10.3	63	64	62.4	91	46	86	3382
South Korea	0.901	34541	4	0.067	82.1	12.2	31.6	NA	83.5	98	526	267	3975
Spain	0.884	32779	6.4	0.081	82.8	9.8	36.2	78.1	77.6	100	93	150	4481
Sweden	0.913	46251	10	0.048	82.3	12.3	29.2	81.7	85.4	100	24	494	6668
Taiwan***	0.885	45582	NA	NA	80.2	NA	33.6	NA	NA	NA	NA	24	2622
Thailand	0.74	14519	5.6	0.366	74.6	7.9	37.8	58.3	34.4	96	135	33	1755
United Arab Emirates	0.84	66203	2.6	0.232	77.1	9.5	NA	70.9	84.7	100	111	2	2592
United States	0.92	53245	8.3	0.203	79.2	13.2	41.5	84.6	82.6	99	35	2522	4107
Uruguay	0.795	19148	6.1	0.284	77.4	8.6	39.7	69.7	92.6	100	20	10	3600
Venezuela	0.767	15129	1.5	0.461	74.4	9.4	46.9	50.2	93.7	93	36	15	710
Wales	0.909	37931	7.6	0.131	80.8	13.3	33.2	84.2	79.7	100	271	NA	5778
Zimbabwe	0.516	1588	NA	0.54	59.2	7.7	43.2	NA	39.1	80	42	8	2103

Note: HDI = Human Development Index, GNI = Gross National Income, GDP = Gross Domestic Product, GII = Gender Inequality Index, NA= not available. Sources of information: a., United Nations Development Programme;[21] b. and e., the World Bank;[94,95] c., the Economist Intelligence Unit;[96] d., United Nations, Department of Economic and Social Affairs,[97] f., the Wikimedia Foundation,[98] and g., the distance to the Equator was calculated from the latitude and longitude from *Latlong.net*.[99] * For Guernsey, the HDI sourced from the United Nations Economic and Social Commission for Asia and the Pacific,[100] the life expectancy at birth, population size, and the population density sourced from the United States Central Intelligence Agency,[101] and the Gini index sourced from the State of Guernsey.[102]

1199 **For Jersey, the HDI sourced from[100], the life expectancy at birth, population size, and the population
1200 density sourced from the United States Central Intelligence Agency,[101] and the Gini index sourced from
1201 the State of Jersey.[103] ***For Taiwan, the HDI, the GNI per Capita, the life expectancy at birth and the
1202 Gini index come from the National Statistics, Republic of China (Taiwan).[104] For England, Scotland, and
1203 Wales, the official data for UK were reported.

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Table 4: Grades assigned to the 10 core physical activity indicators for the 49 countries of the Global Matrix 3.0

	PA	SP	AP	AT	SB	PF	FAM	SCH	COM	GOV	AVG
Australia	D-	B-	INC	D+	D-	D+	C+	B+	A-	D	C-
Bangladesh	C-	INC	INC	C-	A-	INC	INC	INC	INC	C-	C
Belgium (Flanders)	F	B	INC	C+	C	INC	C+	B-	B	B	C
Botswana	INC	INC	D-	C	B-	INC	INC	C-	INC	C	C-
Brazil	D	C+	D+	C	D-	D	C-	C	C-	D+	D+
Bulgaria	D+	C+	C+	B-	D	INC	D	C	C	INC	C-
Canada	D+	B+	D	D-	D+	D	C+	B-	B+	C+	C-
Chile	D-	D-	INC	F	C-	D	F	D	B	B-	D
China	F	D-	D+	C+	F	D	D+	D+	F	F	D-
Colombia	D+	C	INC	B	D+	D-	INC	D	B-	B	C-
Czech Republic	D	B-	D-	C+	D-	C+	C+	B+	B	C+	C
Denmark	D-	A-	INC	B+	D+	INC	INC	A-	B+	A-	B-
Ecuador	D	INC	INC	C-	C	INC	F	INC	D+	INC	D
England	C-	D+	INC	C-	D+	C-	INC	B+	C	INC	C-
Estonia	D-	C	F	D	F	INC	D	C+	B	B	D+
Ethiopia	D	C	B	C	F	INC	F	D	F	D	D
Finland	D	C+	C	B+	D-	C	B-	A	B+	A-	C+
France	D	C-	INC	C-	D-	B-	INC	B	INC	C	C-
Germany	D-	B	D-	C-	D-	INC	B-	B+	B+	INC	C
Ghana	C	C+	B-	C+	INC	INC	F	D	D+	D	D+
Guernsey	D	C+	INC	D	C	INC	INC	INC	INC	D	D+
Hong Kong	C-	C	INC	B+	C-	D	D-	C	B	C	C-
India	D	INC	C-	B-	C-	F	D	INC	D	D	D
Japan	INC	B-	INC	A-	C-	A	C-	B+	B-	B	B-
Jersey	D-	INC	INC	D+	C	D	C	B-	C	D	D+
Lebanon	D	F	INC	D	C-	INC	INC	D	INC	C+	D

Lithuania	C-	C	INC	C-	C-	C+	D	C+	C	C	C-
Mexico	D+	C	INC	C+	D-	INC	INC	D+	D+	C	D+
Nepal	D+	INC	INC	A-	B+	INC	A	INC	C-	INC	B-
Netherlands	C	B	B	B-	C-	INC	INC	C	INC	INC	C+
New Zealand	D-	B	C+	C-	D	INC	C-	B-	B	B+	C
Nigeria	C	C-	C	B	B-	INC	INC	C-	INC	B	C
Poland	D-	D	INC	C	D	C-	C-	B	C	C+	C-
Portugal	D	B-	INC	C-	C-	C	C	A	B	B	C+
Qatar	D	D+	INC	N/A	D+	INC	INC	C	INC	B+	C-
Scotland	F	B	INC	C	F	INC	INC	INC	B-	C	D+
Slovenia	A-	C+	D	C	B+	A-	B+	A	B	A	B
South Africa	C	D	INC	C	INC	INC	C-	D-	C-	C	D+
South Korea	F	C	INC	B+	D	D+	INC	D+	INC	D	D+
Spain	D	B	C-	B-	B+	INC	INC	C+	INC	INC	C+
Sweden	D+	B+	INC	C	C+	INC	INC	C+	A	B	C+
Taiwan	F	D-	INC	C-	C-	B-	INC	B+	B+	B+	C
Thailand	D-	C-	F	C	D-	INC	B	B	B-	B+	C-
United Arab Emirates	F	INC	INC	INC	C-	INC	INC	D-	INC	B+	D+
United States	D-	C	INC	D-	D	C-	INC	D-	C	INC	D
Uruguay	D	F	INC	C	C-	C-	INC	C-	INC	D	D
Venezuela	D	D	INC	B-	INC	INC	INC	INC	D-	F	D
Wales	D+	C+	C-	D+	F	INC	D	INC	INC	C+	D+
Zimbabwe	C+	B	D+	A-	B	INC	INC	C	D	C-	C

Note: PA = Physical Activity, SP = Organized Sport and Physical Activity, AP = Active Play, AT = Active Transportation, SB = Sedentary Behaviors, PF = Physical Fitness, FAM = Family and Peers, SCH = School, COM = Community and Environment, GOV = Government, AVG = Average, INC = incomplete grade, and N/A = not applicable.

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Table 5: Descriptive statistics of the grades by indicator and groups of indicators for the 49 countries of the Global Matrix 3.0

	Grade count	Incomplete grades	Mean number grade	SD	Mean letter grade
Overall Physical Activity	47	2	5.2	2.1	D
Organized Sport and Physical Activity	42	7	8.2	2.7	C
Active Play	20	29	6.5	2.7	D+
Active Transportation	47	2	8.3	2.5	C
Sedentary Behaviors	46	3	6.4	2.8	D+
Physical Fitness	22	27	7.1	2.9	C-
Family and Peers	27	22	7.0	3.1	D+
School	41	8	8.8	3.0	C
Community and Environment	36	13	8.9	3.0	C
Government	41	8	8.6	3.1	C
Behavioral indicators	49	0	7.0	1.6	C-
Sources of influence indicators	49	0	8.3	2.5	C
All indicators	49	0	7.5	1.6	C-

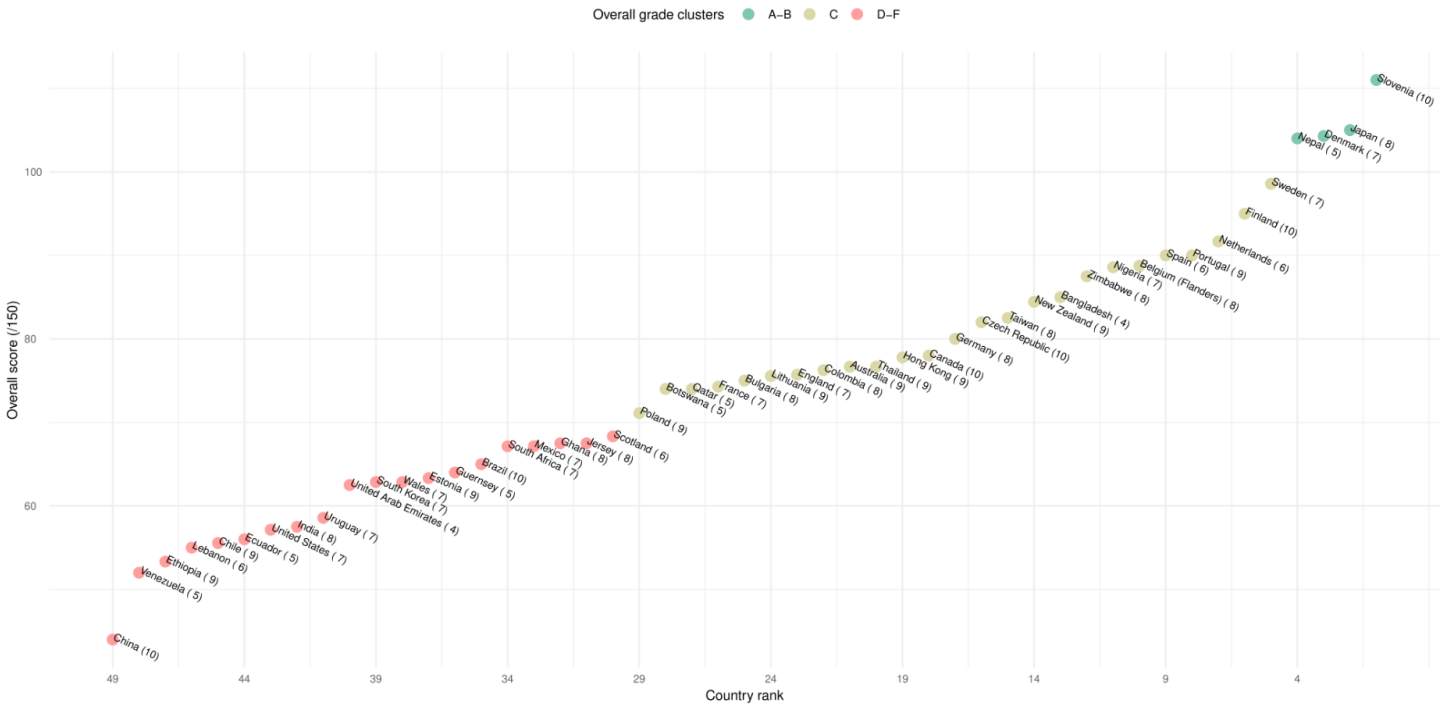
Note: Behavioral indicators = Average of Overall Physical Activity, Organized Sport and Physical Activity, Active Play, Active Transportation, Sedentary Behavior indicator grades; Source of influence indicators = Average of Family and Peers, School, Community and Environment, and Government indicator grades. Physical Fitness was not included in the behavioral indicators cluster. There are no missing grades for the bottom three rows because these scores are adjusted for missing grades.

Table 6: Average grades by indicator and group of indicators for the three HDI categories (low and medium, high, and very high)

	Low and medium HDI	High HDI	Very high HDI
Overall Physical Activity	C-	D-	D-
Organized Sport and Physical Activity	C	D+	C+
Active Play	C-	D	D+
Active Transportation	C+	C	C-
Sedentary Behaviors	C+	D	D+
Physical Fitness	F	D	C-
Family and Peers	D+	D+	C-
School	D+	C-	C+
Community and Environment	D	D+	B-
Government	C-	D+	C+
Behavioral indicators	C	D+	D+
Sources of influence indicators	D+	D+	C+
All indicators	C-	D+	C-

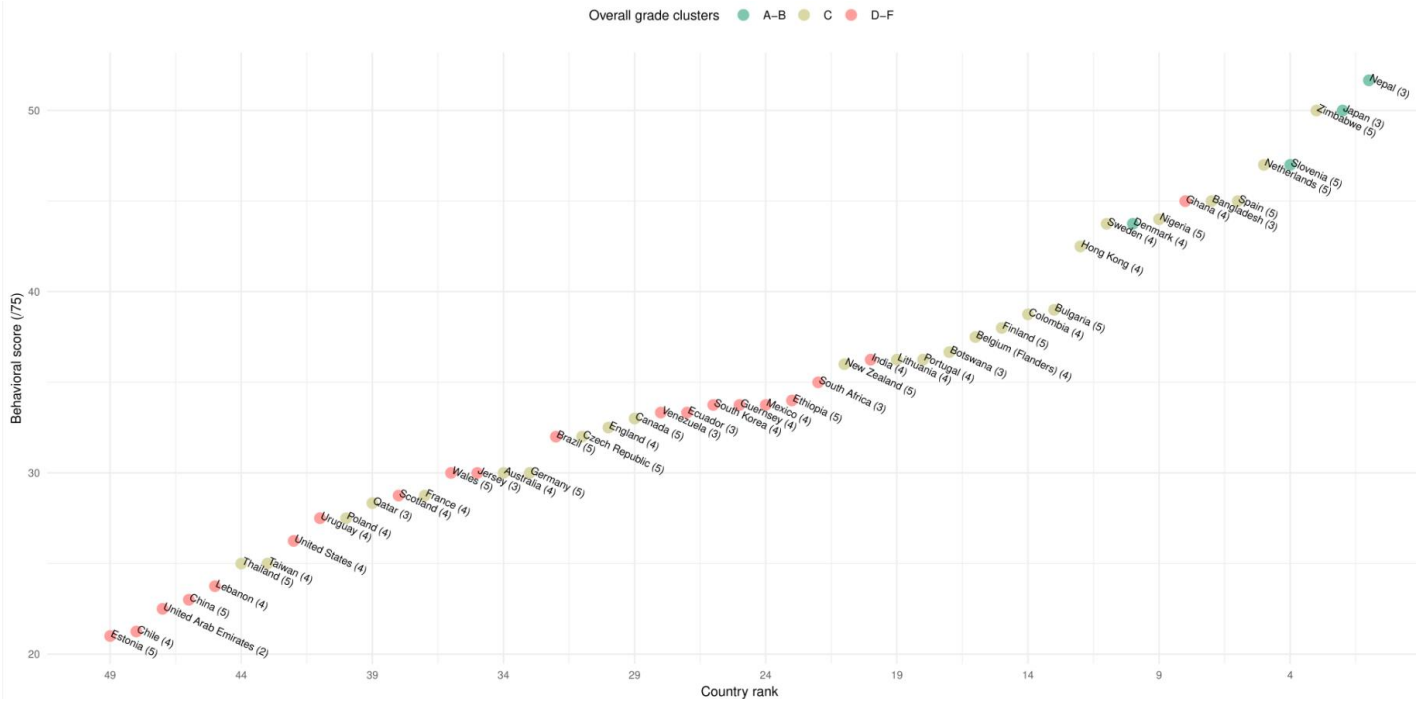
Note: HDI = Human development index; Behavioral indicators = Average of Overall Physical Activity, Organized Sport and Physical Activity, Active Play, Active Transportation, Sedentary Behavior indicator grades; Source of influence indicators = Average of Family and Peers, School, Community and Environment, and Government indicator grades. Physical Fitness was not included in the behavioral indicators cluster. There are no missing grades for the bottom three rows because these scores are adjusted for missing grades.

Figure 1: Plot of the overall score estimated for the 10 core indicators for the 49 countries of the Global Matrix 3.0



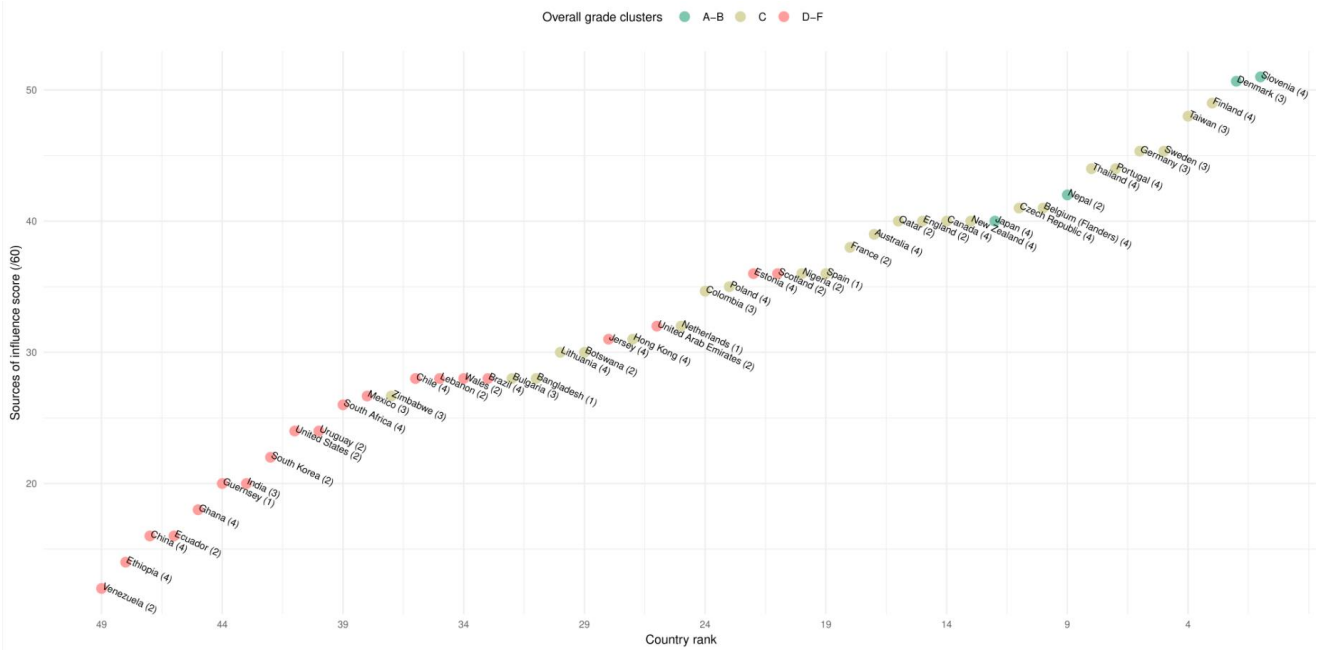
Note: The overall score was adjusted for missing and incomplete grades. The number in parenthesis shows the number of grades available for the calculation of the score.

Figure 2: Plot of the behavioral score estimated for the 49 countries of the Global Matrix 3.0



Note: The behavioral score was adjusted for missing and incomplete grades. The number in parenthesis shows the number of grades available for the calculation of the score.

Figure 3: Plot of the source of influence indicators score for the 49 countries of the Global Matrix 3.0



Note: The source of influence score was adjusted for missing and incomplete grades. The number in parenthesis shows the number of grades available for the calculation of the score. These estimates of sources of influence score are interpreted with a high degree of caution as they are likely imprecise estimates of sources of influence due to the level of missing data used to determine this score.