



Global Matrix 2.0: Report Card Grades on the Physical Activity of Children and Youth Comparing 38 Countries

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Global Matrix 2.0: Report Card Grades on the Physical Activity of Children and Youth
Comparing 38 Countries

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Abstract

The Active Healthy Kids Global Alliance organized the concurrent preparation of Report Cards on the physical activity of children and youth in 38 countries from six continents (representing 60% of the world's population). Nine common indicators were used (Overall Physical Activity, Organized Sport Participation, Active Play, Active Transportation, Sedentary Behaviour, Family and Peers, School, Community and the Built Environment, and Government Strategies and Investments) and all Report Cards were generated through a harmonized development process and a standardized grading framework (from "A" = excellent to "F" = failing). The 38 Report Cards were presented at the *International Congress on Physical Activity and Public Health* in Bangkok, Thailand on November 16, 2016. The consolidated findings are summarized in the form of a Global Matrix demonstrating substantial variation in grades both within and across countries. Countries that lead in certain indicators often lag in others. Average grades for both Overall Physical Activity and Sedentary Behaviour around the world are "D" (low/poor). In contrast, the average grade for indicators related to supports for physical activity was "C". Lower income countries generally had better grades on Overall Physical Activity, Active Transportation and Sedentary Behaviours compared to higher income countries, yet worse grades for supports from Family and Peers, Community and the Built Environment, and Government Strategies and Investments. Average grades for all indicators combined were highest (best) in Denmark, Slovenia and the Netherlands. Many surveillance and research gaps were apparent, especially for the Active Play and Family and Peers indicators. International cooperation and cross-fertilization is encouraged to address existing challenges, understand underlying determinants, conceive innovative solutions and mitigate the global childhood inactivity crisis. The paradox of higher physical activity and lower sedentary behaviour in countries reporting poorer infrastructure, and lower physical activity and higher sedentary behaviour in countries reporting better infrastructure suggests that autonomy to play and/or fewer attractive sedentary pursuits, rather than infrastructure and structured activities may facilitate higher levels of physical activity.

Key words: international, play, policy, sedentary behaviour, sport, active transportation

Introduction

Recent systematic reviews confirm the extensive health benefits of regular physical activity for school-aged children and youth,¹ as well as the harmful effects of excessive or uninterrupted sedentary behaviour, especially screen time.^{2,3} Recent reports reinforce global public health concerns related to physical inactivity⁴⁻⁸ resulting in calls for more comprehensive, coordinated, and sustained efforts.^{4,5,9} Yet global efforts to increase physical activity and decrease sedentary behaviours have been underway for years and progress has remained elusive.¹⁰ For example, trends over the past 12 years from the Canadian Report Card on Physical Activity for Children and Youth show a general improvement in structures and supports for physical activity, yet no commensurate improvement in physical activity behaviours.¹¹ The general lack of progress may be related to insufficient effort or investment; lack of or poorly implemented policies, programs and practices; an inadequate period of sustained effort; and/or there may be a mismatch between strategies and requirements for systemic behavioural change.

The development and release of report cards on physical activity for children and youth have been used in many countries for advocacy and social mobilization to get kids moving by influencing perceptions, priorities, policies and practices.¹²⁻¹⁴ In 2014, 15 countries produced and released Report Cards following a harmonized process, resulting in a *Global Matrix of Grades*.¹⁵ This cross-country comparison model produced provocative findings showing that lower levels of structure, strategies and investments to promote physical activity for children and youth were actually related to higher levels of overall physical activity challenging the conventional thinking “if you build it they will come”.¹⁵ This paradoxical finding suggests a “one size fits all” approach, or one informed only by evidence from high-income countries (HIC), or by conventional dogma, may need to be challenged or reconsidered.

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3 The relationship between household income and child physical activity shows
4 considerable between-country variation with a positive correlation observed in high income
5 countries and a negative correlation generally observed in lower income countries.^{7,15} Similar
6 interactions have been observed with childhood obesity levels¹⁶ and physical activity levels in
7 adults.¹⁷ These findings are consistent with the constructs of the epidemiological, nutrition and
8 physical activity transitions.^{18,19,20} Furthermore, country-level factors, such as per capita income,
9 income inequality, and Human Development Index (HDI, [http://hdr.undp.org/en/content/human-](http://hdr.undp.org/en/content/human-development-index-hdi)
10 [development-index-hdi](http://hdr.undp.org/en/content/human-development-index-hdi)) have been shown to be related to levels of childhood physical activity
11 in different ways in different countries.^{7,21,22}

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24 With escalating interest in global solutions to current childhood inactivity and obesity
25 levels,^{4,6,10} it is responsible and pragmatic to reflect on the universality of proposed solutions
26 and shared experiences to such pandemics. Indeed, the various sources of evidence cited
27 above suggest the success of a universal “one-size-fits-all” approach may be limited.
28 Furthermore, given the lack of progress resulting from purported solutions,¹⁰ perhaps a revisiting
29 of such approaches, with evidence across multiple cultures, countries and geographies, is
30 warranted.

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41 The *Global Matrix of Grades* cited previously¹⁵ was a pilot effort in this regard; however,
42 it was recognized that this initial effort was limited by the relatively small number of participating
43 countries. Building on the success of the *Global Matrix 1.0* in 2014¹⁵ the lead investigators from
44 each country committed to repeating and further developing the Global Matrix initiative.¹⁶
45 Accordingly, the *Global Matrix 2.0* project was initiated.²³ The purposes of this paper are to
46 describe the *Global Matrix 2.0* project, consolidate findings from participating countries, analyse
47 global variations, discuss areas in which countries are leading and lagging and explore why,
48 and provide lessons learned from the project in the form of recommendations for improving the
49 grades in all countries.

Methods

In July of 2014 the Active Healthy Kids Global Alliance distributed an open call through established networks for interested countries to participate in the *Global Matrix 2.0* project. Countries were required to register their interest by the deadline of October 2015, and pay a modest participation fee (US \$500) to cover costs associated with the project. Forty countries from six continents responded and 38 fully participated in the *Global Matrix 2.0*. Each participating country was assigned a mentor who had participated in the *Global Matrix 1.0* to guide them, ensure adherence to the harmonized processes,¹² and make sure they stayed on schedule.

Similar to the *Global Matrix 1.0*,¹⁵ all countries gathered the best and most recent available evidence or, in some cases, data were collected prospectively, and reported on nine common indicators (*Behaviours*: Overall Physical Activity, Organized Sport Participation, Active Play, Active Transportation, Sedentary Behaviour; *Sources of influence*: Family and Peers, School, Community and the Built Environment, and *Government Strategies and Investments*). Writing groups employed a rigorous and transparent process for information and data gathering, to synthesize findings and reach consensus, and followed a harmonized Report Card development process. Each country engaged a diverse set of national experts from multiple sectors related to physical activity, and adhered to a standardized grading framework. Full details of the Report Card development process have been previously described.^{12,13,15} The Report Card was designed as a knowledge synthesis, translation and mobilization instrument serving as an advocacy mechanism to drive social action by stimulating debate, motivating policy, practice, action and inspiring change.^{12,13,15} Consequently, some countries added other indicators to their Report Cards (e.g., obesity, physical fitness, movement skills, nongovernment strategies and investments) beyond the nine common indicators. In two cases, common indicators were not graded (Qatar, Active Transportation; Scotland, School). Details of the

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3 process, data availability, and involvement of experts in each country are described in this issue
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5 of the *Journal of Physical Activity and Health*.²⁴⁻⁶⁰ Central to the process in each country was the
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7 gathering of the best available evidence, interpretation by the expert committee formed, and
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9 transparent reporting.
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13 The grading framework and benchmarks used are provided in Tables 1 and 2. While the
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15 quality and quantity of data and evidence available in each country varied substantially,
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17 countries were advised to consider and synthesize the best available evidence for each
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19 indicator. This is the same process employed for the *Global Matrix 1.0*. The expert committee,
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21 comprised of different stakeholders, in each country discussed the total evidence base, added
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23 their expert opinion, and reached consensus on the grade assigned for each indicator. The
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25 rationale for each assigned grade is provided in the respective country papers.²⁴⁻⁶⁰ Despite
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27 variation in country data sources it is believed that the grades across all indicators provide a
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29 basis for comparison, and are informative of global variation in these indicators related to the
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31 physical activity of children and youth.
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36 Each country packaged their findings in a short-form highlight Report Card and/or long-
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38 form Report Card that provided substantiation of the grades and full data source information, as
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40 well as a list of expert committee members. Countries developed a “cover story” based on
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42 important themes in their Report Card findings, to help market the Report Card, its findings, and
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44 recommendations. Illustrations of the cover story from each country are provided in the country-
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46 specific papers.²⁴⁻⁶⁰ Complete copies of each country’s Report Cards are available at
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48 www.activehealthykids.org. The *Global Matrix 2.0* findings and each country’s Report Card were
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50 presented at the *International Congress on Physical Activity and Public Health* in Bangkok,
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52 Thailand in November, 2016.
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In addition to descriptive presentation and narrative interpretation of results within and between countries, quantitative analyses were also performed. A correlational analysis was performed to determine the extent to which report card grades were related to several global descriptors and demographic indices, including: the HDI (2014 data calculated from life expectancy at birth, mean and expected years of schooling, gross national income per capita; greater scores represent greater human development),⁶¹ the GINI Index (1995-2013 data calculated from distribution of income; greater scores represent greater income inequality),⁶² the Gender Inequality Index (2014 data calculated from maternal mortality ratio and adolescent birth rates, proportion of parliamentary seats occupied by females and proportion of adult females and males aged 25 years and older with at least some secondary education, labour force participation rate of female and male populations aged 15 years and older; greater scores represent greater gender inequality),^{63,64} the Global Food Security Index (2016 data calculated from measures of affordability, availability, quality and safety; greater scores represent greater food security),⁶⁵ summer Olympic medal count (indicator of sporting success; 1896-2016 data)⁶⁶ and distance from the Equator (broad indicator of climate/weather/temperature/seasonal variations; calculated from the geographic center of each country⁶⁷ using a latitude/longitude distance calculator).⁶⁸ England, Scotland and Wales were grouped together for this analysis because these indices had data for Great Britain only and not the individual countries.

All report card letter grades were converted to numeric ordinal scores (“A” = 5, “B” = 4, “C” = 3, “D” = 2, “F” = 1). For simplicity, signed letter grades were treated as non-signed letter grades (e.g., “A+”, “A-“, “A” = 5) for the conversion. The arithmetic mean (overall Report Card grade) was calculated for each country by summing the ordinal scores for all nine common indicators and dividing by the number of ordinal scores. The behaviour grade and the sources of influence grade were calculated similar to the overall Report Card grade but with the ordinal scores limited to the first five (Overall Physical Activity, Organized Sport Participation, Active

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3 Play, Active Transportation, Sedentary Behaviour) and last four (Family and Peers, School,
4 Community and the Built Environment, and Government Strategies and Investments) common
5 indicators respectively. Due to the ordinal nature of the grade data, Spearman's rank correlation
6 coefficients were calculated. Statistical significance tests were also performed on these
7 coefficients and α was adjusted for multiple comparisons ($0.05/18 = 0.003$). All correlation and
8 significance tests were performed using R version 3.3.0 (Vienna: The R Foundation for
9 Statistical Computing Platform).

19 Results

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23 Figure 1 depicts the global dispersion of the countries participating in the *Global Matrix*
24 *2.0*. The 38 participating countries represent approximately 20% of the countries in the world
25 (including all inhabited continents), 40% of the world's land mass, 60% of the world's population,
26 and >150% increase in participating countries compared to the *Global Matrix 1.0*.²³

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33 The consolidated findings are summarized in the form of a Global Matrix, which
34 demonstrates substantial variation in grades both within and across countries (Table 3). The
35 *Global Matrix 2.0* results are presented in different formats to facilitate interpretation. Table 3
36 presents the *Global Matrix 2.0* with grades organized by country, listed alphabetically within
37 continents. Table 4 presents the countries organized hierarchically by grade for each indicator.
38 These tables show a large spread in grades across countries (Overall Physical Activity "F" to "A-"
39 "; Organized Sport Participation "F" to "A"; Active Play "F" to "B"; Active Transportation "F" to
40 "A"; Sedentary Behaviours "F" to "B+"; Family and Peers "F" to "B"; School "D-" to "A";
41 Community and the Built Environment "F" to "A"; Government Strategies and Investments "F" to
42 "A-") and that most countries are having both successes and challenges. Several countries had
43 inadequate information to assign a grade ("INC"), most notably for Active Play (21 countries)

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3 and Family and Peers (17 countries). Venezuela was the most evidence-limited country,
4 reporting “INC” grades for 6 of 9 indicators.
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9 The findings showed that on average the grades were low (“D”) for Overall Physical
10 Activity, Active Play, and Sedentary Behaviour (Table 3). The grades for sources of influence
11 were generally higher than the behaviour grades. The Community and the Built Environment
12 indicator had the highest overall grade, though 12 countries reported “INC”. Overall behaviour
13 grades (Overall Physical Activity, Organized Sport Participation, Active Play, Active
14 Transportation, Sedentary Behaviour) were lower in participating Asian, North American and
15 South American countries compared to countries from the other continents. Average grades
16 across all indicators were highest in Denmark,³¹ Slovenia⁵¹ and the Netherlands.⁴⁴ Sixteen
17 countries reported at least one “F” grade and 30 countries reported at least one “D” grade. In
18 contrast, only six countries reported at least one “A” grade.
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32 Results of the correlational analysis of grades according to several global descriptors
33 and demographic indices are presented in Table 5. No significant relationships were observed
34 with Overall Behaviour grades. For the Sources of Influence grades, strong positive
35 relationships were observed with HDI⁶¹ and Global Food Security Index⁶⁵ while strong negative
36 relationships were observed with the GINI Index⁶² and Gender Inequality Index.^{63,64} A significant
37 positive relationship with distance from the equator^{67,68} was also observed. No significant
38 relationship between grades and summer Olympic medal count⁶⁶ was observed, although it did
39 show a rather strong positive correlation with Sources of Influence grades.
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50 The Community and the Built Environment indicator received high grades in HIC and
51 lower grades in lower-income countries. There was a pattern of higher Overall Physical Activity
52 in countries reporting poorer infrastructure (i.e., grades on Sources of Influence), and lower
53 Overall Physical Activity in countries reporting better infrastructure. Similarly, some countries
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3 have relatively high grades for the policy environment but relatively low grades for the health
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5 behaviour indicators the policies are targeting (for countries with “A” or “B” grades for
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7 Government Strategies and Investments Spearman’s rho (Overall Physical Activity ~
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9 Government grade) = -0.17, $p = 0.58$).

11 12 13 **Discussion**

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17 The findings from this paper represent the richest and most diverse comparison of
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19 physical activity related indicators for children and youth assembled to date, involving 38
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21 countries from six continents. The wide range of grades observed, from “A” to “F” for most
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23 indicators, demonstrates that success is possible, at least for some countries. This reality
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25 provides for creative and innovative learning opportunities across countries and reinforces,
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27 while extending, the learning gained from the *Global Matrix 1.0*.¹⁵ Because of the substantial
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29 variation in grades, the global matrix provides a useful framework for consolidating and
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31 assessing the best available evidence aimed at understanding differences between and within
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33 countries. From Tables 3 and 4 it is clear that no one country is leading or lagging in all
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35 indicators but, rather, each country has a blend of successes and challenges.²⁴⁻⁶⁰ Not
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37 surprisingly, the wide distribution of grades results in global average grades for all indicators
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39 being “D” or “C”. The evidence contained in the *Global Matrix 2.0* shows that the challenge of
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41 enhancing physical activity behaviours and opportunities for children and youth around the
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43 world remains unresolved, and tackling this challenge together may provide unique insights,
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45 motivation and synergy that could not be achieved in isolation.

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49 The overall findings from the *Global Matrix 2.0* showed that on average the grades were
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51 low for Overall Physical Activity, Active Play, and Sedentary Behaviour reinforcing the global
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53 concern about childhood physical activity levels.^{15,69} Similar to the *Global Matrix 1.0*, the grades
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55 for sources of influence were generally higher than the behaviours they aim to influence,
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3 suggesting that “making the healthy choice the easy choice” through environmental and policy
4 supports has a substantial latent period before the influence is translated into behaviour change,
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6 or it is not as strong a behaviour driver as generally believed.
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11 While there are successes and challenges across countries, the grades for Denmark,³¹
12 the Netherlands,⁴⁴ and Slovenia⁵¹ generally showed greater success. In these countries there is
13 both a well-developed infrastructure and policy support network for healthy active living as well
14 as individual commitment to habitual physical activity embedded in all aspects of life (e.g.,
15 recreation, play, transportation, school).
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23 The Danish Report Card illustrates that despite a high priority at a governmental level to
24 facilitate physical activity and many strategies to promote physical activity, a large proportion of
25 Danish children seem not to comply with the recommendation for physical activity. This
26 highlights, that even if a country performs very well at the strategic and political level, the impact
27 at the individual level is not assured. There is a gap between the governmental level and the
28 individual level that needs to be bridged to increase physical activity and decrease sedentary
29 behaviour in children. So despite the relatively high average grade across all indicators, the
30 grade that is most coveted, Overall Physical Activity, remains below desired levels.
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41 In the Netherlands, every city or village has an extensive layout of cycle paths and
42 routes. In many urban areas separate cycle paths are not uncommon. Further, there is a high
43 percentage of bike ownership, 84% of the Dutch inhabitants from age 4 years and older own a
44 bicycle.⁴⁴ Furthermore, many municipalities are promoting bike use and are banning cars from
45 the inner cities. However, despite robust policies and infrastructure, these supports are not
46 sufficient to score highly on overall physical activity.⁴⁴
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3 In Slovenia, physical activity in children is closely monitored within the school system.
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5 Every April, the majority of Slovenian children and youth (aged 6-19 y) are included in nation-
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7 wide, school-based physical fitness measurements; this initiative is called SLOfit– the Sport
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9 Educational Chart programme. SLOfit is obligatory for all Slovenian primary and secondary
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11 schools across the country. For more than 30 years, this system has given teachers,
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13 researchers, and policy-makers access to high-quality, standardized data on physical fitness,
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15 which in turn, allows for relatively responsive evidence-based policy adjustments when needed.
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17 For example, based on more recent evidence of declining physical fitness from the SLOfit
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19 database, Slovenia introduced a health-oriented physical activity intervention program called
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21 Healthy Lifestyle in the school year 2010/2011, offering children two optional, additional hours of
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23 physical activity per week. Healthy Lifestyle is considered part of a school’s regular
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25 extracurricular health-oriented physical activity program. This project currently includes more
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27 than 30% of the entire primary-school population. Before this initiative, Slovenian kids had been
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29 experiencing negative trends in motor and physical fitness for over two decades, but since
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31 2011, physical fitness in 6 to 14 year-olds has been steadily improving.⁷⁰
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37 **Successes and Challenges Based on Indicator Grades**

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39 Findings for each of the nine common indicators are discussed further in sub-sections
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41 below.
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45 *Overall Physical Activity*

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48 Slovenia reported the highest grade (“A-”)⁵¹ for Overall Physical Activity while 20
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50 countries reported low (“D”) and seven countries failing (“F”) grades, suggesting there is
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52 widespread evidence of a childhood physical inactivity crisis. One country (Japan) assigned an
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54 “INC” grade.³⁹ The high grade achieved in Slovenia is attributed to highly developed and
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3 apparently effective structured physical activity opportunities through school physical education
4 and structured sport opportunities both in school and in the community.⁵¹ The low grades in
5 most countries are consistent with earlier reports.^{7,15,69} Grades were generally higher in low-
6 middle income countries (LMIC; Brazil,²⁶ India,³⁷ Kenya,⁴⁰ Mexico,⁴² Mozambique,⁴³ Nigeria,⁴⁶
7 South Africa,⁵² Zimbabwe⁶⁰) but this relationship was not uniform as Slovenia⁵¹ and New
8 Zealand⁴⁵ also reported high grades and no significant correlation between HDI and overall
9 behaviour grades was observed (Table 5).
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20 Caution needs to be employed when interpreting direct comparisons among countries
21 because of significant variation in sampling and measurement procedures among countries.
22 Despite these well-described limitations^{71,72} some insights can be drawn from the variations
23 observed in global physical activity levels. The lower overall behaviour grades reported by
24 Asian, North American and South American countries compared to countries from the other
25 continents is consistent with a recent report of variations in the cardiorespiratory fitness levels of
26 children and youth across 50 countries.⁷³ The best performing countries on the 20 meter shuttle
27 run were from Africa and Northern Europe while countries from South America were
28 consistently among the worst performing countries.⁷³ The Report Card overall grades showed
29 negative relationships with GINI Index (country-specific income inequality)⁶² and Gender
30 Inequality Index^{63,64} indicating that greater inequality is associated with lower grades. A similar
31 pattern was observed with the 20 meter shuttle run performances reported by Lang et al.⁷³ The
32 pattern of variability observed in the Overall Physical Activity grades is broadly consistent with
33 the theory of an epidemiological¹⁸ and physical activity transition.¹⁹ A systematic review of data
34 from Sub-Saharan African school-aged children by Muthuri et al.⁷⁴ found inverse associations
35 between physical activity and fitness, and urban living and higher socioeconomic status,
36 suggesting that economic development may be related to reduced healthy active lifestyles and
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3 fitness. Nevertheless, the success achieved in Slovenia suggests that behavioural changes
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5 associated with such transitions are not inevitable.
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8 9 *Organized Sport Participation*

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12 The average grade for Organized Sport Participation was a “C”, the highest average
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14 grade for any of the behaviour indicators. Denmark had the highest grade (“A”)³¹ and nine
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16 countries had grades of “B” or higher. Only seven countries reported grades of “D” or “F”, and
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18 seven countries reported “INC” grades. Nine out of the top 10 grades for this indicator were from
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20 HIC while the only two “F” grades were from LMIC. The average grade of “C” indicates that
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22 approximately half of children and youth report participating in sport.
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27 Grades for Organized Sport Participation seem positively related to grades on the
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29 School and Community and the Built Environment indicators (e.g., countries with good grades
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31 for Organized Sport Participation also reported relatively good grades for School and
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33 Community and the Built Environment (e.g., Australia,²⁴ Canada,²⁷ Denmark,³¹ the
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35 Netherlands,⁴⁴ Sweden⁵⁵), whereas countries with low grades for Organized Sport Participation
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37 often reported low grades for School and Community and the Built Environment (e.g., Chile,²⁸
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39 Mexico,⁴² Mozambique⁴³). This relationship was significant (Spearman’s rho for Organized Sport
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41 Participation grade ~ School + Community and Environment grades = 0.42, p = 0.02) and is not
42
43 surprising considering that organized sport opportunities require space, facilities, equipment,
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45 programs, safety precautions and supervision. While most countries assigned grades for
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47 Organized Sport Participation, details of the quality, frequency, duration, intensity, context (e.g.,
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49 physical education, extra-curricular, community sport) and seasonality of participation varied
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51 significantly and/or were generally lacking.
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55 56 *Active Play*

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3 No countries reported a grade of “A” for Active Play; the highest grade was “B” (Ghana,³⁵
4 Kenya,⁴⁰ the Netherlands⁴⁴). Eight countries reported low grades (“D” or “F”). Notably, 21
5
6 countries reported “INC” grades, identifying the need for greater clarity on the definition and
7
8 benchmarks, and subsequent surveillance of this important indicator. One problem often cited
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10 was the lack of valid and reliable measurement methodologies and instruments to accurately
11
12 quantify Active Play; consensus is required on a definition for Active Play and how to measure
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14 it. No clear pattern of country characteristics associated with high or low grades emerged.
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19 The 2015 ParticipACTION Report Card from Canada focused on active outdoor play⁷⁵
20 and included a *Position Statement on Active Outdoor Play* developed by several organizations
21 in Canada and informed by two systematic reviews.⁷⁶⁻⁷⁸ The benefits of active outdoor play
22 (defined as freely chosen, spontaneous and self-directed physical activity involving an element
23 of fun done in the outdoors) are diverse, substantial and substantiated.⁷⁶ Indeed, the trend --
24 especially in HIC – is towards greater indoor time, which the *Position Statement* argues is in fact
25 a greater risk than the outdoors, because of the greater likelihood of low physical activity, high
26 sedentary behaviour, relatively higher risk of contact with cyber-predators, greater incidental
27 eating, exposure to toxins in indoor air, among other factors.⁷⁶ A recent report demonstrated
28 that each additional hour spent outdoors is associated with seven additional minutes of
29 moderate- to vigorous-intensity physical activity (MVPA) and 13 less minutes of sedentary time,
30 as well as lower odds of negative psychosocial outcomes, among 7-14 year-old Canadian
31 children.⁷⁹ Active play, especially in the outdoors, seems to be increasingly replaced by use of
32 electronic screens for entertainment, used almost always indoors.^{75,76} This trend makes the
33 careful monitoring and surveillance of active play important for guiding future strategies and
34 interventions.
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55 Much active play is likely light-intensity physical activity and may not be captured in the
56 evaluation of the Overall Physical Activity grade. The importance of light-intensity physical
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3 activity, especially in the form of active play, is largely unknown and likely varies significantly
4 among countries, between sexes, across ages and in urban and rural areas. An emerging
5 interest in the contribution of light-intensity physical activity, such as is typically obtained through
6 Active Play, is evident in the recommendations from the World Health Organization Commission
7 on Ending Childhood Obesity⁸⁰ and the new Canadian 24-Hour Movement Guidelines for
8 Children and Youth.⁸¹ With play identified as a fundamental right of children,^{82,83} and with high
9 levels of sitting^{84,85} and indoor time,⁷⁹ the opportunities to promote physical activity through an
10 increase in active play, especially outdoors, are plentiful and should be a high priority.^{15,76}

21 *Active Transportation*

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25 Active Transportation grades showed a wide distribution with the Netherlands reporting
26 an “A”,⁴⁴ Zimbabwe an “A-”,⁶⁰ seven countries a “B”, 19 countries a “C”, five countries a “D”, two
27 countries (United Arab Emirates,⁵⁶ United States⁵⁷) an “F” and three countries an “INC”. While
28 Active Transportation may be a necessity for some children in countries such as Zimbabwe,⁶⁰
29 Nigeria,⁴⁶ and Kenya,⁴⁰ in other countries with high grades it represents a choice that may be
30 driven more by supportive policies and/or traditional cultural norms (e.g., Denmark,³¹ Finland,³⁴
31 the Netherlands⁴⁴). Multi-country studies have shown similar proportions of active transportation
32 involvement in significantly differing contexts.^{86,87} To understand these patterns a “need-based
33 framework” has been proposed for LMIC, where active transportation represents the only option
34 for transportation because motorized vehicle availability remains relatively low in comparison
35 with HIC. The patterns observed in HIC can be understood within a “choice-based framework”
36 where policies and infrastructure facilitate active transportation as an option to commute.

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49 Interestingly, countries with high grades for this indicator come from very diverse
50 climates, suggesting weather is not necessarily a key determinant. The grades for countries in
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3 Africa were on average better than grades from countries in other continents. The grades for
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5 North American countries were generally lower than those from other continents.
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9 While active transportation has been associated with increased physical activity,⁸⁸
10 cardiorespiratory fitness,⁸⁸ and lower measures of adiposity,⁸⁷ evidence suggests that levels of
11 active transportation are declining.⁸⁹⁻⁹⁷ Generational declines in active transportation^{98,99} and
12 independent mobility¹⁰⁰ have also been observed. These trends are consistent with the
13 increased fear of the outdoors and a convenience lifestyle.⁷⁶ The fact that several countries
14 have been able to resist or counter these trends is encouraging and provides for the
15 transference of evidence and experiences between countries leading and lagging in this
16 indicator. Active transportation, whether for school, work, chores or play varies dramatically
17 between urban and rural settings, especially in LMIC where motorized transport is often not
18 available.^{19,98,101} It will be important to carefully monitor active transportation behaviours in rural
19 areas in developing countries as motorized transport becomes increasingly available and
20 subsistence demands become increasingly mechanized.¹⁹ During this transition in these needs-
21 based circumstances, it is also important to monitor and mitigate the unintended consequence
22 of pedestrian injuries associated with children actively commuting.
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40 *Sedentary Behaviour*

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43 There is considerable global variation in grades for sedentary behaviours although the
44 majority of countries have very poor or failing grades. Slovenia,⁵¹ Kenya⁴⁰ and Zimbabwe⁶⁰ had
45 grades in the “B” range while 24 countries had grades of “D” or “F”. All continents had an
46 average of a “D” grade. These grades identify a serious and widespread problem of excess
47 screen viewing (guideline of ≤ 2 hours per day of recreational screen time^{102,103}). Access to
48 convenience and digital technology (e.g., motorized vehicles, electronic screens) is likely
49 facilitating sedentary behaviour. Recent research comparing 17 high-, middle- and low-income
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3 countries demonstrated that household ownership of televisions, computers and cars increased
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5 as country income level increased; that ownership was positively associated with obesity and
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7 diabetes in LMIC; and this relationship was partially mediated by decreased physical activity
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9 and increased sedentary behaviour.¹⁰⁴ Temptations for sedentary behaviours are increasing as
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11 the world becomes increasingly cyber-centric, auto-dependent and urbanized, consistent with
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13 epidemiological and physical activity transitions.^{18,19,98} Self-report sedentary behaviour data on
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15 representative samples of children and youth from 42 countries revealed that 62% and 63% of
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17 13- and 15-year-olds, respectively, watched ≥ 2 hours of television per day on weekdays.⁷
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19 Despite evidence that television viewing time in some countries may be decreasing among
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21 children, other sedentary screen time use (e.g., computers, tablets, smartphones, electronic
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23 games) has more than compensated for this decline.⁷ Many parents agree that their children
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25 spend too much time watching television or playing electronic games.¹⁰⁵
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31 The overall findings from the *Global Matrix 2.0* and international surveys suggest that
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33 when sedentary behaviours are high (i.e., low grades), physical activity levels are low
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35 (Spearman's $\rho = 0.44$, $p < 0.01$). The study of sedentary behaviour, from a movement
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37 behaviour perspective, has gained significant momentum in recent years, in recognition of the
38
39 significant relationship with measures of health and health risk.^{85,102-111} The ubiquity of low
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41 grades in the *Global Matrix 2.0* suggests that public health messaging around limiting sedentary
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43 behaviour, and screen time in particular, may be an important area of focus and research, as
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45 lifestyle transitions occur throughout the world. Measures of screen time are evolving rapidly,
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47 along with the technology and future surveillance must attempt to keep pace with this evolution.
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49 It should be noted that the sedentary behaviour indicator in the Report Cards was informed in all
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51 countries exclusively by screen-time, or specifically television viewing time. In the future,
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53 measurement of non-screen sedentary behaviours, (e.g., time spent sitting while not in front of
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55 screens), fragmentation of sedentary time (e.g., interruptions, breaks), and research on their
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3 relationship with health outcomes are needed. At the present time, overall sedentary behaviour
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5 (i.e., total or leisure-time sitting) guidelines do not exist for children and youth, making it difficult
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7 to create benchmarks to inform the development of a grading rubric. Future research should be
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9 directed towards identifying dose-response relationships between total time spent in sedentary
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11 behaviours and health outcomes in children and youth, that will in turn inform the development
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13 of comprehensive sedentary behaviour guidelines. In this regard, a recent meta-analysis by Liu
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15 et al.³ suggests that screen time in children and adolescents is associated with depression risk
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17 in a non-linear dose–response manner.
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20 21 22 *Family and Peers*

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25 China,²⁹ the Netherlands,⁴⁴ and Thailand⁵⁶ had the highest grades (“B”) for the Family
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27 and Peers indicator, while Ghana³⁵ had the lowest grade (“F”). Similar to the Active Play
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29 indicator, many countries (17) assigned an “INC” grade. Participating experts and recent
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31 reviews¹¹²⁻¹¹⁵ support the importance of Family and Peers as a core indicator of the physical
32
33 activity of children and youth, however, the lack of valid and reliable measurement instruments
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35 has led to a dearth of empirical data for the established benchmarks (Table 2). Countries from
36
37 Africa had a lower average grade for the Family and Peers indicator compared to the other
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39 continents, perhaps suggesting that physical activity was more a routine requirement of daily
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41 living (e.g., chores, active transportation, active play) with less attentiveness or need for family
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43 and peer support. Alternatively, a lower awareness of the importance of habitual physical
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45 activity may have contributed to this slightly lower continental average. Published literature in
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47 this area is difficult to find. A survey of parents in 25 countries with children up to 12 years of
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49 age in 2010 reported playing with their children an average of 14.3 hours per week in a typical
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51 week.¹⁰⁵ Wide country variations were noted with means ranging from 10.5 hours in Denmark to
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53 20.0 hours in China.¹⁰⁵ A number of confounding variables, including family size and
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3 composition, employment logistics, urban-rural residence, climate, and variable definitions of
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5 “play” complicate the interpretation of these findings.
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9 The importance of positive role modelling of parents and their support of childhood
10 physical activity is well known.¹¹⁶⁻¹¹⁸ A recent cohort study reinforced the importance of parental
11 role modelling for both physical activity and sedentary behaviour, demonstrating significant
12 associations between preschool children’s behaviours and their parents, and further observing
13 the potentially important role of same and different sex parental-child relationships.¹¹⁹ While the
14 role of peers and parents in creating supportive environments for physical activity is
15 unequivocal, drawing any firm insights from the *Global Matrix 2.0* in this regard is difficult.
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24 *School*

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28 Grades for the School indicator ranged from “A” in Slovenia⁵¹ to “D-” in Mexico⁴² with a
29 relatively even distribution of grades by other countries between these extremes (Table 4).
30 There was a clear trend towards higher grades in HICs, and lower grades in LMICs. The high
31 grade for Slovenia was associated with the fact that physical education is a standardized,
32 compulsory subject in all primary and secondary schools. Although total activity hours can vary
33 by grade level, from grade six through secondary school, 100% of physical education classes
34 (and more than two thirds in primary schools) are taught by physical education specialists with a
35 university degree in that field. Regarding school sports infrastructure, all primary schools (and
36 most secondary schools) have at least one sport hall fully-equipped with the necessary sports
37 equipment and additional outdoor facilities. All schools in Slovenia also have defined, explicit
38 physical activity policies (e.g., bike racks at school, traffic calming on school property, outdoor
39 time). In general, the grades for School do not appear to be closely related to the Overall
40 Physical Activity grades. This observation is supported by the average School grades by
41 continent (Table 3) with Oceania, Europe and North America reporting two full grades higher for
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3 the School indicator than the Overall Physical Activity indicators whereas in Africa the School
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5 indicator was a full grade lower than the Overall Physical Activity Indicator.
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9 International comparisons of school-based physical activity supports, opportunities,
10 facilities and policies are scarce. A recent comprehensive report of 30 European countries
11 around school-based initiatives and strategies to promote and support physical education and
12 school-based physical activity highlighted important differences across Europe,¹²⁰ and noted
13 that in some countries time devoted to physical education was <10% of total curricular time.¹²⁰
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15 To reduce costs and/or create more time for other subjects, a trend towards a reduction in the
16 quality and/or quantity of physical education has been observed in many countries in recent
17 years.¹²¹⁻¹²³ In contrast, areas of Australia have shown small increases in time and resources
18 committed to physical education.^{92,124} This apparent depreciation of physical education is
19 unfortunate as recent research has shown that more MVPA is achieved on school days with a
20 physical education class (9 more minutes in the United States and 16 more minutes in Finland)
21 compared to those without¹²⁵ and these differences account for a significant proportion of time
22 towards meeting physical activity guidelines.^{81,126} The relative importance of school-based
23 support for physical activity may be greater in HICs where organized and structured physical
24 activity is disproportionately relied upon.
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42 *Community and the Built Environment*

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45 For this indicator three countries (Netherlands,⁴⁴ Australia,²⁴ Canada²⁷) had grades in the
46 “A” range while Ghana,³⁵ Mozambique⁴³ and Zimbabwe⁶⁰ reported “F” grades. Eleven countries
47 reported an “INC” grade. All countries with a grade of “C+” or higher were HICs whereas seven
48 out of nine countries with a grade of “C-” or lower were LMICs. Grades from participating
49 countries in North America and Europe were higher than those from other continents. The
50 general pattern of higher grades in HICs and lower grades in LMICs was consistent with the
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3 *Global Matrix 1.0* and makes intuitive sense. The importance of improving the built environment
4 to facilitate healthy active living and make the healthy choice the easy choice has gained
5 significant popularity, especially in HICs.¹²⁷ However, several countries report that the
6 infrastructure for this indicator is already quite good. Countries with high grades for this indicator
7 reported rather good physical activity infrastructure, availability and programming,^{24,27,31,38,44} but
8 often without the desired impact on habitual physical activity. In fact, the Spearman's rho for
9 Overall Physical Activity grade ~ Community and Built Environment grade is -0.28 (p = 0.18),
10 indicates an overall *negative* relationship, albeit weak.
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22 Characteristics of the built environment are a potential source of influence of the physical
23 activity level of children, youth and adults. In a study using latent class analysis of built
24 environment features reported by adults from 11 countries, two specific neighborhood patterns
25 were positively associated with meeting physical activity guidelines: an overall activity
26 supportive environment (e.g., many shops and transit stops within walking distance, sidewalks
27 on most streets, low cost recreation facilities near-by), and highly walkable yet unsafe
28 environments with few recreation amenities.¹²⁸ The IPEN study also examined the associations
29 between objectively measured characteristics of the environment and objectively measured
30 physical activity in 14 countries, finding that residential density, intersection density, public
31 transport density and the number of parks in a 0.5 km buffer were linearly and positively
32 associated to MVPA.¹²⁹ Similar results were obtained in a descriptive review examining the
33 association between children's physical activity and environmental attributes among thirty-three
34 quantitative studies.¹³⁰ Children's participation in physical activity was found to be positively
35 associated with publicly provided recreational infrastructure (e.g., access to recreational
36 facilities and schools) and specific transport infrastructure (e.g., presence of sidewalks and
37 controlled intersections, access to destinations and public transportation) and negatively
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3 associated with an increased number of roads to cross, increased traffic density and speed, and
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5 unsafe local conditions.¹³⁰
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9 While it is intuitive and perhaps obvious that physical activity-promoting environments
10 will encourage and ultimately lead to an increase in childhood physical activity, we need to be
11 open to the possibility that either the perception of what constitutes a physical activity promoting
12 environment may be incorrect, or that the built environment, organizational structure or facilities
13 alone may be insufficient to have demonstrable impact on childhood physical activity levels. The
14 physical, organizational and social structure-centric approach commonly employed and
15 seemingly preferred in high-income countries is arguably not working. As stated in the *Global*
16 *Matrix 1.0* paper¹⁵ “in some cases it may be that “less is more” for the promotion of exploratory
17 play and incidental physical activity for some children”, as seen more so in LMICs. This “less is
18 more” approach is also supported by the *Position Statement on Active Outdoor Play* referred to
19 earlier,⁷⁶⁻⁷⁸ is less cost-intensive, is fundamentally more accessible for vulnerable, marginalized,
20 rural and remote populations, and is rooted in history. An increase in independence, including
21 greater independent mobility and freedom to play, may turn out to be more effective at
22 increasing habitual physical activity than more structured approaches. Playing outdoors in
23 nature (e.g., unstructured fields, bushes) might be more attractive to children than structured,
24 hyper-safe yet unchallenging playgrounds. Based on the findings from the *Global Matrix 2.0*
25 such an approach at least deserves consideration and will require more social engineering than
26 built environment engineering.
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48 49 *Government Strategies and Investments*

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52 Denmark³¹ reported the highest (“A-”) grade for the Government Strategies and
53 Investments indicator followed by Slovenia⁵¹ and the United Arab Emirates⁵⁷ (“B+”). Twelve
54 other countries reported grades in the “B” range while only one country (Mozambique⁴³)
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3 reported an “F” grade. In contrast to the *Global Matrix 1.0* where 5/15 countries assigned an
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5 “INC” grade, only 6/38 countries in the *Global Matrix 2.0* assigned “INC” grades. The continental
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7 average grades were rather uniform around the world, regardless of country HDI. The individual
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9 country report cards²⁴⁻⁶⁰ serve as a repository of government policies, strategies and
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11 investments, however, a paucity of robust evaluations reduces the strength of the guidance that
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13 can be gleaned from these listings.
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17 While most countries reported adequate to good government physical activity strategies
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19 and policies, several also noted a serious lack of implementation and dearth of quality
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21 assurance or evaluation. This policy-implementation disconnect may help to partially explain the
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23 paradox observed with greater infrastructure and support sometimes negatively associated with
24
25 actual physical activity behaviour. Implementation deficiencies can coexist with insufficient
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27 sustainability and scalability. Also plausible is the possibility that the social-cultural environment
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29 (e.g., parental restrictions/societal norms on active and outdoor play) is counteracting what
30
31 might otherwise be favourable policies and strategies for physical activity. Finally, policies and
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33 strategies may be reactive to problems after they had emerged rather than preventive, thus
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35 making evidence of effectiveness more difficult to demonstrate. Regardless, it remains prudent
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37 advice “to rally support for the implementation of proactive campaigns, strategies and
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39 investments in developing countries in an effort to preserve inherent healthy active living
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41 behaviours.”¹⁵
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46 47 *Other Indicators*

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49 Many countries included additional indicators of country, cultural, professional or political
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51 importance. These results are not presented or discussed in this paper, but examples of
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53 additional indicators included body weight status, nutrition/healthy eating indicators, physical
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3 fitness, movement skills, and non-governmental strategies and investments among others.
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5 Details are reported in individual country Report Cards.²⁴⁻⁶⁰
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8 9 **Disparities and Inequities**

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12 Disparities and inequities are evident and variable in the *Global Matrix 2.0* in several
13 ways. The most obvious may be at the country level with some countries reporting better grades
14 than others. It is this variation that makes the process informative and can lead to insights that
15 may help to “level the playing field” across countries. Also obvious from an examination of the
16 individual country Report Cards²⁴⁻⁶⁰ is the lack of data and consequent discussion related to
17 children and youth with a disability (physical, mental, sensory), similar to the *Global Matrix 1.0*.¹⁵
18 This large and particularly vulnerable group arguably has the most to gain from a “level playing
19 field”. The prevalence of children and youth with disabilities varies substantially among countries
20 and disability category^{131,132} and the Global Matrix process could help to identify and circulate
21 best practice strategies.
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35 Similar to the *Global Matrix 1.0*, the most notable within-country disparity or inequity was
36 seen with the Organized Sport Participation indicator, likely because of the resource
37 requirement for registration fees, equipment, and travel. This disparity is evident with
38 socioeconomic (favouring middle- and high income), geographic (favouring urban dwelling), and
39 sex (favouring boys) gradients. The attention paid to such gradients in most Report Cards was
40 rather superficial and represents an important area for improvement in future international
41 comparison efforts. Indeed, the strong and significant negative correlation seen between both
42 the GINI Index⁶² and Gender Inequality Index,⁶³ and Sources of Influence for physical activity
43 (Table 5) suggests that country level indices of inequality and empowerment may be important
44 targets, or beacons, for innovative interventions.
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3 Other international comparison research has shown interesting interactions between
4 physical activity and outcome indicators across family-level sociodemographic gradients as well
5 as country-level indices such as HDI and GINI Index. For example, the International Study of
6 Childhood Obesity, Lifestyle and the Environment (ISCOLE),¹³³ which collected data on 9-11
7 year-old children in 12 countries varying widely on HDI, found opposite relationships between
8 family socioeconomic indicators (i.e., income and education) and physical activity and obesity
9 levels^{16,21,22} between HICs and LMICs. Child physical activity levels were higher in higher-
10 income households in HICs but lower in higher-income households in LMICs.^{21,22} Child obesity
11 levels were lower in higher-income households in HICs and higher in higher-income households
12 in LMICs.^{16,21} Clearly there is much to learn from such disparities and inequities and much
13 further to be understood and this should be a priority focus for future comparison initiatives.
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28 **Data Gaps and Research Priorities**

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31 The high proportion of incomplete grades (“INC”), especially for the Active Play and
32 Family and Peers indicators, suggests there is a need for clearer definitions and more thorough
33 data collection methods in most countries. Furthermore, in many countries there is a lack of
34 nationally representative data, and the extent to which inherent biases in existing data distort
35 the true situation is unknown. The collection of data using harmonized measures, including
36 objective measures of physical activity, on larger, more representative samples would improve
37 the validity and reliability of the findings, while also adding greater resolution on within and
38 between country differences by sex, age, socioeconomic status, urban/rural living, cultural
39 minorities, children and youth with a disability and other population stratifications that could help
40 inform future strategies and interventions to improve the grade. Expert recommendations for
41 physical activity surveillance have been published recently in the United States.¹³⁴ Specific
42 future surveillance and research priorities include:
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- Expanding the *Global Matrix (i.e., 3.0)* to include even greater global representation (current areas with less representation include the Middle East, South America, Pacific Islands, Caribbean, Russia; see Figure 1);
- Using robust, standardized measures of physical activity and sedentary behaviours on children and youth from countries around the world;
- Standardization of interpretation of accelerometer data using agreed upon cut-points for accelerometer types;
- Developing a clear accepted definition and valid and reliable measures of active play;
- Developing valid and reliable measures of the influence of family and peers on physical activity behaviours of children and youth;
- Further prospective multi-country intervention research on the determinants of physical activity and sedentary behaviours in children and youth from countries at different stages of the physical activity transition;¹⁹
- The measurement and surveillance of healthy movement behaviours (including physical activities of all intensities, sedentary behaviours, and sleep) information on young children (toddlers and preschoolers, aged 1-5 years) from countries around the world to understand and inform best practices for the promotion of healthy growth and developmental trajectories;⁸⁰
- An extension of measures to include emerging health behaviours that have not been typically measured in the past (e.g., sitting time, breaks in sitting time, non-screen time sedentary behaviours, light physical activity) and further research to understand their relationship with health and wellbeing indicators in childhood;
- Adding physical fitness as an indicator in future Report Card comparisons;
- Further research and surveillance of marginalized groups including children and youth with a disability, new immigrants and refugees, and rural and remote communities;

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- Further evaluation of policies and programs intended to promote physical activity among children and youth, to identify the best and scalable practices, and how they can be best implemented in differing settings;
 - Cost effectiveness studies of strategies to improve physical activity and sedentary behaviours in children and youth;
 - Exploration of current surveillance practices at the country level to delineate which variables are over- and under-surveyed (for example, the Scotland 2016 Report Card⁵⁰ revealed over-surveillance of Active Transportation with four different national surveys, in contrast to no surveillance of Active Play or Organized Sport Participation).

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Unrelated to the *Global Matrix 2.0* project, a Delphi survey of international experts established research priorities for child and adolescent physical activity and sedentary behaviour,¹³⁵ with the top priorities being: development of effective and sustainable interventions to increase long-term physical activity among children and youth; assessment of policy and/or environmental changes and their influence on physical activity and sedentary behaviours of children and youth; and implementation of prospective, longitudinal studies to examine the independent effects of physical activity and sedentary behaviours on health from birth to middle age.¹³⁵

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Recommendations for Improving the Grades and Future Directions

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Recommendations to improve the grade were forwarded by country report card leaders (coauthors of this paper) and include (presented in random order):

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- Promoting, and reducing restrictions (e.g., overprotectionism) for active play;
 - Prioritizing the establishment and preservation of safe environments for active play and unstructured physical activity;

- Promoting and facilitating safe active transport to school and other destinations;
- Ensuring schools have comprehensive physical activity policies in place that outline ways to encourage and engage students in physical activity throughout the entire school day to promote physical, mental, social and academic benefits. For example, in addition to formal physical education classes, schools should promote in-class physical activity and "energizer" breaks. This should be developed in consultation with teachers, parents and students and reviewed over the course of a school year;
- Promising and scalable community interventions in public spaces represent an opportunity to promote physical activity in a socially inclusive environment that could contribute to decrease the unequal access to recreational opportunities, mainly in LMIC.^{136,137} For example, Ciclovías or Open Streets programs, implemented in at least 12 out of the 38 countries participating in the Global Matrix 2.0, are globally recognized as a program to promote physical activity. However, the impact of these programs on children's physical activity levels requires evaluation.
- Improving physical activity and sedentary behaviour surveillance by implementing systematic and robust measures (e.g., use of objective measures like accelerometry and validated questionnaires) on representative samples across all childhood ages (e.g., toddlers through to adolescents);
- Evaluating the implementation, efficacy and effectiveness of national strategies and policies;
- Establishing culturally and geographically (e.g., urban vs. rural) appropriate policy interventions and programs;
- Ensuring that children, young people and their families are continually educated on the importance of balancing different types of sedentary behaviours, especially since some are more likely to be detrimental than others (e.g., screen time for entertainment vs. study for school vs. reading a book). Parents could use autonomous and supportive parenting

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3 practices, whereby they involve children in the formation of household rules and
4 consequences/rewards;

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8 • Ensuring the acquisition of fundamental motor skills in early childhood to increase self-
9 efficacy and habitual physical activity;
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12 • Encouraging and supporting organized sports clubs to be more inclusive to reduce gender
13 and social inequalities in organized sports participation and also reach the less sports
14 talented.
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18 19 **Strengths and limitations**

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22 The *Global Matrix 2.0* initiative has several strengths, including the >150% expansion in
23 the number of participating countries compared to *Global Matrix 1.0*; the commensurate
24 expansion in the geographical distribution allowing for insights from more genuinely global data;
25 capacity development (see Table 6 for selected quotes from country participants); the clear and
26 transparent identification of data gaps and research needs; the ability to run some statistical
27 comparisons; the facilitation of research collaborations and professional networking; and the
28 formation of a team passionately committed to improving the current and future health and
29 wellbeing of children through increased physical activity.
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41 While the *Global Matrix 2.0* represents a significant improvement over the *Global Matrix*
42 *1.0*,¹⁵ there remain significant limitations and room for improvement. The substantial variation in
43 the quality and quantity of data used to inform the grades between countries remains the
44 greatest limitation to the comparison process. Despite this serious limitation, country leaders
45 believe that the convening of a diverse set of country experts, presented with the collection of
46 the best available data, represents the most authentic and robust method presently available to
47 make such comprehensive comparisons across countries. A recent paper examining the
48 correlates of agreement between accelerometry and self-reported physical activity data
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3 demonstrated systematic cultural and sociodemographic differences raising questions about the
4 comparability of physical activity data across countries.¹³⁸ This concern, although demonstrated
5 in adults, lends some support to the comprehensive data synthesis approach taken in the
6 development and grading of the Report Cards.¹² Other limitations of the *Global Matrix 2.0*
7 include the lack of inclusion of most of the world's countries; little exploration of disparities and
8 inequities across ability levels, gender, socioeconomic status, or urban vs. rural dwelling; no
9 formal auditing procedure for assigned grades; and lack of clarity on indicator definitions and
10 benchmarks. It is hoped that *Global Matrix 3.0* will show substantial progress towards mitigating
11 these limitations. To this end, country leaders participating in the *Global Matrix 2.0* met in
12 Bangkok immediately after the *2016 International Congress on Physical Activity and Public*
13 *Health* to debrief on the experience, expose limitations to within and between country
14 comparisons and discuss potential improvements for the *Global Matrix 3.0*.
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30 **Conclusion**

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34 The *Global Matrix 2.0* provides a comprehensive summary of physical activity behaviour
35 and sources of influence indicators, from 38 countries using a harmonized data gathering,
36 assessing and grading process. The results suggest a complex network of strengths and
37 limitations across countries, with some global patterns emerging when comparing countries
38 clustered by continent, HDI,⁶¹ and inequality.⁶²⁻⁶⁴ There is some evidence of higher physical
39 activity and lower sedentary behaviour in countries reporting poorer infrastructure and a greater
40 reliance on Active Play and Active Transportation; and lower physical activity and higher
41 sedentary behaviour in countries reporting better infrastructure and a greater reliance on
42 Organized Sport Participation and better School and Community facilities and policies. This
43 paradox suggests autonomy to play and greater independent mobility rather than infrastructure
44 and structured activities may facilitate higher levels of physical activity.
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3 The *Global Matrix 2.0* serves as a source of information for researchers, advocates,
4 practitioners and policy-makers to learn from and build upon. Moreover, the *Global Matrix 2.0* is
5 an effective medium for capacity development, especially in LMICs. It facilitates professional
6 networking; cross-fertilization of ideas; conceptualization of strategies and solutions; inception of
7 research collaborations; promotion of advocacy synergy; momentum for change; and inspiration
8 for future work. In the ongoing effort to overcome the persistent and pervasive challenge of
9 increasing childhood physical activity, and to ‘power the movement to get kids moving’, it is
10 recommended that the *Global Matrix* framework be expanded, improved and repeated.
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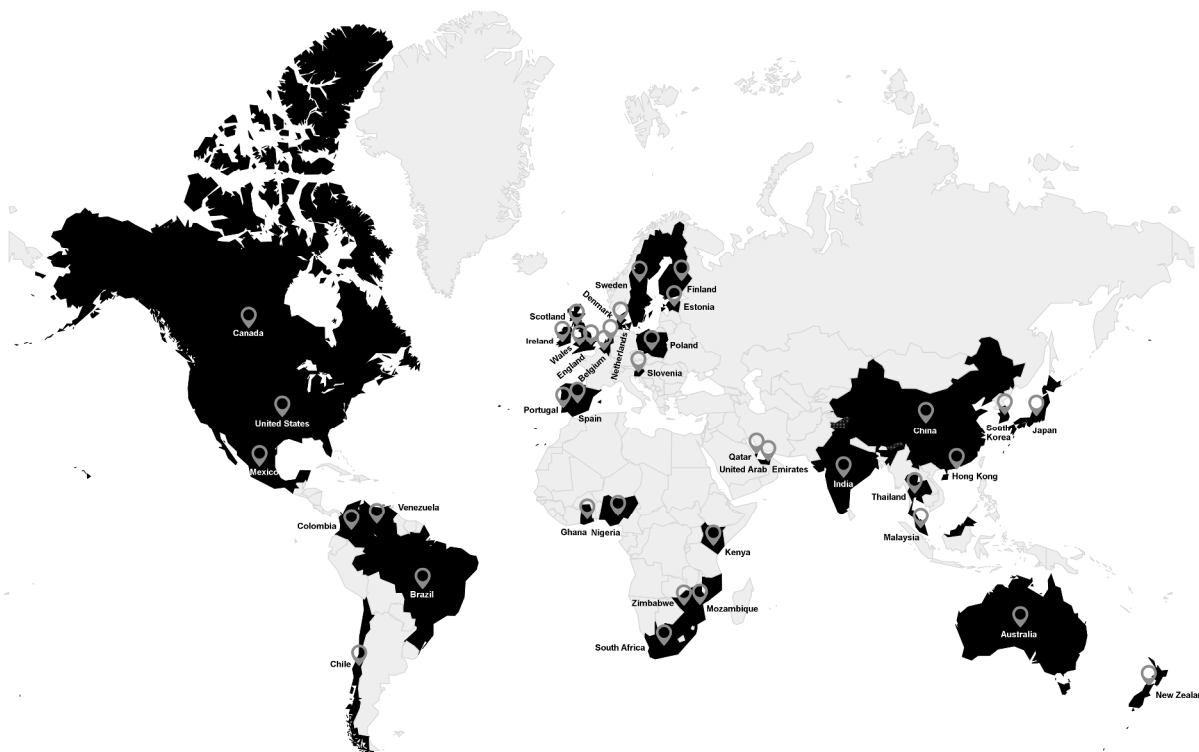


Figure 1: Global map indicating location of countries participating in the *Global Matrix 2.0* (in black).

Table 1: Grading framework for the Report Card.

Grade	Interpretation
A	We are succeeding with a large majority of children and youth ($\geq 80\%$).
B	We are succeeding with well over half of children and youth (60-79%).
C	We are succeeding with about half of children and youth (40-59%).
D	We are succeeding with less than half but some children and youth (20-39%).
F	We are succeeding with very few children and youth ($< 20\%$).
INC	Incomplete - inadequate information to assign a grade.

“+” and “-” signs are added to the grades in some circumstances to indicate the high or low end of the grade continuum respectively and/or to indicate the presence (“-”) or absence (“+”) of significant gender, geographic, ethnic or socioeconomic disparities).

Table 2: Benchmarks used to guide the grade assignment for each indicator.

Indicator	Benchmark
Overall Physical Activity	% of children and youth who meet physical activity guidelines
Organized Sport Participation	% 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 for several hours a day
Active Transportation	% of children and youth who use active transportation to get to and from places (school, park, mall, friend's place)
Sedentary Behaviour	% of children and youth who meet sedentary behaviour or screen-time guidelines
Family and Peers	% of parents 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 physical activity guidelines for adults
	% of parents 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 Physical Activity, recess, "everyone plays" approach, bike racks at school, traffic calming on school property, outdoor time)
	% of schools where the majority ($\geq 80\%$) of students are taught by a Physical Education specialist
	% of schools where the majority ($\geq 80\%$) of students are offered at least 150 minutes of Physical Education per week
	% of schools that offer physical activity opportunities (excluding Physical Education) to the majority ($\geq 80\%$) of students
	% of parents with children and youth who have access to physical activity opportunities at school in addition to Physical Education
	% of schools with students who have regular access to facilities and equipment that support physical activity (e.g., gymnasium, outdoor playgrounds, sporting fields, equipment in good condition)
Community and the Built 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 infrastructure (e.g., sidewalks, trails, paths, bike lanes) specifically geared toward promoting physical activity
	% of children or parents with facilities, programs, parks and playgrounds available to them in their community
	% of children or parents living in a safe neighborhood where they can be physically active
	% of children or parents reporting well-maintained facilities, parks/playgrounds in their community that are safe
	% of children and youth who report being outdoors for several hours a day
Government Strategies and Investments	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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Table 3: Global Matrix 2.0 with countries presented alphabetically within continents.

Country	Overall Physical Activity Levels	Organized Sport Participation	Active Play	Active Transportation	Sedentary Behaviours	Family and Peers	School	Community and the Environment	Government Strategies and Investments	Average Across All Indicators
Africa										
Ghana	D	C	B	C	D	F	D	F	D	D
Kenya	C	C	B	B	B	D	C	D	C	C
Mozambique	C	F	D	C	INC	INC	D	F	F	D
Nigeria	C	INC	C	B	F	INC	C-	INC	B	C
South Africa	C	C	INC	C	F	C-	D	C-	B	C
Zimbabwe	C+	B	D+	A-	B	INC	D	F	D	C
<i>Average</i>	<i>C</i>	<i>C</i>	<i>C</i>	<i>B</i>	<i>D</i>	<i>D</i>	<i>D</i>	<i>D</i>	<i>C</i>	<i>C</i>
Asia										
China	F	F	D-	C-	F	B	B+	D+	D	D
Hong Kong	D	C-	INC	B	C	D	C	B	INC	C
India	C-	INC	INC	C	C	INC	INC	INC	D	C
Japan	INC	C	INC	B	C	D	B	D	B	C
Malaysia	D	INC	INC	D	D	INC	B	INC	B	C
Qatar	F	D	INC	D	D	D	INC	INC	B	D
South Korea	D-	C-	INC	C+	F	INC	D	INC	C	D
Thailand	D-	C	F	B	D-	B	C	C	C+	C
United Arab Emirates	D-/F-	INC	INC	D-/F-	C-	C-	D	INC	B	C
<i>Average</i>	<i>D</i>	<i>C</i>	<i>F/D</i>	<i>C</i>	<i>D</i>	<i>C</i>	<i>C</i>	<i>C</i>	<i>C</i>	<i>C</i>
Oceania										
Australia	D-	B	INC	C-	D-	C+	B-	A-	D	C
New Zealand	B-	C+	B-	C	C	C	C+	B	B-	C
<i>Average</i>	<i>C</i>	<i>C/B</i>	<i>B</i>	<i>C</i>	<i>D/C</i>	<i>C</i>	<i>C/B</i>	<i>B/A</i>	<i>C</i>	<i>C</i>
Europe										
Belgium	F+	C-	C+	C-	D-	INC	B-	INC	C+	C
Denmark	D+	A	INC	B	INC	INC	B	B+	A-	B
England	D-	D	INC	C-	INC	INC	B+	B	INC	C
Estonia	F	C	INC	INC	F	C	C	B	C	C
Finland	D	C	C	B	D	C	B	B	B	C
Ireland	D	C-/C+	INC	D	C-	INC	D	B+	INC	C
Netherlands	D	B	B	A	C	B	C	A	INC	B
Poland	D	D	INC	C	D	C	B	C	C	C
Portugal	D	B	D	C	D	C	B	D	C	C
Scotland	F	INC	INC	C	F	D-	-	B	B	C
Slovenia	A-	B-	D	C	B+	INC	A	INC	B+	B
Spain	D-	B	C+	C	D	INC	C	INC	INC	C
Sweden	D	B+	INC	C+	C	INC	C+	B	B	C
Wales	D-	C	C	C	D-	D+	B	C	B-	C
<i>Average</i>	<i>D</i>	<i>C</i>	<i>C</i>	<i>C</i>	<i>D</i>	<i>C</i>	<i>B</i>	<i>B</i>	<i>B</i>	<i>C</i>
North America										
Canada	D-	B	D+	D	F	C+	B	A-	B-	C
Mexico	C	D	D-	C	D	INC	D-	D	C	D
United States	D-	C-	INC	F	D-	INC	D+	B-	INC	D
<i>Average</i>	<i>D</i>	<i>C</i>	<i>D</i>	<i>D</i>	<i>D</i>	<i>C</i>	<i>C</i>	<i>B</i>	<i>C/B</i>	<i>D</i>

South America											
Brazil	C-	INC	INC	C+	D+	C+	INC	INC	D	C	
Chile	F	D	INC	C-	D	D	D	C	C	D	
Colombia	D	C	INC	D	D	INC	D	C	B/B	C	
Venezuela	D	INC	INC	INC	D/F	INC	INC	INC	D	D	
<i>Average</i>	<i>D</i>	<i>D/C</i>	-	<i>C</i>	<i>D</i>	<i>C/D</i>	<i>D</i>	<i>C</i>	<i>C</i>	<i>D/C</i>	
Overall average	<i>D</i>	<i>C</i>	<i>C</i>	<i>C</i>	<i>D</i>	<i>C</i>	<i>C</i>	<i>C</i>	<i>C</i>	<i>C</i>	

For Peer Review

Table 4: Global Matrix 2.0 presented in rank order by grade.

Grade	Overall Physical Activity	Organized Sport Participation	Active Play	Active Transportation	Sedentary Behaviours	Family & Peers	School	Community & Environment	Government Strategies & Investments
A+									
A		Denmark		Netherlands			Slovenia	Netherlands	
A-	Slovenia			Zimbabwe				Australia Canada	Denmark
B+		Sweden			Slovenia		China England	Denmark Ireland	Slovenia United Arab Emirates
B		Australia Canada Netherlands Portugal Spain Zimbabwe	Ghana Kenya Netherlands	Denmark Finland Hong Kong Japan Kenya Nigeria Thailand	Kenya Zimbabwe	China Netherlands Thailand	Canada Denmark Finland Japan Malaysia Poland Portugal Wales	England Estonia Finland Hong Kong New Zealand Scotland Sweden	Colombia Finland Japan Malaysia Nigeria Qatar Scotland South Africa Sweden
B-	New Zealand	Slovenia	New Zealand				Australia Belgium	United States	Canada New Zealand Wales
C+	Zimbabwe	New Zealand	Belgium Spain	Brazil South Korea Sweden		Australia Brazil Canada	New Zealand Sweden		Belgium
C	Kenya Mexico Mozambique Nigeria South Africa	Colombia Estonia Finland Ghana Ireland Japan Kenya South Africa Thailand Wales	Finland Nigeria Wales	Ghana India Mexico Mozambique New Zealand Poland Portugal Scotland Slovenia South Africa Spain Wales	Hong Kong India Japan Netherlands New Zealand Sweden	Estonia Finland New Zealand Poland Portugal	Estonia Hong Kong Kenya Netherlands Spain Thailand	Chile Colombia Poland Thailand Wales	Chile Estonia Kenya Mexico Poland Portugal South Korea Thailand
C-	Brazil India	Belgium Hong Kong South Korea United States		Australia Belgium Chile China England	Ireland United Arab Emirates	South Africa United Arab Emirates	Nigeria	South Africa	

D+	Denmark		Canada Zimbabwe		Brazil	Wales	United States	China	
D	Colombia Finland Ghana Hong Kong Ireland Malaysia Netherlands Poland Portugal Sweden Venezuela	Chile England Mexico Poland Qatar	Mozambique Portugal Slovenia	Canada Colombia Ireland Malaysia	Chile Colombia Finland Ghana Malaysia Mexico Poland Portugal Qatar Spain	Chile Hong Kong Japan Kenya Qatar	Chile Colombia Ghana Ireland Mozambique South Africa South Korea United Arab Emirates Zimbabwe	Japan Kenya Mexico Portugal	Australia Brazil China Ghana India Venezuela Zimbabwe
D-	Australia Canada England Spain South Korea Thailand United States Wales		China Mexico		Australia Belgium Thailand United States Venezuela Wales	Scotland	Mexico		
F	Belgium Chile China Estonia Qatar Scotland United Arab Emirates	China Mozambique	Thailand	United Arab Emirates United States	Canada China Estonia Nigeria Scotland South Africa South Korea	Ghana		Ghana Mozambique Zimbabwe	Mozambique
INC	Japan	Brazil India Malaysia Nigeria Scotland United Arab Emirates Venezuela	Australia Brazil Chile Colombia Denmark England Estonia Hong Kong India Ireland Japan Malaysia Poland Qatar Scotland	Estonia Qatar Venezuela	Denmark England Mozambique	Belgium Colombia Denmark England India Ireland Malaysia Mexico Mozambique Nigeria Slovenia South Korea Spain Sweden United States	Brazil India Qatar Scotland Venezuela	Belgium Brazil India Malaysia Nigeria Qatar Slovenia South Korea Spain United Arab Emirates Venezuela	England Hong Kong Ireland Netherlands Spain United States

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			South Africa South Korea Sweden United Arab Emirates United States Venezuela			Venezuela Zimbabwe			
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The grade for each indicator is based on the percentage of children and youth meeting a defined benchmark: *A* is 81% to 100%; *B* is 61% to 80%; *C* is 41% to 60%, *D* is 21% to 40%; *F* is 0% to 20%. No grade was assigned when the data were considered to be incomplete (INC).

Table 5: Correlation matrix (Spearman's rho) of average country Report Card grades by global descriptors.

	Health and Education		Income Distribution	Nutrition	Other	
	Income	Empowerment and Labour				
	Human Development Index ⁶¹	Gender Inequality Index ⁶³	GINI Index ⁶²	Global Food Security Index ⁶⁵	Summer Olympic Medal Count ⁶⁶	Distance from the Equator (km) ⁶⁷
Rank (Highest, Lowest)	0.935 (Australia), 0.416 (Mozambique)	0.016 (Slovenia), 0.591 (Mozambique)	25.6 (Slovenia), 63.4 (South Africa)	86.6 (United States), 29.4 (Mozambique)	2,520 (United States), 2 (Mozambique)	2 (Kenya), 7,219 (Finland)
Overall Report Card Grade^a	0.32	-0.55*	-0.44	0.30	0.17	0.29
Behaviour Grade^b	0.12	-0.26	-0.23	0.19	0.04	0.07
Sources of Influence Grade^c	0.60*	-0.77*	-0.55*	0.58*	0.45	0.48*

* $p < 0.003$ (note: due to multiple comparisons, $\alpha = 0.003 [0.05/18]$); ^aAverage of all nine indicators for a country; ^bAverage of Overall Physical Activity, Organized Sport Participation, Active Play, Active Transportation, Sedentary Behaviour indicator grades; ^cAverage of Family and Peers, School, Community and the Built Environment, and Government Strategies and Investments indicator grades.

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Table 6: Selected quotes from participating country leaders.

Country	Quote
Australia	<p>The childhood inactivity crisis is one that many countries are facing. The Global Matrix 2.0 provides a united forum for us all to work towards a common goal; that is, getting the children of today and tomorrow to “move more and sit less”. By bringing together 38 countries to internationally benchmark nine physical activity indicators, the Global Matrix 2.0 allows Australia to compare how well it is performing in promoting and facilitating physical activity opportunities relative to the rest of the world. We believe that participation in the Global matrix 2.0 will help AHKA to inspire change, and facilitate advocacy and strengthen national, state and community efforts aimed at increasing physical activity and reducing sedentary behaviour in young Australians.</p> <p>– Grant Tomkinson and Natasha Schranz</p>
Colombia	<p>Participation in the Global Matrix 2.0 has been a unique opportunity for the group in Colombia to contribute to the surveillance agenda in the country. Based on the nine common indicators included in the Global Matrix, new indicators on physical activity for the National Survey of Nutrition in Colombia have been proposed and are being collected at the national level for the upcoming version of the survey. We also consider that the comparisons with other countries, and for the first time with other countries from the South American region, provide a great opportunity to learn from the successful efforts of other nations to promote active and healthy lifestyles among children and youth.</p> <p>– Silvia Alejandra Gonzalez Cifuentes</p>
Ghana	<p>Ghana’s maiden Report Card on Physical Activity for Children and Youth, published in 2014, established a baseline description of physical activity indicators of Ghanaian children and youth and has since influenced stakeholders to start developing policy guidelines and interventions to raise the grades on physical activity indicators for children and youth in the future.</p> <p>Two intervention strategies that are intended to raise the grades on physical activity indicators for children and youth in Ghana are underway. They include; (1) a Physical Education and School Sports Policy to support the conduct, monitoring and surveillance of physical activity in physical education in school as well as after-school sports and (2) a Community-Based Coaching Program to support after-school and community sports requirements. Both interventions possess the power to encourage children and youth to move to increase their physical activity levels.</p> <p>– Reginald Ocansey</p>

India	<p>It has been an incredible experience to be a part of a complex collaborative effort between active living researchers around the world. I am confident that this knowledge exchange endeavour across countries can initiate changes in how governments and stakeholders look at the value of promoting physical activity among children.</p> <p>– Tarun Katapally</p>
Japan	<p>The Global Matrix 2.0 has been an incredible opportunity to collaborate with researchers and academics across Japan and from around the world. It has been a challenging and exciting experience that I hope will influence not only government policy but also how the public views physical activity in our children and adolescents.</p> <p>However, working on the global report card has made it clear that Japan doesn't have enough data on physical activity for children and adolescents to grade overall physical activity levels. This has been quite disappointing/frustrating but has raised some interesting questions and inspired our team to discuss how to best evaluate physical activity in Japan. For example, could sum of exercise and active play time outside of physical education classes be used in future report cards to evaluate overall physical activity levels? Evaluation methods used by other countries in Matrix 2.0 can also provide examples on effective cross-national ways to evaluate physical activity for the Japanese government and researchers in the field.</p> <p>The report card also inspired us to start planning a report card for each of Japan's 47 prefectures increasing cooperation among researchers and academics and hopefully leading to an improvement in physical activity in children and adolescents across Japan.</p> <p>– Chiaki Tanaka</p>
Mexico	<p>Participating in this edition for the 2016 Report Card for Children in México and the Global Matrix 2.0, has been an extraordinary experience. It has been an honor to be involved with such distinguished researchers from around the world, but most importantly, working with a very talented and extraordinary young group in México has been beyond my expectations.</p> <p>– Juan Lopez Taylor</p>
New Zealand	<p>For me personally, involvement in this project has been very valuable to become more aware of the existing national datasets and reports that describe different physical activity indicators in New Zealand and experience the process of creating this national-level report. But the most valuable experience for me was the opportunity to connect and work together with other academics and researchers across New Zealand. I hope that this work will be a springboard for future national-level collaborations in the physical activity field in New Zealand.</p> <p>– Member of New Zealand Report Card Committee</p>

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Scotland	<p>The global matrix should have substantial impact in Scotland — the grades from Scottish children and adolescents did not compare favourably with the rest of the world, attracting a great deal of publicity. Seeing our position relative to other nations has provided impetus to do better in future physical activity and health policy.</p> <p>The launch of the global matrix provided an important insight into why physical activity levels are so low in Scottish children and adolescents. The comparative approach to physical activity in the global matrix revealed that “we have built it but they have not come”: having good policy and physical environments for child physical activity is insufficient to create active healthy children.</p> <p>– John Reilly</p>
Slovenia	<p>It is a fantastic opportunity for the Republic of Slovenia to be involved in the Global Matrix 2.0. not just to see where our country ranks in terms of overall physical activity patterns in children and youth globally, but also as a way of communicating the current state of research and policy within Slovenia to a wider audience.</p> <p>– Shawnda Morrison</p>
United States	<p>The US Report Card is a major collaboration among partners of the National Physical Activity Plan Alliance. Having the Report Card initiative under this umbrella has been very rewarding as it allows for the rapid uptake of the results with organizations that can respond with strategies to improve the grades.</p> <p>– Peter Katzmarzyk</p>
Zimbabwe	<p>Being part of the Global Matrix 2.0 has been a great privilege, honour and an enriching experience at both personal and academic levels for me. Co-leading the development of Zimbabwe’s first ever Report Card introduced me to this incredible global network of dedicated scientists, policy makers and researchers. The process exposed me to a great network of local researchers and other influential stakeholders. Only through such genuine global efforts can we learn from, and with each other as peers. There is no doubt in my mind about the importance and positive impact of the report card to our efforts in promoting active and healthy lifestyles among Zimbabwean children and youth. This has been an incredible experience for me.</p> <p>– Taru Manyanga</p>