

Canadian 24-Hour Movement Guidelines for Children and Youth: An Integration of Physical Activity, Sedentary Behaviour, and Sleep¹

Mark S. Tremblay, Valerie Carson, Jean-Philippe Chaput, Sarah Connor Gorber, Thy Dinh, Mary Duggan, Guy Faulkner, Casey E. Gray, Reut Gruber, Katherine Janson, Ian Janssen, Peter T. Katzmarzyk, Michelle E. Kho, Amy E. Latimer-Cheung, Claire LeBlanc, Anthony D. Okely, Timothy Olds, Russell R. Pate, Andrea Phillips, Veronica J. Poitras, Sophie Rodenburg, Margaret Sampson, Travis J. Saunders, James A. Stone, Gareth Stratton, Shelly K. Weiss, and Lori Zehr

Abstract: Leaders from the Canadian Society for Exercise Physiology convened representatives of national organizations, content experts, methodologists, stakeholders, and end-users who followed rigorous and transparent guideline development procedures to create the *Canadian 24-Hour Movement Guidelines for Children and Youth: An Integration of Physical Activity, Sedentary Behaviour, and Sleep*. These novel guidelines for children and youth aged 5–17 years respect the natural and intuitive integration of movement behaviours across the whole day (24-h period). The development process was guided by the Appraisal of Guidelines for Research Evaluation (AGREE) II instrument and systematic reviews of evidence informing the guidelines were assessed using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach. Four systematic reviews (physical activity, sedentary behaviour, sleep, integrated behaviours) examining the relationships between and among movement behaviours and several health indicators were completed and interpreted by expert consensus. Complementary compositional analyses were performed using Canadian Health Measures Survey data to examine the relationships between movement behaviours and health indicators. A stakeholder survey was employed ($n = 590$) and 28 focus groups/stakeholder interviews ($n = 104$) were completed to gather feedback on draft guidelines. Following an introductory preamble, the guidelines provide evidence-informed recommendations for a healthy day (24 h), comprising a combination of sleep, sedentary behaviours, light-, moderate-, and vigorous-intensity physical activity. Proactive dissemination, promotion, implementation, and evaluation plans have been prepared in an effort to optimize uptake and activation of the new guidelines. Future research should consider the integrated relationships among movement behaviours, and similar integrated guidelines for other age groups should be developed.

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M.S. Tremblay and J.-P. Chaput. Healthy Active Living and Obesity Research Group, Children's Hospital of Eastern Ontario Research Institute, Ottawa, ON K1H 8L1, Canada; Department of Pediatrics, University of Ottawa, ON K1H 8L1, Canada.

V. Carson. Faculty of Physical Education and Recreation, University of Alberta, Edmonton, AB T6G 2H9, Canada.

S. Connor Gorber.* Public Health Agency of Canada, Ottawa, ON K1A 0K9, Canada.

T. Dinh. The Conference Board of Canada, Ottawa, ON K1H 8M7, Canada.

M. Duggan. Canadian Society for Exercise Physiology, Ottawa, ON K1R 6Y6, Canada.

G. Faulkner. School of Kinesiology, University of British Columbia, Vancouver, BC V6T 1Z3, Canada.

C.E. Gray, V.J. Poitras, and M. Sampson. Healthy Active Living and Obesity Research Group, Children's Hospital of Eastern Ontario Research Institute, Ottawa, ON K1H 8L1, Canada.

R. Gruber. Attention, Behavior, and Sleep Laboratory, Douglas Mental Health University Institute, Verdun, QC H4H 1R3, Canada.

K. Janson. ParticipACTION, Toronto, ON M5S 1M2, Canada.

I. Janssen. School of Kinesiology and Health Studies, Queen's University, Kingston, ON K7L 3N6, Canada; Department of Public Health Sciences, Queen's University, Kingston, ON K7L 3N6, Canada.

P.T. Katzmarzyk. Pennington Biomedical Research Center, Baton Rouge, LA 70808, USA.

M.E. Kho. School of Rehabilitation Science, McMaster University, Hamilton, ON L8S 1C7, Canada.

A.E. Latimer-Cheung. Healthy Active Living and Obesity Research Group, Children's Hospital of Eastern Ontario Research Institute, Ottawa, ON K1H 8L1, Canada; School of Kinesiology and Health Studies, Queen's University, Kingston, ON K7L 3N6, Canada.

C. LeBlanc. Department of Pediatrics, McGill University, Montreal, QC H4A 3J1, Canada.

A.D. Okely. Early Start Research Institute, Faculty of Social Sciences, University of Wollongong, Wollongong, New South Wales 2522, Australia.

T. Olds. Alliance for Research in Exercise, Nutrition and Activity (ARENA), Sansom Institute of Health Research, University of South Australia, Adelaide 5001, Australia.

R.R. Pate. Department of Exercise Science, Arnold School of Public Health, University of South Carolina, Columbia, SC 29208, USA.

A. Phillips and S. Rodenburg. No affiliation.

T.J. Saunders. Applied Human Sciences, Faculty of Science, University of Prince Edward Island, Charlottetown, PE C1A 4P3, Canada.

J.A. Stone. Cardiovascular Health and Stroke Strategic Clinical Network, Cumming School of Medicine, University of Calgary, Calgary, AB T2N 4N1, Canada.

G. Stratton. Applied Sport Technology Exercise and Medicine Research Centre, College of Engineering, Swansea University, Wales, SA2 8PP, UK.

S.K. Weiss. Division of Neurology, The Hospital for Sick Children, University of Toronto, Toronto, ON M5G 1X8, Canada.

L. Zehr. Canadian Society for Exercise Physiology, Ottawa, ON K1R 6Y6, Canada; Camosun College, Victoria, BC V9E 2C1, Canada.

Corresponding author: Mark S. Tremblay (email: mtremblay@cheo.on.ca).

*Present address: Canadian Institutes of Health Research, 160 Elgin Street, 10th Floor, Ottawa, ON K1A 0W9, Canada.

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Key words: public health, recommendations, exercise, lifestyle, healthy living, clinical practice guidelines, GRADE.

Résumé : Des dirigeants de la Société canadienne de physiologie de l'exercice ont convié des représentants d'organismes nationaux, des experts en la matière, des spécialistes de la méthodologie, des intervenants et des utilisateurs finaux afin de créer des *Directives canadiennes en matière de mouvements sur 24 heures pour les enfants et les jeunes : une approche intégrée regroupant l'activité physique, le comportement sédentaire et le sommeil*; des procédures strictes et claires ont été suivies dans l'élaboration des directives. Ces nouvelles lignes directrices à l'intention des enfants âgés de 5 à 17 ans prennent en compte l'intégration naturelle et intuitive des comportements kinésiques durant toute une journée (24 h). Le processus d'élaboration est dicté par la grille AGREE II (*Appraisal of Guidelines for Research Evaluation*) et l'analyse documentaire systématique à l'appui des directives utilise la méthodologie GRADE (*Grading of Recommendations Assessment, Development, and Evaluation*). Quatre analyses documentaires systématiques (activité physique, comportement sédentaire, sommeil, comportements intégrés) traitant de la relation entre et parmi les comportements kinésiques et plusieurs indicateurs de santé sont réalisées et interprétées selon un consensus d'experts. On effectue des analyses compositionnelles complémentaires des données de l'Enquête canadienne sur les mesures de la santé afin de déterminer les relations entre les comportements kinésiques et les indicateurs de santé. On réalise un sondage auprès des intervenants ($n = 590$) et on effectue 28 entrevues auprès de groupes de discussion/intervenants ($n = 104$) afin d'obtenir des rétroactions à propos de l'ébauche des directives. Après la présentation d'un préambule introductif, les directives comprennent des recommandations probantes pour une journée saine (24 h) incluant une combinaison de sommeil, de comportements sédentaires, d'activité physique d'intensité légère, modérée et vigoureuse. Des plans de diffusion proactive, de promotion, de mise en application et d'évaluation sont élaborés afin d'optimiser l'accueil et la mise en place des nouvelles directives. D'autres études devraient prendre en compte les liens étroits entre les comportements kinésiques et des directives similaires d'intégration à l'intention d'autres groupes d'âge devraient être élaborées. [Traduit par la Rédaction]

Mots-clés : santé publique, recommandations, exercice physique, mode de vie, vie saine, directives pour la pratique clinique, GRADE.

Introduction

Public health concerns regarding trends in childhood physical activity (Colley et al. 2011; ParticipACTION 2015, 2016; Poitras et al. 2016), sedentary behaviour (Carson et al. 2016a; Colley et al. 2011; ParticipACTION 2015, 2016), sleep (Chaput et al. 2016; Owens 2014; Matricciani et al. 2012; ParticipACTION 2016), and obesity (Gotay et al. 2013; Ng et al. 2014) have galvanized attention and established the resolution and reversal of such trends as a strategic priority (Canadian Ministers of Health/Healthy Living and Sport, Physical Activity and Recreation 2016; Tremblay 2012; Tremblay et al. 2016). Multiple, concurrent correlates and determinants related to each individual behaviour (i.e., sleep, sedentary behaviour, physical activity) conflate and conspire to perpetuate these trends. Recently, leaders in healthy active living, public health, and preventive medicine have shown increased interest in how the various movement-related behaviours (i.e., sleep, sedentary behaviour, and physical activity of all intensities) that make up the whole day (24-h period) interact to influence holistic health (Chaput et al. 2014; Saunders et al. 2016; Thompson et al. 2015; Tremblay et al. 2010a, 2016). While it may seem inappropriate or counter-intuitive to include sedentary behaviour and sleep in a list of "movement behaviours", we do so throughout this paper and the guidelines in the context of a movement continuum (Tremblay et al. 2010a) and to succinctly capture the relevant components of the whole day. Furthermore, novel analysis procedures have opened new opportunities to quantitatively assess behaviour compositions in relation to health indicators of interest (Carson et al. 2016b; Chastin et al. 2015; Pedisic 2014).

Canada has a rich history of producing and promoting evidence-informed physical activity guidelines (Tremblay et al. 2007a, 2007b; 2011a, 2012a) and more recently, sedentary behaviour guidelines (Tremblay et al. 2011b, 2012b) for the promotion of population health. While awareness of the existing guidelines is low (LeBlanc et al. 2015), feedback from a variety of stakeholders (e.g., parents, teachers, physical activity professionals, pediatricians) indicates that integrated guidelines that combine the movement behaviours across the whole day would be welcomed and preferred over a series of segregated guidelines (Carson et al. 2013a; Faulkner et al. 2016). Therefore, the purpose of this manuscript is to outline the process and outcomes for the development of the *Canadian 24-Hour Movement Guidelines for Children and Youth: An Integration of Physical Activity, Sedentary Behaviour, and Sleep* that were released

by the Canadian Society for Exercise Physiology and partners on June 16, 2016.

Materials and methods

Guideline development structure

The guideline development process followed the framework explained in detail by Tremblay and Haskell (2012). This framework, which includes 15 stages (summarized in Fig. 1), was further enhanced through the application of the Appraisal of Guidelines for Research Evaluation (AGREE) II instrument (Brouwers et al. 2010a, 2010b, 2010c, 2016) from the outset, the early engagement of guideline development methodologists, and from extensive experience and learning from earlier guideline development, dissemination, and implementation efforts.

The process began with the establishment of a Leadership Committee made up of the project Principal Investigators (Tremblay, Carson, Chaput) and representatives from each of the funding partners (Canadian Society for Exercise Physiology (CSEP); Healthy Active Living and Obesity Research Group (HALO) at the Children's Hospital of Eastern Ontario Research Institute; The Conference Board of Canada; Public Health Agency of Canada (PHAC); and ParticipACTION). This Committee, formed in October 2014, met monthly to provide oversight, strategic direction, and fiscal accountability for the project. Two guideline development consultants were immediately engaged and a commitment to using the AGREE II instrument was made. A subset of members of the Leadership Committee and the methodology consultants formed an operational Steering Committee to deal with methodological issues as they arose. Finally, a guideline development Consensus Panel was formed with members including research experts, stakeholder groups and knowledge users, international collaborators, methodology consultants, target population users (parent and youth), and project managers (Table 1).

The Consensus Panel met in December 2014 for 2.5 days. The objectives of this initial meeting were to provide an overview of the guideline development process, responsibilities, and timelines; introduce the methodology consultants and explain their responsibilities; hear from international delegates about other country guideline processes and potential harmonization and efficiencies; finalize the systematic review parameters; finalize the search strategies for the systematic reviews; discuss and set timelines for the systematic reviews; and initiate discussions regarding knowledge translation, dissemination, and evaluation. At this meeting,

Fig. 1. Timelines and sequence of events involved in the development of the *Canadian 24-Hour Movement Guidelines for Children and Youth: An Integration of Physical Activity, Sedentary Behaviour, and Sleep*. AGREE, Appraisal of Guidelines for Research Evaluation; APNM, Applied Physiology, Nutrition, and Metabolism; CSEP, Canadian Society for Exercise Physiology; PICO, Population, Intervention, Comparator, Outcomes.



the group also identified and prioritized the outcomes/indicators for each of the systematic reviews.

Systematic reviews

It was determined that 4 systematic reviews were required to inform the development of the 24-h movement guidelines. A brief overview of each systematic review is provided below, with full details available in the systematic review papers (Carson et al. 2016a; Chaput et al. 2016; Poitras et al. 2016; Saunders et al. 2016).

For all systematic reviews, the quality of evidence was assessed by outcome/indicator and study design, using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach (Balslem et al. 2011; Guyatt et al. 2011).

The first systematic review examined the relationships between objectively measured physical activity (total and all intensities) and health indicators in children and youth (PROSPERO registration: CRD42015015488) (Poitras et al. 2016). The population included apparently healthy children and youth aged 5–17 years (i.e., general population samples, including those with overweight/obesity, but with absence of diagnosed disease or condition); the intervention/exposure/comparator included volumes, durations, frequencies/intensities, and patterns of objectively measured physical activity; and health outcomes/indicators included body composition, cardiometabolic biomarkers, physical fitness, behavioural conduct/pro-social behaviour, cognition/academic achievement, quality of life/well-being, harms, bone health, motor skill development, psychological distress, and self-esteem (Poitras et al. 2016).

The second systematic review was an update of the review (Tremblay et al. 2011c) that informed the existing sedentary behaviour guidelines (Tremblay et al. 2011b) examining the relationships between objectively and subjectively measured sedentary behaviour and health indicators in children and youth (PROSPERO registration: CRD42015015494) (Carson et al. 2016a). The population included apparently healthy children and youth aged 5–17 years; the intervention/exposure/comparator included durations, patterns, and types of sedentary behaviours; and the health outcomes/indicators included body composition, metabolic syndrome/cardiovascular disease risk factors, behavioural conduct/pro-social behaviour, academic achievement, fitness, and self-esteem (Carson et al. 2016a).

The third systematic review examined the relationships between objectively and subjectively measured sleep duration and various health indicators in children and youth (PROSPERO Registration: CRD42015015492) (Chaput et al. 2016). The population included apparently healthy children and youth aged 5–17 years; the intervention/exposure/comparator included various sleep durations; and health outcomes/indicators included adiposity, emotional regulation, cognition/academic achievement, quality of life/well-being, harms/injuries, and cardiometabolic biomarkers (Chaput et al. 2016).

The fourth systematic review examined how combinations of physical activity, sedentary behaviour, and sleep were associated with important health indicators in children and youth (PROSPERO registration: CRD42015015493) (Saunders et al. 2016). The population included apparently healthy children and youth aged 5–17 years; the intervention/exposure/comparator included different combinations of physical activity, sedentary behaviour, and sleep; and health outcomes/indicators included adiposity, cardiometabolic biomarkers, physical fitness, emotional regulation/psychological distress, behavioural conduct/pro-social behaviour, cognition, quality of life/well-being, injuries, bone density, motor skill development, and self-esteem. Studies that examined physical activity were included if the behaviour was measured objectively, while measures of sleep and sedentary behaviours could be objective or subjective (Saunders et al. 2016).

Compositional analyses

Movement behaviours have traditionally been assessed in isolation and consequently the evidence base is similarly constructed. While 3 of the systematic reviews outlined above provide a comprehensive assessment of the relationships between each individual movement behaviour (i.e., sleep, sedentary behaviour, physical activity) and indicators of health, only the review by Saunders et al. (2016) examined evidence in relation to combinations of multiple movement behaviours. Examining the combination of behaviours that constitute the complete 24-h period creates inherent analytical challenges that have been largely disregarded in the movement science literature (Chastin et al. 2015; Pedisic 2014).

Table 1. Guideline Consensus Panel.

Panel member	Affiliation	Role	Conflict of interest declaration
Research experts			
Valerie Carson, PhD	Assistant Professor, University of Alberta (Canada)	Compositional Analyses Leader, PA and SB Content Expert, Leadership Committee, Steering Committee, Surveillance Sub-Committee, Systematic Review Author	None
Jean-Philippe Chaput, PhD	Research Scientist, HALO (Canada)	Sleep, PA, and SB Content Expert, Leadership Committee, Steering Committee, Surveillance Sub-Committee, Systematic Review Author	None
Guy Faulkner, PhD	Professor and CIHR-PHAC Chair in Applied Public Health, University of British Columbia (Canada)	PA Content Expert, Stakeholder Consultation (Focus Groups)	None
Reut Gruber, PhD	Professor, McGill University; Director, Attention Behavior and Sleep Lab, Douglas Mental Health University Institute (Canada)	Sleep Content Expert, Systematic Review Author	None
Ian Janssen, PhD	Professor and Canada Research Chair in Physical Activity and Obesity, Queen's University (Canada)	PA and SB Content Expert, Surveillance Sub-Committee, Systematic Review Author	None
Amy E. Latimer-Cheung, PhD	Associate Professor, Queen's University; Canada Research Chair, Tier 2 (Canada)	Creative Development and Marketing, PA Content Expert, Stakeholder Consultation (Focus Groups), Dissemination and Implementation, Evaluation	None
Travis J. Saunders, PhD	Assistant Professor, University of Prince Edward Island (Canada)	SB and PA Content Expert, Invited Representative (Sedentary Behaviour Research Network), Systematic Review Author	Has received research and/or in-kind support from StepsCount, Pacific Rim Wellness, and Ergotron
Mark S. Tremblay, PhD	Director, Healthy Active Living and Obesity Research Group (HALO), Children's Hospital of Eastern Ontario Research Institute (Canada)	Chair, PA and SB Content Expert, Leadership Committee, Surveillance Sub-Committee, Steering Committee, Systematic Review Author, Supporting Papers Author, Dissemination and Implementation, Evaluation	None
Stakeholder groups and knowledge users			
Thy Dinh, PhD	Director of Health Economics, Public Policy Division, Conference Board of Canada (Canada)	PA and SB Content Expert, Invited Representative (The Conference Board of Canada), Leadership Committee	None
Mary Duggan, CAE	Manager, Canadian Society for Exercise Physiology (Canada)	Leadership Committee, CSEP Representative, Dissemination and Implementation, Evaluation	None
Katherine Janson	Director of Communications and Public Affairs, ParticipACTION (Canada)	Creative Development and Marketing, Invited Representative (ParticipACTION), Leadership Committee	None
Claire LeBlanc, MD, FRCPC	Pediatric Rheumatologist and Sport Medicine Physician, Montreal Children's Hospital (Canada)	Invited Representative (Canadian Pediatric Society), PA, SB, and Sleep Content Expert	None
Andrea Phillips	Parent (Canada)	Stakeholder Representative (parent)	None
Sophie Rodenburg	High-school student (Canada)	Stakeholder Representative (youth)	None
James A. Stone, MD, PhD, FRCPC	Clinical Professor, University of Calgary; Consultant Cardiologist (Canada)	Invited Representative (C-CHANGE), PA Content Expert	None

Table 1 (concluded).

Panel member	Affiliation	Role	Conflict of interest declaration
Shelly K. Weiss, MD, FRCPC	Professor, Pediatric Neurologist, The Hospital for Sick Children, University of Toronto; President, Canadian Sleep Society (Canada)	Sleep Content Expert, Invited Representative (Canadian Sleep Society)	None
Lori Zehr, MSc, CSEP Certified Exercise Physiologist	President, CSEP (Canada)	Invited Representative (CSEP), Leadership Committee, Steering Committee, Dissemination and Implementation, PA Content Expert	None
International collaborators			
Peter T. Katzmarzyk, PhD	Professor and Associate Executive Director for Population and Public Health Sciences; Marie Edana Corcoran Endowed Chair in Pediatric Obesity and Diabetes; Pennington Biomedical Research Center (USA)	PA and SB Content Expert, International Representative, Surveillance Sub-Committee, Systematic Review Author	Recently completed a childhood obesity study funded by the Coca-Cola company
Anthony D. Okely, PhD	Professorial Fellow and Director, Early Start Institute, University of Wollongong (Australia)	SB and PA Content Expert, International Representative, Systematic Review Author	None
Timothy Olds, PhD	Professor, University of South Australia (Australia)	Sleep, SB and PA Content Expert, International Representative, Systematic Review Author	Has received funding from Australian government bodies and Coca-Cola funding to present research findings in Dubai (presentation title: "The International Study of Childhood Obesity, Lifestyle and Environment"); was part of a multi-national study funded by Coca-Cola but does not receive direct funding from Coca-Cola at his institution
Russell R. Pate, PhD	Professor, University of South Carolina (USA)	PA and SB Content Expert, International Representative, Systematic Review Author	None
Gareth Stratton, PhD	Professor, Swansea University (Wales)	PA Content Expert, International Representative	None
Methodology consultants and project management			
Sarah Connor Gorber, PhD	Office of the Task Force on Preventive Health Care, PHAC (Canada)	AGREE II and GRADE Methodological Consultant; Steering Committee, Systematic Review Author	None
Casey E. Gray, PhD	Project Manager, HALO (Canada)	PA and SB Content Expert, Leadership Committee, Steering Committee, Systematic Review Author	None
Michelle E. Kho, PT, PhD	Assistant Professor, McMaster University; Tier 2 Canada Research Chair in Critical Care Rehabilitation and Knowledge Translation (Canada)	AGREE II and GRADE Methodological Consultant; Steering Committee, Systematic Review Author	Received honorarium for methodological consultation
Veronica J. Poitras, PhD	Research Coordinator, HALO (Canada)	PA and SB Content Expert, Leadership Committee, Steering Committee, Surveillance Sub-Committee, Systematic Review Author, Evaluation	None
Margaret Sampson, PhD	Manager, Media House and Library Services, Children's Hospital of Eastern Ontario (Canada)	Methodology Expert, Research Librarian, Systematic Review Author	None

Note: AGREE, Appraisal of Guidelines for Research Evaluation; CAE, Certified Association Executive; C-CHANGE, Canadian Cardiovascular Harmonized National Guidelines Endeavour; CIHR, Canadian Institutes of Health Research; CSEP, Canadian Society for Exercise Physiology; FRCPC, Fellow of the Royal College of Physicians of Canada; GRADE, Grading of Recommendations Assessment, Development, and Evaluation; HALO, Healthy Active Living and Obesity Research Group; PA, physical activity; PHAC, Public Health Agency of Canada; SB, sedentary behaviour.

Because the constituent parts (sleep, sedentary behaviour, physical activity) explain the entire 24-h period, any change in a behaviour must be done at the expense of one of the other behaviours, making the variables time-dependent and constitutionally colinear. Traditional statistical procedures (e.g., regression, correlation) fail to adequately address this geometric reality and may produce incorrect results. Compositional data analyses can be used to appropriately analyze data that are a proportion of a finite whole (e.g., 24 h), whereby results are interpreted as a proportion relative to the other behaviours instead of being independent of other behaviours (Chastin et al. 2015).

To further inform the 24-h guidelines, compositional analyses were used to examine the relationships among movement behaviours (sleep duration, sedentary time, physical activity) and health indicators in a representative sample of 4169 children and youth (aged 6–17 years) from cycles 1 to 3 of the Canadian Health Measures Survey (Tremblay et al. 2007c). Sedentary time, light-intensity physical activity, and moderate- to vigorous-intensity physical activity (MVPA) were accelerometer-derived. Sleep duration was subjectively measured. Body mass index *z* score, waist circumference, blood pressure, behavioural strengths and difficulties, aerobic fitness, triglycerides, high-density lipoprotein cholesterol, C-reactive protein, and insulin were measured and used as indicators of health. For complete details on the compositional analyses see Carson et al. (2016b).

Guidelines recommendations and stakeholder consultations

The results from the systematic reviews and compositional analyses were presented at the second meeting of the Consensus Panel in August 2015. The specific objectives of this 3-day meeting were to review findings from the systematic reviews; develop individual movement behaviour guideline recommendations; review findings from the compositional analyses; create 24-h integrated movement guideline recommendations and a preamble for these recommendations; identify research gaps; and plan the launch, dissemination, promotion, and evaluation activities. Draft guideline recommendations were created and subsequently translated into French and back-translated for verification. All Consensus Panel members endorsed the draft guidelines for the stakeholder consultations.

An online survey was developed to solicit assessments and comments from stakeholders on the draft guidelines. Research Ethics Board approval was obtained for the administration of the survey and use of a passive consent process (Children's Hospital of Eastern Ontario Research Ethics Board no. 15/133X). The survey sought assessments of the clarity of the various sections of the guidelines as well as levels of agreement with the text. Basic demographic information was requested and an opportunity was provided to offer open comments on any aspect of the guidelines. The complete survey, in both English and French, is available in the Guideline Development Report (csep.ca/guidelines). The survey was disseminated through the various networks of Consensus Panel members, and followed a snowball sampling methodology (to optimize dissemination) to maximize reach and input from relevant stakeholders. The survey was live from November 24 to December 18, 2015. After the survey closed, the empirical responses from the 590 participants were tabulated and analyzed. Written comments were consolidated into themes and summaries were prepared. The stakeholder survey also permitted respondents to express their interest in publicly disclosing their support for the guidelines pending their review of the final draft. To facilitate this, interested respondents were asked to provide an email address where the final guidelines could be sent. The list of individuals and organizations publicly supporting the new guidelines is available at csep.ca/guidelines.

In addition to the online stakeholder survey, a series of focus groups and interviews targeting youth, parents, teachers, pediatricians, and exercise professionals (e.g., Certified Exercise Physi-

ologists, personal trainers) were also held to discuss the perceived acceptability of the guidelines, potential barriers to implementation, and preferred methods and messengers of dissemination (Faulkner et al. 2016). A total of 104 individuals participated in 20 focus groups (3 to 9 participants) and 8 interviews (1 or 2 participants). Focus groups and interviews were conducted from October 2015 to January 2016 in Toronto, Hamilton, Ottawa, and Vancouver. Two focus groups were conducted in French and the remaining focus groups and interviews were conducted in English. The audiotaped focus groups and interviews were transcribed verbatim and inductive and thematic data analyses were employed. Ethics approval was obtained from Research Ethics Boards in Ontario and British Columbia. Full details on the methodology are available elsewhere (Faulkner et al. 2016).

A subcommittee of the Consensus Panel reviewed the survey, focus group and interview results, and revised the Guidelines based on the feedback, ensuring changes remained true to the available evidence base. Subsequently, the revised Guidelines were circulated to the entire Consensus Panel for comment and final revisions. Consensus was achieved on the final Guidelines. Revisions were translated to finalize the French version. The 2 methodological consultants and 2 additional independent reviewers conducted an AGREE II appraisal using the guideline materials and systematic reviews (Brouwers et al. 2010a, 2010b, 2010c, 2016).

Dissemination, implementation, and evaluation plans

In the context of the movement behaviour continuum and these new guidelines, the concept that the “whole day matters” represents a paradigm shift in this field. This shift creates an opportunity for the redevelopment of guideline dissemination and implementation practices. Previous efforts have focused on creating awareness through passive dissemination strategies (e.g., Website posts, distribution of print resources). For the new 24-h guidelines to impact public health, efforts need to move beyond dissemination and raising awareness to implementation, activation, and behaviour change. To achieve these goals requires new, innovative approaches to intervention including interdisciplinary collaboration, policy change, and refocused service provision. A subgroup of the Consensus Panel, with additional members from CSEP, thoroughly considered the resources and supports necessary to facilitate strategic and proactive dissemination, promotion and implementation of the new guidelines (Latimer-Cheung et al. 2016). The manuscript by Latimer-Cheung et al. (2016) discusses the implications of the new guidelines for practitioners, professionals, and organizations and identifies strategies to optimize guideline uptake and activation through these stakeholder groups. A list of initial resources and tools being developed is provided. Resources not yet developed but necessary for full activation of the guidelines are also identified. Aligned with these efforts, ParticipACTION orchestrated the development of the visual identity of the new 24-h guidelines as well as the development of an integrated marketing and communications plan for sustained dissemination and implementation following the initial guideline launch.

A phased evaluation plan has been developed. The first phase includes gathering data from CSEP and ParticipACTION that will provide a cursory indication of dissemination reach. The second phase is a proposal for a comprehensive, theory-based process and outcome evaluation.

Research gaps and surveillance recommendations

Research gaps were identified through the systematic reviews and the Consensus Panel meetings and were recorded. The new paradigm of the 24-h movement guidelines demands a rethink of traditional surveillance measures that have focused on individual behaviours (i.e., sleep, sedentary behaviours (or sedentary time), and physical activity (predominantly MVPA)). The new paradigm suggests that diminished attention be given to the individual be-

haviours and increased attention be given to the combination or composition of the behaviours. In essence, the focus should be on a healthy movement behaviour profile rather than a single healthy movement behaviour, analogous to what is done for healthy eating (Health Canada 2011). Consequently, a Surveillance Subcommittee of the Consensus Panel, with additional members with extensive movement behaviour surveillance experience, convened to discuss and develop preliminary recommendations for the monitoring and surveillance of the new 24-h guidelines. Surveillance and monitoring issues that need to be addressed were identified, including: determining what data are available with existing surveillance mechanisms, the rationale for surveillance recommendations and how to explain corresponding apparent changes in population trends, and possible changes required to existing surveys to accommodate future monitoring and surveillance needs. Discussions were guided by the underlying research data.

Results

Systematic reviews

Complete results of all systematic reviews are available elsewhere in this special issue of *Applied Physiology, Nutrition, and Metabolism* (Carson et al. 2016a; Chaput et al. 2016; Poitras et al. 2016; Saunders et al. 2016). Because of significant heterogeneity in a variety of variables, meta-analyses could not be performed for any of the systematic reviews, so all employed narrative syntheses. Briefly, for physical activity, 6227 studies were identified through all searching sources, with 499 studies remaining after screening titles and abstracts; 162 studies (from 70 unique samples) met inclusion criteria for the systematic review (Poitras et al. 2016). These studies represented 204 171 participants from 31 countries. The quality of the evidence ranged from very low to moderate across the health indicators using GRADE criteria (Balslem et al. 2011). In general, total physical activity was favourably associated with physical, psychological/social, and cognitive health indicators. Relationships were more consistent and robust for higher-intensity compared with lighter-intensity physical activity. Nevertheless, light-intensity physical activity was favourably associated with cardiometabolic biomarkers. All patterns of activity (sporadic, bouts, continuous) provided health benefits. No studies were found that evaluated harms associated with objectively measured physical activity. Overall, the findings provide no evidence to change the current guidelines recommending that children and youth accumulate at least 60 min/day of MVPA for disease prevention and health promotion (Tremblay et al. 2011a). The findings also highlight the potential benefits of both light-intensity physical activity and total physical activity, neither of which were captured in the previous guidelines (Poitras et al. 2016).

The sedentary behaviour systematic review update search captured 8338 studies, with 923 studies after screening titles and abstracts, and 235 studies representing 194 unique samples ultimately included (Carson et al. 2016a). These studies represented 1 657 064 participants from 71 different countries. Thirty-five studies used objective measures of sedentary time, while the remaining 200 measured sedentary behaviours subjectively using parental-, pediatrician-, or self-report questionnaire; diary; or interview. Quality of the evidence ranged from very low to moderate across the different health indicators. Overall, the review found that higher durations and/or frequencies of screen time and television (TV) viewing were associated with unfavourable body composition; higher duration and/or frequency of TV viewing was associated with higher clustered cardiometabolic disease risk scores; higher durations of TV viewing and video game use were associated with unfavourable behavioural conduct/pro-social behaviour indicators; higher durations of reading and doing homework were associated with higher academic achievement; higher duration of screen time was associated with lower fitness; and

higher durations of screen time and computer use were associated with lower self-esteem (Carson et al. 2016a). Generally, the evidence suggests screen time (and especially TV viewing) has a stronger relationship with health indicators compared with overall sedentary time and that different types of sedentary behaviour may have different impacts on different indicators of health. A gradient was observed across most health indicators, indicating that less sedentary behaviour (especially screen time) was associated with better health indicator profiles; however, higher quality studies are needed to confirm this primarily observational evidence (Carson et al. 2016a).

The sleep systematic review identified 4493 studies, with 318 studies after screening titles and abstracts; 141 studies representing 110 unique samples were included, encompassing 592 215 participants from 40 different countries (Chaput et al. 2016). Sleep duration was measured objectively in 29 studies and through self-report or parental-report questionnaires or diaries in the remaining studies. The quality of evidence ranged from very low to high across different health indicators. Overall, longer sleep duration was associated with favourable indicators of adiposity, emotional regulation, academic achievement, and quality of life/well-being; however, the evidence was equivocal or limited for the association between sleep duration and cognition, harms/injuries, and cardiometabolic biomarkers (Chaput et al. 2016). It was concluded that shorter sleep duration is associated with adverse physical and mental health outcomes but that higher quality research designs with more robust measures are needed to have a better sense of dose-response relationships and to establish optimal sleep thresholds (Chaput et al. 2016).

The final systematic review included studies that investigated how combinations of physical activity, sedentary behaviour, and sleep were associated with important health indicators. The searches yielded 489 studies, with 71 remaining after screening titles and abstracts; 14 studies representing 36 560 participants from 20 different countries were included (Saunders et al. 2016). The overall quality of evidence from the review was rated as low. In general, the findings indicated that school-aged children and youth having a high physical activity + high sleep + low sedentary behaviour profile generally had more desirable measures of adiposity and cardiometabolic health when compared with those with a combination of low physical activity + low sleep + high sedentary behaviour. Similarly, those with high physical activity + high sleep or high physical activity + low sedentary behaviour profiles demonstrated favourable health indicators compared with low physical activity + low sleep, or low physical activity + high sedentary behaviour profiles (Saunders et al. 2016). The available evidence suggests optimal health benefits may be achieved from replacing sedentary behaviour with MVPA (Saunders et al. 2016). Similar to each individual behaviour systematic review, a stronger evidence-base would lead to greater confidence in the findings.

Compositional analyses

The novel compositional analyses completed by Carson et al. (2016b) provide unique, albeit cross-sectional, insight into the relevance of the composition of movement behaviours that make up the 24-h period to important indicators of health. Data from the Canadian Health Measures Survey show that 6–17-year-old Canadians spend 40% of the 24-h period in sleep, 38% in sedentary time, 18% in light-intensity physical activity, and 4% in MVPA (Carson et al. 2016b). Importantly, the *composition* (i.e., specific combination) of movement behaviours was significantly associated with all health indicators. The portion of variance in health indicators explained by the composition of movement behaviours ranged from 1% to 44% (Carson et al. 2016b). Overall, the findings highlight and support the importance of MVPA for optimal health in children and youth. However, the findings also support the importance of the time spent in other movement behaviours outside of MVPA for health benefits, supporting the notion that guidelines

Table 2. Summary results of closed-ended stakeholder survey questions.

Question	Strongly agree, % (n)	Somewhat agree, % (n)	Neither agree nor disagree, % (n)	Somewhat disagree, % (n)	Strongly disagree, % (n)	Total responses (n)
Is the title clearly stated?	49.3% (291)	42.0% (248)	3.1% (18)	5.6% (33)	0.0% (0)	590
Do you agree with the title?	41.4% (241)	43.1% (251)	8.8% (51)	6.2% (36)	0.5% (3)	582
Is the preamble clearly stated?	55.8% (286)	38.4% (197)	3.5% (18)	2.1% (11)	0.2% (1)	513
Do you agree with the preamble?	62.0% (317)	32.5% (166)	3.1% (16)	2.0% (10)	0.4% (2)	511
Are the Guidelines clearly stated?	59.6% (298)	35.8% (179)	1.6% (8)	2.6% (13)	0.4% (2)	500
Do you agree with the Guidelines?	66.0% (330)	27.8% (139)	3.8% (19)	2.2% (11)	0.2% (1)	500
	Much more useful, % (n)	More useful, % (n)	Neutral, % (n)	Less useful, % (n)	Much less useful, % (n)	Total responses (n)
In comparison to separate physical activity, sedentary behaviour, and sleep guidelines, do you find these integrated Guidelines...	29.0% (137)	50.2% (237)	19.5% (92)	0.6% (3)	0.6% (3)	472

and public health messaging aimed at optimizing health in pediatric populations should consider an integrated movement behaviour approach (Carson et al. 2016b).

Stakeholder consultations and final guidelines

The draft guidelines developed and approved by consensus at the August 2015 meeting of the Consensus Panel were used for the online stakeholder survey and for the focus groups and stakeholder interviews. During the 3 and a half weeks that the online stakeholder survey was open, 824 respondents landed on the front page. The number of responses varied by question (463 to 590 responses for close-ended questions; 107 to 275 responses for open-ended questions), with lower rates on questions in the middle to end of the survey. Respondents were from every province and 1 of the 3 territories in Canada with the majority living in Ontario (30%), Alberta (20%), Québec (13%), British Columbia (6%), Manitoba (6%), and Saskatchewan (5%). International respondents (2%) were from 5 of the 7 continents including North America, South America, Europe, Asia, and Australia. The majority of respondents identified as being from the following sectors: public health (22%), healthcare (18%), research (16%), education (13%), and physical activity/fitness (13%).

For all sections of the Guidelines (title, preamble, guidelines), the proportion of respondents who strongly agreed or somewhat agreed that the sections were clearly stated ranged from 91% to 95%. The proportion who strongly agreed or somewhat agreed with the message in these sections ranged from 85% to 94%. A more detailed breakdown of the stakeholder survey responses is provided in Table 2. From the open-ended questions, the most frequently occurring concerns and suggestions were in relation to the Guidelines terminology (e.g., title too long, “movement” not required for sedentary behaviour and sleep, preamble and Guidelines too technical). Changes were made accordingly as described in the Methods. Many respondents ($n = 194$) indicated interest in publicly supporting the Guidelines once finalized.

Feedback obtained through the focus groups and interviews generally supported the findings from the on-line survey (Faulkner et al. 2016). Overall, there was consistent support across all stakeholder groups for the 24-h guidelines, with the exception of the focus groups with youth. Youth generally lacked interest in the new guidelines and found them to be of low relevance because future health issues were not an immediate concern. Adult participants identified a range of barriers to the uptake of the guidelines including concerns with accurately defining key terms such as “recreational” screen time, everyday challenges such as financial and time constraints, and the possibility of the 24-hour guidelines becoming just another source of stress and guilt for already busy and overwhelmed parents (Faulkner et al. 2016). All participants recommended that future dissemination efforts, in a variety of forms and formats, should be done primarily through schools and medical settings. Overall, participants representing a

range of stakeholder groups were receptive to the new 24-h guidelines and endorsed their value (Faulkner et al. 2016).

Details of the changes made to the draft guidelines can be found in the final Guideline Development Report (csep.ca/guidelines). The final guidelines, including the title and preamble, are provided in Figs. 2a (English) and 2b (French). Based on the totality of evidence informing the guidelines, the following evidence-to-recommendation synthesis is made: the moderate-to-high confidence in the relationships between movement behaviours and highly valued outcomes (from very low- to high-quality evidence across all health indicators in 4 systematic reviews, with relative uniformity of findings), the lack of evidence of harms, the low costs associated with the recommended behaviours, and the values and preferences of the target population which indicated that most would support adoption of these guidelines, support the *strong recommendation* of these guidelines.

Dissemination, implementation, and evaluation plans

While the dissemination, implementation and evaluation of these new guidelines will be done in the future, a series of proactive activities were completed to “set the stage” for efficient and effective efforts in this regard. These activities included:

- Issuing advance notification through electronic newsletters and social media to practitioners, professionals, and organizations of the imminent release of the new guidelines, to raise awareness and pique interest.
- Developing a “visual identity” (concept brand) for the 24-h guidelines (Fig. 3) that can extend beyond the child and youth age group.
- Creating a toolkit of resources for stakeholder groups (e.g., infographics, tear-sheets, case studies, banners, social media posts, blogs, apps, professional development modules, curriculum updates, retraining workshops) (see Latimer-Cheung et al. 2016 for complete listing and further details).
- Establishing a broad and deep network of organizations, stakeholders and end-users for immediate dissemination upon the release of the new guidelines, with support materials for the promotion and uptake of the new guidelines.
- Having a high-profile release of the *Canadian 24-Hour Movement Guidelines for Children and Youth: An Integration of Physical Activity, Sedentary Behaviour, and Sleep*, including a comprehensive public relations and media strategy with spokespeople available across Canada.
- Preparing to gather data providing an indication of dissemination reach through established mechanisms that ParticipACTION and CSEP already have in place (e.g., media monitoring, Google Analytics).
- Creating an integrated marketing and communications strategy to facilitate sustained implementation and activation of the new 24-h guidelines following the initial guideline launch.

Fig. 2. (a) Final Canadian 24-Hour Movement Guidelines for Children and Youth: An Integration of Physical Activity, Sedentary Behaviour, and Sleep, 2016 (English). (b) Final Canadian 24-Hour Movement Guidelines for Children and Youth: An Integration of Physical Activity, Sedentary Behaviour, and Sleep, 2016 (French).

a)

Canadian 24-Hour Movement Guidelines for Children and Youth:
An Integration of Physical Activity, Sedentary Behaviour, and Sleep

Preamble

These guidelines are relevant to apparently healthy children and youth (aged 5–17 years) irrespective of gender, race, ethnicity, or the socio-economic status of the family. Children and youth are encouraged to live an active lifestyle with a daily balance of sleep, sedentary behaviours, and physical activities that supports their healthy development.

Children and youth should practice healthy sleep hygiene (habits and practices that are conducive to sleeping well), limit sedentary behaviours (especially screen time), and participate in a range of physical activities in a variety of environments (e.g., home/school/community; indoors/outdoors; land/water; summer/winter) and contexts (e.g., play, recreation, sport, active transportation, hobbies, and chores).

For those not currently meeting these 24-hour movement guidelines, a progressive adjustment toward them is recommended. Following these guidelines is associated with better body composition, cardiorespiratory and musculoskeletal fitness, academic achievement and cognition, emotional regulation, pro-social behaviours, cardiovascular and metabolic health, and overall quality of life. The benefits of following these guidelines far exceed potential risks.

These guidelines may be appropriate for children and youth with a disability or medical condition; however, a health professional should be consulted for additional guidance.

The specific guidelines and more details on the background research informing them, their interpretation, guidance on how to achieve them, and recommendations for research and surveillance are available at www.csep.ca/guidelines.

Guidelines

For optimal health benefits, children and youth (aged 5–17 years) should achieve high levels of physical activity, low levels of sedentary behaviour, and sufficient sleep each day.

A healthy 24 hours includes:

- Uninterrupted 9 to 11 hours of sleep per night for those aged 5–13 years and 8 to 10 hours per night for those aged 14–17 years, with consistent bed and wake-up times;
- An accumulation of at least 60 minutes per day of moderate to vigorous physical activity involving a variety of aerobic activities. Vigorous physical activities and muscle and bone strengthening activities should each be incorporated at least 3 days per week;
- Several hours of a variety of structured and unstructured light physical activities;
- No more than 2 hours per day of recreational screen time;
- Limited sitting for extended periods.

Preserving sufficient sleep, trading indoor time for outdoor time, and replacing sedentary behaviours and light physical activity with additional moderate to vigorous physical activity can provide greater health benefits.

b)

Directives canadiennes en matière de mouvement sur 24 heures pour les enfants et les jeunes:
une approche intégrée regroupant l'activité physique, le comportement sédentaire et le sommeil

Préambule

Ces directives s'appliquent à tous les enfants et les jeunes (âgés de 5 à 17 ans) vraisemblablement en santé sans égard au genre, à la race, à l'origine ethnique ou au statut socioéconomique familial. Les enfants et les jeunes sont encouragés à adopter un mode de vie actif et à maintenir un équilibre au quotidien entre le sommeil, le comportement sédentaire et les activités physiques afin de favoriser un développement sain.

Les enfants et les jeunes devraient adopter une hygiène de sommeil saine (des habitudes et pratiques qui amènent à bien dormir), limiter les comportements sédentaires (particulièrement le temps passé devant un écran) et participer à une gamme d'activités physiques dans une variété d'environnements (p. ex. à la maison/à l'école/dans la communauté; à l'intérieur/à l'extérieur; sur le sol/dans l'eau; l'été/l'hiver) et de contextes (p. ex. jeux, loisirs, sports, transport actif, passe-temps et tâches ménagères).

Pour celles et ceux qui ne respectent pas ces directives en matière de mouvement sur 24 heures, un ajustement progressif est recommandé afin de parvenir à les appliquer. Suivre ces directives est associé à un meilleur profil de composition corporelle, de condition physique cardiovasculaire et musculosquelettique, de réussite scolaire, de cognition, de régulation des émotions, de comportements prosociaux, de santé cardiovasculaire et métabolique, et de qualité de vie globale. Les avantages associés à l'adoption de ces directives surpassent de loin les risques potentiels.

Ces directives pourraient convenir aux enfants et aux jeunes ayant une incapacité ou un trouble médical. Toutefois, un professionnel de la santé devrait être consulté pour obtenir des conseils additionnels.

Les directives en tant que telles et plus de renseignements sur la recherche ayant mené à leur mise au point et à leur interprétation, ainsi que des conseils pour les mettre en application et des recommandations sur la recherche et la surveillance sont disponibles au www.scppe.ca/directives.

Directives

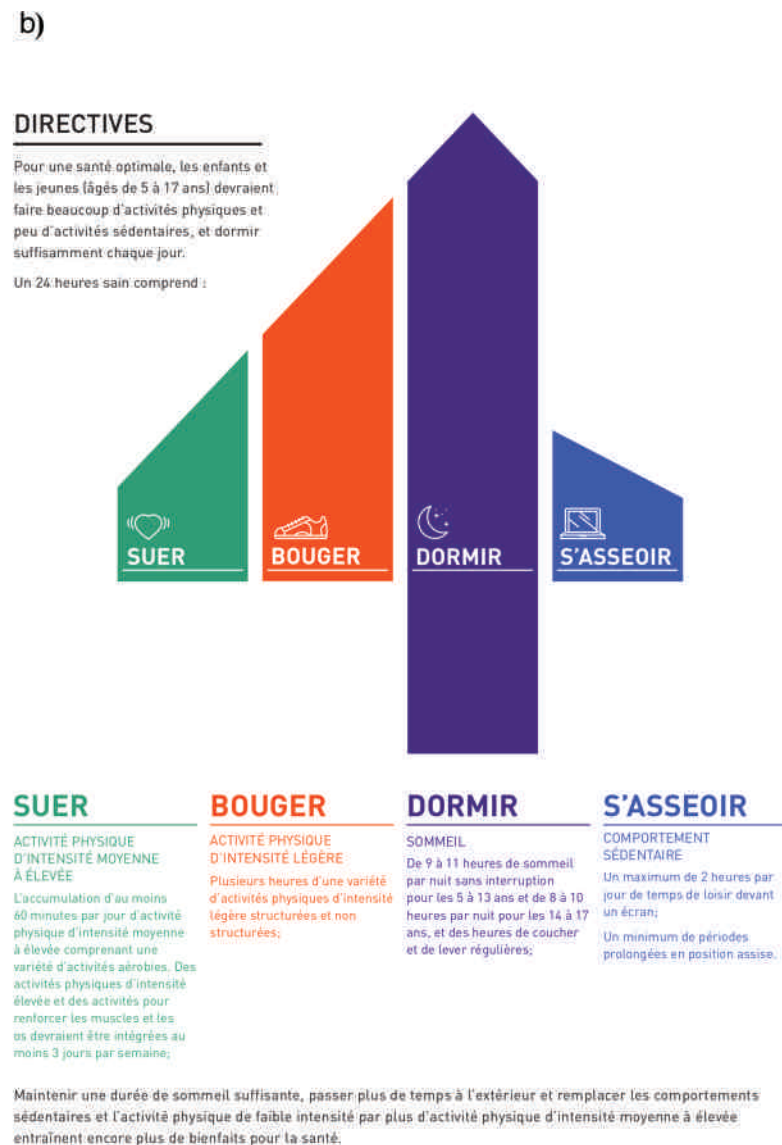
Pour une santé optimale, les enfants et les jeunes (âgés de 5 à 17 ans) devraient faire beaucoup d'activités physiques et peu d'activités sédentaires, et dormir suffisamment chaque jour.

Un 24 heures sain comprend :

- De 9 à 11 heures de sommeil par nuit sans interruption pour les 5 à 13 ans et de 8 à 10 heures par nuit pour les 14 à 17 ans, et des heures de coucher et de lever régulières;
- L'accumulation d'au moins 60 minutes par jour d'activité physique d'intensité moyenne à élevée comprenant une variété d'activités aérobies. Des activités physiques d'intensité élevée et des activités pour renforcer les muscles et les os devraient être intégrées au moins 3 jours par semaine;
- Plusieurs heures d'une variété d'activités physiques d'intensité légère structurées et non structurées;
- Un maximum de 2 heures par jour de temps de loisir devant un écran;
- Un minimum de périodes prolongées en position assise.

Maintenir une durée de sommeil suffisante, passer plus de temps à l'extérieur et remplacer les comportements sédentaires et l'activité physique de faible intensité par plus d'activité physique d'intensité moyenne à élevée entraînent encore plus de bienfaits pour la santé.

Fig. 3. Visual identity (concept branding) of the 24-hour guidelines. (a) English and (b) French.



A comprehensive theory-based evaluation strategy that includes a process and an outcome evaluation is planned. The strategy is guided by Rogers's (2003) diffusion of innovation theory and Evans's brand equity framework (Evans and Hastings 2008). Diffusion of innovation theory provides a foundation for understanding how an innovation (e.g., the guidelines) is spread through a social system (e.g., stakeholder organizations, parents, youth) over time (diffusion). The application of a brand equity framework will provide specific insight into the impact of the visual identity created for the guidelines on their uptake and implementation as well as the impact of the guidelines on the public's perceptions of endorsing organizations. Using these frameworks as a guide, the objective of the proposed process evaluation is to assess the overall uptake of the guidelines (e.g., presence of the guidelines on stakeholders' websites and frequency at which they are accessed) and the extent of their implementation in practice (e.g., assessment of how schools have modified the school day and their policies to align with the guidelines). The outcome evaluation will assess the immediate (proximal outcomes; e.g., awareness, brand equity) and long-term (distal outcomes; e.g., change in children and youths' behaviour) impact of the dissemination and implementation strategies.

Research gaps and surveillance recommendations

Research gaps identified through the systematic reviews, compositional analyses, Consensus Panel meetings, dissemination and implementation planning, and preparation of this manuscript are catalogued in Table 3. Because these guidelines represent a paradigm shift in thinking, there are many data gaps, research needs and unresolved questions and it is likely that this will be a burgeoning area of research in the coming years.

The new paradigm of 24-h guidelines changes the focus from individual behaviours to the collective or composition of behaviours across the whole day. With these new guidelines come new surveillance needs, challenges, and opportunities. The Surveillance Subcommittee recommended that adherence to the new guidelines be assessed using *average* weekly behaviours (see Table 4 for details). This was primarily because the importance of average weekly behaviours was supported by the evidence that informed the guidelines (Carson et al. 2016a; Chaput et al. 2016; Poitras et al. 2016; Saunders et al. 2016), but also because this allows for some day-to-day variability, reflects the "healthy living pattern" message of the guidelines, and gives equal weighting to the movement behaviours (physical activity, sedentary behaviour, and sleep) that comprise the 24-h guidelines. This differs from how some guideline adherences (i.e., MVPA) were evaluated in the past (e.g., see Colley et al. 2011), when individual movement behaviours were examined in isolation. To allow for sensible monitoring of trends over time for individual behaviours, it is recommended that *daily* measures (e.g., as per previous methodology for physical activity guidelines; Colley et al. 2011) be used to monitor temporal trends in individual behaviours. Discussions regarding necessary changes to existing surveys to accommodate future monitoring and surveillance needs are ongoing; see Table 4 for preliminary recommendations.

The summary evaluation from the AGREE II assessment is provided in Table 5. Four independent reviewers applied the AGREE II assessment, and domain scores were computed using the AGREE II Instrument calculation (AGREE Next Steps Consortium 2009). All 4 reviewers indicated that they would recommend the guideline for use, and the across-reviewer overall rating of the quality of the guideline was 92%. Additional details on all aspects of the guideline development process are available in the Guideline Development Report at csep.ca/guidelines.

Discussion

This paper outlines the process and outcomes for the development of *Canadian 24-Hour Movement Guidelines for Children and Youth:*

An Integration of Physical Activity, Sedentary Behaviour, and Sleep. The development of 24-h guidelines that integrate all movement behaviours represents a paradigm shift in thinking; a shift that is supported by existing literature, compositional analyses from a nationally representative dataset, evidence from other behavioural research, and common-sense. Evidence from the individual behaviour systematic reviews shows that total physical activity, light-intensity physical activity and especially MVPA are favourably related to a variety of health indicators in children and youth (Poitras et al. 2016). Similarly, excessive sedentary behaviour, and especially screen time, is associated with adverse health indicators (Carson et al. 2016a), as is short sleep duration (Chaput et al. 2016). Superficially, these daily movement behaviour components can be summed to give guidance regarding how the 24-h period should be constituted in an effort to promote health and prevent disease. The systematic review by Saunders et al. (2016) provides deeper insight as to how the individual behaviours interact and relate to health in various combinations. More sophisticated analyses show clearly that the *composition* of behaviours that make up the day is significantly related to a number of important health indicators (Carson et al. 2016b). Together these studies provide compelling evidence that the "whole day matters". While the 24-h guidelines may initially be viewed as another challenge and potential source of stress by busy parents, the overall concept of the integration of all behaviours on the movement continuum is widely supported by stakeholders and end-users (Carson et al. 2013a; Faulkner et al. 2016).

It could be argued that developing 24-h movement guidelines is premature given the relative paucity of experimental evidence examining the health consequences of manipulating the time devoted to sleep, sedentary behaviour and various intensities of physical activity, and the generally low quality of available evidence. Indeed, there was much discussion in relation to this, both at the Consensus Panel meetings and through email deliberations. In the end, there was agreement that proceeding with the 24-h guidelines using the best available evidence and expert consensus, while being transparent about the quantity and quality of the evidence base and the strength of the guideline recommendations, was the prudent approach in providing public health recommendations regarding movement behaviours for a healthy day. It was agreed that it was more important to help *push* this approach than wait for it to be *pulled* by more and higher quality research evidence, which ideally will be driven by this initiative. It was believed that public and population health had more to gain than lose by such an approach, though it is fully understood that there will be individuals and jurisdictions that disagree. The Consensus Panel believes that the evidence is supportive of all of our recommendations, and where the evidence is weakest the potential for benefits still exists, while the likelihood of harm is minimal to nonexistent. The benefits of changing the paradigm to one that considers the whole day have been shown to be aligned with what stakeholders and end-users prefer and value, and are likely to far exceed the risks associated with the change. Challenges to these recommendations are encouraged and will result in more refined and informed guideline recommendations in the future.

The guideline development procedures used here followed comprehensive, rigorous, and transparent processes (Brouwers et al. 2010a; Guyatt et al. 2011; Tremblay and Haskell 2012) incorporating systematic review findings, consultation findings, compositional analysis findings, and expert, stakeholder, and end-user input as has been done in the past (Tremblay et al. 2010b, 2011a, 2011b, 2012a, 2012b). Indeed, with experience, the Canadian guideline development process has become even more robust. For example, the Leadership Committee for these 24-h guidelines was larger and more diverse (including representatives from research, professional practice, marketing and communications, nongovernmental organizations, and government) than in the past allowing for new perspectives, extended communication channels, and

Table 3. Summary of research needs to address data gaps related to the development of 24-h movement guidelines.

Research needs

Research needs arising from systematic reviews

- Higher quality studies in pediatric populations (e.g., randomized controlled trials or longitudinal studies with validated objective measures, larger and more diverse sample sizes, and reporting of adverse events)
- Prospective examination of the impact of combinations of movement behaviours on health indicators, including time-use research
- Examination of “intermediate” combinations of movement behaviours (e.g., high physical activity + high sleep + low sedentary behaviour, vs low physical activity + high sleep + low sedentary behaviour)
- Use of standardized measures and analytical techniques to facilitate comparison across studies. For physical activity, future work should adhere to standardized accelerometry cut-points or adopt new analytic techniques such as pattern recognition, and use shorter sampling intervals. For sedentary behaviour, inclinometers should be used to more accurately capture postures, and objective and subjective measures (with known validity and reliability) should be combined to enable context-specific information to be captured. For sleep, there is a need for more accurate and ecologically valid measures of sleep duration
- As technology evolves, there is a need to understand how new types of sedentary behaviour, different forms of engagement (e.g., handheld portable devices), and multitasking (e.g., using multiple screen-based devices simultaneously) impact health
- There is a need to discern whether and which health impacts of screen use are inherent to the devices (regardless of posture) or are due to sedentary behaviour during their use
- Identification of how to accurately capture light-intensity physical activity and to isolate the intensity that best differentiates sedentary behaviour from light-intensity physical activity to achieve health benefits in children and youth, while examining potential age and sex differences
- Exploration of relationships between objectively measured physical activity and the following health indicators: behavioural conduct/pro-social behaviour, cognition/academic achievement, quality of life/well-being, motor skill development, psychological distress, and self-esteem
- Exploration of relationships between sleep duration and the following health indicators: quality of life/well-being, and harms/injuries
- Exploration of relationships between combinations of objectively measured physical activity and objectively or subjectively measured sedentary behaviour and sleep and the following health indicators: bone health, motor skill development, and psychosocial health

Research needs arising from compositional analyses

- Longitudinal and intervention research to confirm cross-sectional findings
- Research further dividing sedentary behaviour into screen time and nonscreen time to examine if associations with health indicators differ
- Research further dividing light physical activity into low and high or measuring sedentary behaviour with alternative devices, such as inclinometers that better classify postures, to examine if associations with health indicators differ
- Research examining whether associations differ between demographic subgroups
- Observational and experimental research to determine the optimal composition of movement behaviours within a 24-h period for improved health

Research needs arising from consensus panel meetings and discussions

- PA
 - Randomized intervention studies examining different doses of physical activity in varying frequencies, intensities, and durations
 - Research examining the significance of bouts, patterns, variability, and timing of PA
 - Well-controlled trials testing the 60 min/d of MVPA recommendation vs other cut points (e.g., 60 min vs 40 min vs 20 min, etc.), and daily vs weekly adherence to the 60 min/d guideline and the effects of these differences
 - The role of light-intensity physical activity in health
 - Research examining the impact of different PA contexts on health outcomes, independent of PA level (e.g., indoors vs nature and the outdoors)
- SB
 - Research examining the relationships between objectively measured SB and health indicators
 - Research further examining the role of bouts and breaks in relation to health indicators
 - Research assessing the potential harms of screens/devices (e.g., walking accidents, bullying, self-esteem)
 - Exploration of the relationships between other types of sedentary behaviour and/or other screens and health indicators (i.e., more context specific work, such as total sedentary time or passive transport)
 - Research exploring posture and sedentary behaviour
- Sleep
 - Research using objective measures of sleep duration
 - Research to identify optimal sleep duration in order to determine accurate upper and lower limits for children and youth
 - More intervention studies with larger sample sizes using objective measures of sleep duration
 - Investigation of how screens in the bedroom impact sleep
- Integrated movement behaviours
 - Longitudinal and intervention research to confirm cross-sectional findings
 - Time-use research (e.g., how time use changes over the rest of the day when children increase their time spent in MVPA)
 - Research exploring the relationships with psychosocial indicators
 - Research examining whether metabolic syndrome risk is a clinically meaningful outcome in children and youth

Stakeholder, intermediary, and end-user consultation and engagement research needs

- More focused future examination is needed in exploring children and youth perceptions of the Movement Guidelines and how children and youth might be engaged in shaping guideline communications to ensure they are more salient to their developmental stage
 - A broader stakeholder engagement would be beneficial for including the perspectives of service organizations, public health promotion professionals, and practitioners
-

Table 3 (concluded).

Research needs

International and inter-jurisdictional research needs and opportunities

- Standardize guidelines and their operationalization internationally
- Create online searchable data repositories to encourage research in developing countries (e.g., by creating accelerometry databanks and global mentoring systems)

Other research needs

- Cost effectiveness analyses of implementing the new guidelines at both organizational and individual levels
- Development of population-health-based simulation models to allow for health forecasting of different intervention scenarios
- Further research is required to inform and assess surveillance procedures for the new 24-h guidelines. This should include sensitivity and specificity analyses and inclusion of additional elements of the guidelines

Note: MVPA, moderate- to vigorous-intensity physical activity; PA, physical activity; SB, sedentary behaviour.

greater reach. This larger team may also reflect the broader base of interest as the guidelines become more inclusive and meaningful across behaviours. The composition of the Consensus Panel was also more diverse than in the past because of the inclusion of researchers and stakeholders from across the movement continuum (sleep, sedentary behaviour, and physical activity) and the inclusion of a parent and youth end-user (see Table 1). Involvement of international experts (Australia, USA, Wales) was preserved in an attempt to harmonize guidelines across jurisdictions while also reducing duplication of efforts.

The final guidelines (Figs. 2a and 2b) adhere to the structure used with previous guidelines (Tremblay et al. 2011a, 2011b, 2012a, 2012b), whereby context is provided for the guidelines through a preamble followed by the guidelines themselves. The preamble and guidelines in this form are intended for practitioners, professionals, stakeholders and researchers. Supplementary “user-friendly” messaging materials, as outlined in the Dissemination, implementation, and evaluation plans section of the Results, and in the paper by Latimer-Cheung et al. (2016), are in development for the general public. Developmental-framed messages (e.g., promotion of physical literacy) instead of risk-framed messages (e.g., related to health) will be particularly important for communications directly targeted to youth. These new guidelines are informed by the best available evidence, novel new analyses, expert opinion, stakeholder feedback, and end-user input. They are realistic and have wide support.

The individual behaviour components of the 24-h guidelines have not changed significantly from earlier guidelines (Tremblay et al. 2011a, 2011b). The major change is the integration of all movement behaviours across the 24-h period, with the most notable additions being specific recommendations regarding light-intensity physical activity and sleep duration. There is growing evidence that while not as efficacious as MVPA, light-intensity physical activity is associated with some health benefits, especially when it replaces sedentary behaviours (Buman et al. 2014; Carson et al. 2013b, 2016b; Poitras et al. 2016; Stone and Faulkner 2014), although this area remains relatively understudied. There is also evidence of a “play movement” (Tremblay et al. 2015), where activities of all intensities, especially in nature and the outdoors, have been clearly associated with improved health. Furthermore, the promotion of active play for children and youth is more natural or “organic” than the regimented approach often taken to ensure children and youth get enough exercise, which may make it more scalable, appealing, accessible, and sustainable. Remarkably, the sleep component marks the first sleep guidelines for children and youth in Canada created using robust guideline development procedures. Integrating them into the 24-h period is even more groundbreaking.

Despite being presented as new “24-hour guidelines”, it is not possible to give precise recommendations that add exactly to 24 h, because there are ranges provided for all behaviour components (e.g., 9–11 h of sleep, at least 60 min of MVPA, no more than 2 h of recreational screen time). Obviously if 1 child sleeps 9 h and another 11 h, the former has 2 additional hours of time to be distrib-

uted among the wake-time behaviours. Moreover, some degree of day-to-day variability is normal, and provision of ranges allows for this flexibility. For these reasons, and to be accommodating to different schedules and changes in schedules, the guidelines provide recommendations such as “Several hours of a variety of structured and unstructured light physical activities”, “Limited sitting for extended periods”, and “replacing sedentary behaviours and light physical activity with additional moderate to vigorous physical activity” to give directional advice while recognizing the dynamics of the component behaviours between and within individuals. Collectively, guidance for a healthy 24-h period is provided.

Release, dissemination, implementation, and activation planning

The new guidelines were released on June 16, 2016. Supporting the release were public relations and media plans, a suite of prepared messaging and communication tools, a captivating visual identity, and the foundation for a long-term, multi-platform, multi-sector, multi-jurisdictional, and multi-disciplinary marketing and communications plan to facilitate uptake and activation of the new guidelines. At minimum, the impact and success of the launch of the new guidelines will be assessed using a basic, descriptive set of indicators of dissemination reach. A plan has been developed for a comprehensive evaluation of the subsequent dissemination and implementation activities.

Updating the guidelines

The final stage in the guideline development cycle is the planning of updates and revisions (Tremblay and Haskell 2012). The Consensus Panel recommends that these guidelines be reviewed, and updated if necessary, every 10 years or when significant new research emerges warranting change. Ten years was recommended as an appropriate period that allows for complete sector penetration and normative utilization by stakeholders, intermediaries, and end-users, while also providing sufficient time for research gaps to be addressed, and is supported by the literature (Balas and Boren 2000; Green 2008).

Strengths and limitations

Strengths of the guideline development process employed here include adhering to clinical guideline development standards (Brouwers et al. 2010a); independent assessment by methodological consultants; involvement and consultation of a broad assortment of experts, international collaborators, stakeholders, and end-users; consideration of a range of holistic health indicators; using both systematic reviews and novel compositional data analyses to provide a comprehensive evidence base; proactive planning for dissemination, promotion, implementation, and evaluation; and publishing all scholarly work in open-access, refereed, peer-reviewed outlets.

The guidelines and related development processes also have limitations. First, the quality of evidence upon which the guidelines are based is generally low; however, we conducted rigorous systematic reviews that synthesized the current state of the original research. Second, there was very little research available to

Table 4. Surveillance recommendations for the new Canadian 24-Hour Movement Guidelines for Children and Youth.

Movement behaviour	Specific guideline recommendation	Specific surveillance recommendation	Rationale for specific surveillance recommendation	Recommendation for minimum inclusion in overall guideline surveillance ^a
Sleep	Uninterrupted 9 to 11 h of sleep per night for those aged 5–13 y and 8 to 10 h/night for those aged 14–17 y	Average sleep duration per night is 9 to 11 h or 8 to 10 h, respectively ^b	The evidence upon which the guideline is based is predominantly comprised of studies that used average sleep duration per night in their analyses An average allows for some normal day-to-day variability	✓
	Consistent bed and wake-up times	No specific measure currently available	A metric that assesses consistency of both bed time and wake-up time is not currently available	✗ ^c
Physical activity	An accumulation of at least 60 min/d of MVPA involving a variety of aerobic activities	Average MVPA/d is 60 min or more ^{b,d}	The evidence upon which the guideline is based is predominantly comprised of studies that used average MVPA/d in their analyses An average allows for some normal day-to-day variability	✓
	VPA and muscle and bone strengthening activities should each be incorporated at least 3 d/wk	Average weekly frequency of VPA is ≥3 d Average weekly frequency of muscle and bone strengthening activities is ≥3 d	Evidence for a specific recommendation on duration is lacking so guidelines at present can only speak to frequency	✗
	Several hours of a variety of structured and unstructured LPAs	Average LPA/d ^b	Until enough evidence emerges to provide a specific duration cut-point for LPA, the average LPA/d should be monitored	✗
Sedentary behaviour ^e	No more than 2 h/d of recreational screen time	Average recreational screen time per day is ≤2 h ^{b,f}	Many studies have used ≤2 h as the cut-point to assess other durations and the evidence base indicates that less is better – even to durations below 2 h. However, stakeholders strongly advised that levels <2 h would not be acceptable to end-users and target groups The evidence upon which the guideline is based is predominantly comprised of studies that used average screen time per day in their analyses An average allows for some day-to-day variation in screen time	✓
	Limited sitting for extended periods	Average time spent engaged in sedentary behaviour or sitting per day ^b	Until enough evidence emerges to provide a specific cut-point for “extended periods” of sitting, the average time spent engaged in sedentary behaviour or sitting per day should be monitored	✗

Note: LPA, light-intensity physical activity; MVPA, moderate- to vigorous-intensity physical activity; VPA, vigorous-intensity physical activity.

^aThe current recommended minimum inclusion criteria for overall guideline surveillance incorporates one recommendation with the strongest evidence from each movement behaviour to ensure equal weighting of movement behaviours when determining the percentage of the population meeting the guidelines. Other recommendations should still be measured for descriptive purposes and to determine if changes are occurring prospectively. As evidence grows and surveillance measures evolve for the other recommendations, updates to the minimum criteria may be required.

^bIf weekend and weekday measures are available, it is recommended that average sleep, MVPA, and screen time be weighted 2/7 for weekends and 5/7 for weekdays to most accurately reflect average weekly measures.

^cRequires daily measures of bed time and wake time not typically collected in surveillance surveys.

^dThe specific measure used for surveillance of adherence to the previous physical activity guidelines for children and youth in Canada was the achievement of 60 min of MVPA on at least 6 of 7 days in a week (Colley et al. 2011). It is recommended that the surveillance of MVPA in Canada continue to use this method in addition to the proposed average minutes of MVPA across valid days.

^eIt is recommended that future surveillance work for sedentary behaviour: (i) distinguish between recreational screen time and school/homework, employment, and/or nonrecreational screen time; (ii) incorporate new technology (e.g., tablets, cell phones); and (iii) specifically capture the duration of screen time that occurs while sitting or lying. Furthermore, future surveillance efforts should attempt to account for multitasking during sedentary behaviours.

^fRecreational screen time includes all discretionary (e.g., nonemployment or school required) and leisure-time screen time done while sedentary and typically includes television viewing, video-games use and computer use. Research on the use of small screens has not emerged in the literature yet and will be important to consider in updates to these guidelines.

Table 5. Appraisal of Guidelines for Research and Evaluation (AGREE) II reporting grid.

AGREE II item	Reporting location	Domain score (%)
Domain 1. Scope and purpose		99
1. The overall objective(s) of the guideline is (are) specifically described	<ul style="list-style-type: none"> Guideline Development Report This manuscript Tremblay et al. (2016) 	
2. The health question(s) covered by the guideline is (are) specifically described	<ul style="list-style-type: none"> Guideline Development Report This manuscript 	
3. The population (patients, public, etc.) to whom the guideline is meant to apply is specifically described	<ul style="list-style-type: none"> Guideline Development Report This manuscript 	
Domain 2. Stakeholder involvement		93
4. The guideline development group includes individuals from all the relevant professional groups	<ul style="list-style-type: none"> Guideline Development Report This manuscript 	
5. The views and preferences of the target population (patients, public, etc.) have been sought	<ul style="list-style-type: none"> Guideline Development Report Faulkner et al. (2016) 	
6. The target users of the guideline are clearly defined	<ul style="list-style-type: none"> Guideline Development Report This manuscript Latimer-Cheung et al. (2016) 	
Domain 3. Rigour of development		93
7. Systematic methods were used to search for evidence	<ul style="list-style-type: none"> Guideline Development Report Systematic reviews (Carson et al. 2016a; Chaput et al. 2016; Poitras et al. 2016; Saunders et al. 2016) 	
8. The criteria for selecting the evidence are clearly described	<ul style="list-style-type: none"> Guideline Development Report Systematic reviews (Carson et al. 2016a; Chaput et al. 2016; Poitras et al. 2016; Saunders et al. 2016) 	
9. The strengths and limitations of the body of evidence are clearly described	<ul style="list-style-type: none"> Guideline Development Report This manuscript Systematic reviews (Carson et al. 2016a; Chaput et al. 2016; Poitras et al. 2016; Saunders et al. 2016) 	
10. The methods for formulating the recommendations are clearly described	<ul style="list-style-type: none"> Guideline Development Report This manuscript 	
11. The health benefits, side effects and risks have been considered in formulating the recommendations	<ul style="list-style-type: none"> Guideline Development Report This manuscript Systematic reviews (Carson et al. 2016a; Chaput et al. 2016; Poitras et al. 2016; Saunders et al. 2016) 	
12. There is an explicit link between the recommendations and the supporting evidence	<ul style="list-style-type: none"> Guideline Development Report 	
13. The guideline has been externally reviewed by experts prior to its publication	<ul style="list-style-type: none"> Guideline Development Report This manuscript Faulkner et al. (2016) 	
14. A procedure for updating the guideline is provided	<ul style="list-style-type: none"> Guideline Development Report This manuscript 	
Domain 4. Clarity of presentation		100
15. The recommendations are specific and unambiguous	<ul style="list-style-type: none"> Guideline Development Report This manuscript 	
16. The different options for management of the condition or health issue are clearly presented ^a	<ul style="list-style-type: none"> Not applicable 	
17. Key recommendations are easily identifiable	<ul style="list-style-type: none"> Guideline Development Report This manuscript 	
Domain 5. Applicability		79
18. The guideline describes facilitators and barriers to its application	<ul style="list-style-type: none"> Guideline Development Report Latimer-Cheung et al. (2016) 	
19. The guideline provides advice and/or tools on how the recommendations can be put into practice	<ul style="list-style-type: none"> Guideline Development Report Latimer-Cheung et al. (2016) 	
20. The potential resource implications of applying the recommendations have been considered	<ul style="list-style-type: none"> Guideline Development Report This manuscript 	
21. The guideline presents monitoring and/or auditing criteria	<ul style="list-style-type: none"> Guideline Development Report This manuscript 	

Table 5 (concluded).

AGREE II item	Reporting location	Domain score (%)
Domain 6. Editorial independence		100
22. The views of the funding body have not influenced the content of the guideline	<ul style="list-style-type: none"> Guideline Development Report This manuscript 	
23. Competing interests of guideline development group members have been recorded and addressed	<ul style="list-style-type: none"> This manuscript Systematic reviews (Carson et al. 2016a; Chaput et al. 2016; Poitras et al. 2016; Saunders et al. 2016) 	

Note: Four independent reviewers applied the AGREE II assessment; the Domain Scores (%) were calculated by summing all the scores of the individual items in a domain and by scaling the total as a percentage of the maximum possible score for that domain (as per the AGREE II Instrument, available at agreetrust.org). The "Reporting Location" is not a comprehensive summary of all places where the information in each item can be found. The Guideline Development Report is available at csep.ca/guidelines.

*Item 16 was rated as "not applicable" and was not included in the scaled Domain 4 score.

inform specific aspects of the guidelines (e.g., dose–response studies on behaviour frequency, intensity, or duration). Third, almost no research exists on integrated movement behaviours and health indicators. Because of this third limitation, evidence is presently insufficient to provide specific advice on which behaviour substitution option is best for a particular individual, in a particular situation. Nevertheless, behaviour changes that ensure adequate sleep and increased MVPA are likely to provide health benefits to most individuals. We need to move away from thinking whether more or less of 1 behaviour is good or bad for us, to whether a change in the overall pattern of behaviours is better or worse. For example, a few hours of light physical activity "purchased" at the cost of MVPA or sleep would probably be bad, while a few hours salvaged from sedentary behaviour would probably be good. Fourth, it is possible that the various consultation processes used resulted in biased feedback and that voices of important subsets of the population were missed. Fifth, evidence of the cost effectiveness of the guideline recommendations was not available.

Future research

Specific research needs identified in the development of these guidelines are listed in Table 3. There is much more research that needs to be done. Future research should consider the integrated relationships among movement behaviours, and similar integrated 24-h movement guidelines for other age groups should be developed. Such work holds promise in not only creating new opportunities and approaches for healthy lifestyle interventions but also for the discovery of new and novel relationships among movement behaviours, and the underlying physiology and pathophysiology. These relationships are also relevant to informing future anthropology research.

Conclusion

The new *Canadian 24-Hour Movement Guidelines for Children and Youth: An Integration of Physical Activity, Sedentary Behaviour, and Sleep* represent a paradigm shift in thinking about daily movement behaviours. This fundamental shift from focusing on movement behaviours in isolation to the concept that "the whole day matters" is strongly supported by the available evidence. Consideration of all behaviours along the movement continuum as a collective is warranted, and holds promise in the promotion of population health. These are strong recommendations; the potential benefits of following these guidelines far exceed the potential risks. It is hoped that these guidelines open new avenues for population health promotion and instigate new research on the health effects of integrated movement behaviours.

Conflict of interest statement

Peter T. Katzmarzyk recently completed a childhood obesity study that was funded by the Coca-Cola company. Michelle E. Kho received an honorarium for methodological input to guideline development. Timothy Olds received funding from Australian

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