

GRADE ADOLPMENT Process to Develop 24-Hour Movement Behavior Recommendations and Physical Activity Guidelines for the Under 5s in the UK, 2019

John J Reilly<sup>1</sup>, Adrienne R Hughes<sup>1</sup>, Xanne Janssen<sup>1</sup>, Kathryn Hesketh<sup>3</sup>, Sonia Livingstone<sup>4</sup>, Catherine Hill<sup>5</sup>, Ruth Kipping<sup>6</sup>, Catherine E Draper<sup>7,8</sup>, Anthony D Okely<sup>9</sup> Anne Martin<sup>2</sup>

- 1 University of Strathclyde Glasgow, Physical Activity and Health Group, School of Psychological Sciences and Health,
- 2 MRC/CSO Social and Public Health Sciences Unit, Institute of Health and Wellbeing, University of Glasgow
- 3 Institute of Child Health, University College London
- 4 Department of Media and Communications, The London School of Economics and Political Science
- 5 Division of Clinical Experimental Sciences, Faculty of Medicine, University of Southampton
- 6 Bristol Medical School, University of Bristol
- 7 SA MRC Developmental Pathways for Health Research Unit, University of the Witwatersrand, Johannesburg
- 8 Division of Exercise Science and Sports Medicine, University of Cape Town
- 9 Early Start Research Institute, University of Wollongong Australia

Running Title: UK Physical Activity Guidelines for the Under 5s

Conflicts of Interest: None to declare

Word Count: 4989 (including references)

Keywords: physical activity; sedentary behaviour; sleep; infants; toddlers; children

## ABSTRACT

**Background:** This paper summarises the approach taken to develop UK Chief Medical Officers' (CMOs) Physical Activity Guidelines for the Under 5s, 2019.

**Methods:** The Grading of Recommendations Assessment, Development and Evaluation (GRADE) Adaptation, Adoption, De Novo Development (ADOLPMENT) approach was used, based on guidelines from Canada and Australia, with evidence updated to February 2018. Recommendations were based on associations between (a) time spent in sleep, sedentary time, physical activity and 10 health outcomes, and (b) time spent in physical activity and sedentary behavior on sleep outcomes (duration, latency).

**Results:** For many outcomes more time spent in physical activity and sleep (up to a point) was beneficial, as was less time spent in sedentary behavior. We present, for the first time, evidence in GRADE format on behaviour type-outcome associations for infants, toddlers, and preschoolers. Stakeholders supported all recommendations, but recommendations on sleep and screen time were not accepted by the CMOs; UK guidelines will refer only to physical activity.

**Conclusions:** This is the first European use of GRADE-ADOLPMENT to develop physical activity guidelines. The process is robust, rapid and inexpensive, but the UK experience illustrates a number of challenges which should help development of physical activity guidelines in future.

## INTRODUCTION

The UK first published guidance on physical activity for the early years (birth-school-entry) in 2011<sup>1</sup>. This 2011 ‘Start Active, Stay Active’ guidance was based largely on expert opinion, and limited to only a single quantitative recommendation, that 3-4 year olds should spend a minimum of 180 minutes in physical activity every day<sup>1</sup>. By 2018, there was a larger body of evidence on the benefits of physical activity in the Under 5s than was available to inform ‘Start Active, Stay Active’<sup>2-7</sup>. There has also been a paradigm shift- physical activity is no longer seen in isolation from the other ‘24-hour movement behaviors’<sup>2,8</sup> (sedentary behavior including screen time, and sleep, time spent standing). In a fixed 24-hour day the time spent in one of these behaviors must inevitably influence the others, and by school entry physical activity declines with age, and is displaced by time spent sedentary<sup>9-11</sup>. Sedentary time continues to increase with age, producing further declines in physical activity. Although sleep requirements naturally decrease with age, sleep duration is also affected by time spent in physical activity and sedentary behavior<sup>12,13</sup>. These movement behaviors each influence health and development, and the combination of behaviors also matters<sup>2,7,8</sup>, so that evidence-based recommendations for the full 24-hour period can now be made.

The WHO Ending Childhood Obesity (ECHO) Reports<sup>14,15</sup> concluded that improving 24-hour movement behaviors in the early years was central to prevention and treatment of obesity and related non-communicable diseases (NCDs). The first evidence-based ‘24-Hour Movement Behaviour Guidelines’ for the early years were published in 2017 in Canada, Australia, and New Zealand<sup>2,3</sup>. Evidence-based national guidelines on 24-hour movement behaviors were released in 2018 in South Africa<sup>16</sup>, and international guidance on physical activity, sedentary and sleep behaviors from the WHO published in 2019<sup>17</sup>. This manuscript is aimed to describe the guideline development process for the Under 5s in the UK 2017-2019, to illustrate the strengths and weaknesses of the process so that others can learn from the UK experience, and to provide a more nuanced summary of the evidence base used to develop the recommendations than has been presented to date. The UK guideline development process was based on the principle that the most recent and relevant guidelines should be adapted so that new UK guidelines could be developed relatively quickly and at low cost.

## METHODS

The process was conducted in three phases. Phase 1 saw an initial web consultation to assess support for the guideline update and take suggestions on format and content; the construction of Expert Working Groups (for the Under 5s; for school-age children and adolescents; for adults; for older adults; for sedentary behavior from age 5 to old age; for guideline communication and implementation); the selection of international experts for each working group; formal evidence review and synthesis during 2018, and a website for national consultations on the new UK Chief Medical Officers (CMO, for Scotland, Northern Ireland, Wales and England) guidelines (<http://www.bristol.ac.uk/sps/research/projects/current/physical-activity/>). In Phase 2, draft recommendations were developed and circulated to participants attending two scientific consensus meetings during June and July 2018. Draft recommendations were revised following feedback from the scientific consensus meetings, and responses to end-user or stakeholder feedback were provided. Phase 3 included further national online consultation on the draft recommendations, and a final round of revision. The Expert Working Group then produced a technical report with recommendations for the content and wording of new guidelines which were submitted to the CMOs of Scotland, England, Wales, and Northern Ireland in November 2018 with recommendations as to what the guidelines should contain. In the UK the guidelines are published by the Health Departments and so they alone were responsible for accepting or rejecting these recommendations.

### **Initial Scoping and Planning of the Work for the Under 5s**

Phase 1 began with the formation of the Expert Working Group for the Under 5s at the end of 2017, from a combination of open advertising/competition, and invitation. The aim was to have group members, including early and mid-career academics, with the following characteristics: experience of the UK Start Active Stay Active process 2009-2011; content expertise in the age groups for all three behaviors (sleep, sedentary behavior, physical activity); expertise in guideline development methodology; experience of other ongoing/recently completed Early Years physical activity guidelines. The Expert Working Group received feedback from a UK-wide online consultation (the first of three stages of consultation required in the UK process) in January 2018. This initial consultation supported a guideline update using the concept of 24-hour movement behaviors, emphasised the value of harmonisation with international guidelines, and recommended publication of a summary of the process in the peer-reviewed literature. The working group outlined a schedule of approximately monthly online meetings starting in January 2018, identified tasks and milestones required if the project was to be completed on time, and formed sub-groups for specific tasks. The group was represented on the wider Chairs Panel of UK Expert Working Groups (led by the University of Bristol) which also had monthly online meetings to guide and co-ordinate the work of the UK Expert Working Groups.

A number of practical and scientific considerations underpinned the guideline development work described in this manuscript. First, the work was based on the best (most recent, relevant, evidence-based) existing guidelines internationally. Thus, the starting point for the Under 5s was the 24-hour movement behavior approach<sup>2,3</sup>, and this was approved in principle by the UK CMOs in early 2018. Second-and supported by national consultations- it was agreed that the UK draft recommendations should be as consistent as possible with the best available international guidance<sup>2,3</sup>. Implementing these decisions was possible with external support, in particular from a) the WHO guideline development group (up to February 2018), and b) international experts who led the South African and Australian processes. Implementing these early decisions was also possible because of Grading of Recommendations Assessment, Development and Evaluation (GRADE) Adaptation, Adoption, De Novo Development (ADOLOPMENT) approach<sup>18</sup>. This an evidence-based, and efficient (quick and low cost) process for developing guidelines. Recently, the Australian 24-Hour Movement Behaviour Guidelines were developed by the process of ADOLOPMENT of the Canadian Guidelines<sup>3</sup>. The UK Under 5s Expert Working Group therefore used the GRADE ADOLOPMENT approach.

### **The GRADE ADOLOPMENT Process**

GRADE ADOLOPMENT involves a series of steps leading to adoption, adaptation, and/or de novo development of an existing guideline. The first task of the Expert Working Group, guided by our GRADE methodologist (AM) was to translate these steps into a series of tasks, summarised in brief here, and in **Table 1**. The expert working group was responsible for making draft scientific recommendations by the end of May 2018, for consultation (online and via two Scientific Consensus Meetings attended mainly by academics and policymakers) in June and July 2018. The group then responded to all points raised in this second consultation process and produced revised draft recommendations taking account of scientific review and stakeholder feedback. This manuscript focuses on the Expert Working Group responsibilities, up to the point where final recommendations were made as to the content of the guidelines to the four UK CMOs in November 2018, and after all feedback from stakeholders up to that point had been considered. The first major task was to agree on the source guideline(s)<sup>3,18</sup> on which the new UK guideline should be based (Table 1, item 2). A search for recent relevant guidelines had been carried out by the Bristol Co-ordinating Centre in 2017 and this

did not identify any recent relevant guidelines for the early years. We updated the Bristol search with knowledge of the Canadian and Australian Early Years Guidelines<sup>2,3</sup> (published 20<sup>th</sup> November 2017) and the ongoing South African and WHO Guidelines. In addition, the US Guideline Development Process Evidence Synthesis became available in March 2018, though the US guideline was not published until November 2018. The comparison of candidate guidelines against criteria for selecting a source guideline is summarised in **Table 2**, and supported our judgement that our source guideline would be the Canadian 24-Hour Movement Behaviour Guidelines for the Early Years (<https://csepguidelines.ca/early-years-0-4/>)<sup>2</sup>.

The second major task (**Table 1**, item 3) was to agree that the PICOs (Population, Intervention/Exposure, Comparator, Outcomes) which had been used in the Canadian/Australian and WHO systematic review/evidence synthesis (shared by WHO in February 2018) were appropriate to our UK guideline update. The PICOs were agreed by the Expert Working Group and are summarised in **Online Table 1**. The next major task (Table 1, items 4, 7-9) was to compile GRADE Summary of Findings Tables for each of the target behaviors (time spent asleep, in sedentary behavior including screen time, and in physical activity). **Table 3** gives an overview of the type and number of exposures for the three 24-hour movement behaviors, which indicate that each 24-hour movement behavior is assessed and reported in a number of ways in the literature. For example, 13 exposures for physical activity were identified, three exposures for sedentary time, and seven exposures for sleep. The UK guideline development process departed significantly from previous national and international guidelines in that it was based on ‘deconstructed’ GRADE tables that summarised every distinct combination of unique exposure type, outcome, and population group (age group). These UK GRADE Tables (**Supplementary Table 2**) were derived from the source guideline GRADE Tables but allowed greater clarity over exposure-outcome relationships to be obtained. For example, it was possible to recommend that Toddlers and Pre-schoolers spend time in physically active play in the UK because this was evident for both age groups using the GRADE table deconstructed by exposure type; this was not evident from the original source GRADE tables.

A tenet of the GRADE ADOLPMENT process is that a consensus on the balance of adoption, adaptation, and *de novo* creation of recommendations is reached<sup>3,18</sup>. The *de novo* creation of a recommendation based on sleep outcomes in the UK arose from the desire of the UK Expert Working Group to go beyond the work done by guideline development groups in Canada, Australia, South Africa, and the WHO. Previous 24-hour movement behavior guidelines only considered sleep duration as an *exposure*. This was considered an important omission by UK stakeholders, as sleep is important to health and development<sup>6,19,20</sup>. An additional systematic review was therefore undertaken, using sleep as an *outcome* (e.g. sleep duration, latency of sleep onset, sleep disturbance) with physical activity and sedentary behavior as the exposure variables (**Table 1**; items 6, 10). The details of this work are beyond the scope of the current manuscript, but are reported elsewhere<sup>21</sup>. In the UK the consensus over the balance of adoption and adaptation of the Canadian guideline was achieved at two online meetings of the Expert Working Group in April 2018. Recommendations and an accompanying draft technical report (explaining the basis of the recommendations) were shared with the stakeholders (**Table 1**, items 12-13) using an online consultation in June and July 2018, and face-to-face consultation in the form of the two Scientific Consensus meetings noted above. Expert Working Group recommendations in the UK were therefore ready by the summer of 2018.

## RESULTS

There was consistent evidence that time spent in physical activity, sleep, and sedentary behavior was associated with a range of health and developmental outcomes in the Under 5’s (**Table 4**), allowing the

Expert Working Group to make 24-hour movement behavior recommendations to the CMOs. The *de novo development* part of the process produced a recommendation on the avoidance of screens before bedtime. This new recommendation was based on observational evidence that screen use before bedtime was associated with shorter sleep duration, more night waking, and longer sleep latency (delayed onset of sleep) in Toddlers, and later bedtimes in Pre-schoolers<sup>21</sup> plus mechanistic studies on the impact of light exposure on sleep. Three main adaptations to the Canadian and Australian guidelines were recommended to the CMOs:

1. A recommendation for *active and outdoor play* for Toddlers and Pre-Schoolers, since that was one of the specific physical activity exposures for which evidence was available when the source GRADE Tables were deconstructed as part of the UK process. This type of physical activity was not referred to specifically in the Canadian or Australian guidelines, but has many benefits, few risks<sup>22-24</sup> and was valued highly by the Expert Working Group and by stakeholders.
2. A specific recommendation for moderate-to-vigorous-intensity physical activity (MVPA) was made, which was previously referred to as ‘energetic play’ in the Canadian and Australian guidelines. Inclusion of MVPA was possible because specific evidence of benefit was identified in the deconstructed GRADE tables from studies with MVPA as the exposure in Pre-schoolers. Stakeholders in the second stage of the consultation also welcomed the continuity between the MVPA recommendation for pre-schoolers and that for older children.
3. A relaxation of screen time guidance for Toddlers in the UK: ‘screen time should be no more than one hour’, compared to that in Canadian and Australian guidelines which suggested that ‘For those younger than two years screen time is not recommended’. The rationale for this adaptation arose from limitations in the evidence around the precision of the 1 hour per day exposure (but good evidence that less screen time was better); the possibility that newer forms of sedentary screen time may be less harmful, and may be more beneficial than the more traditional forms (TV/DVD exposure) which dominated the evidence base; and the pragmatic consideration that recommending a limited amount of exposure (versus no exposure) may be seen as more helpful and realistic to modern families.

The UK recommendations derived from the GRADE ADOLOPMENT process are summarised in **Table 5**. In December 2018, the UK CMOs decided to not include the recommendations for sedentary behavior, sleep, and screen time in relation to sleep outcomes, and the final UK 2019 guidelines will therefore be based on physical activity only (see **Table 6**).

## DISCUSSION

The 2019 UK guidelines are an advance on the UK 2011 version as they include more evidence based and more quantitative recommendations, indicating an evolution towards guidelines which are both more scientifically robust and more suitable for future surveillance (though the reliability and validity of existing surveillance methods are unclear<sup>25</sup>). Since 24-hour movement behavior guidelines were not adopted in the UK, it is worth a brief restatement of the rationale for these. First, the approach was rigorous, and the evidence base for sedentary behavior and sleep recommendations was not weaker than that for physical activity recommendations. Second, UK stakeholders supported the 24-hour approach. Evidence from the other countries with recently published 24-hour movement behavior guidelines shows that stakeholder (academic, policymaker, practitioner, family) acceptance of the 24-hour approach is high, and successful public health messaging of 24-hour movement behavior guidelines is realistic<sup>26,27</sup>. Third, the approach would have been consistent with a number of other countries and the WHO guidelines published in 2019. Fourth, obesity prevention is high on the public policy agenda in

the UK and elsewhere and the need for a shift in how the Under 5s spend their 24 hours is central to obesity prevention according to the WHO<sup>14,15</sup>: the movement behaviors in early life are major drivers of the obesity epidemic<sup>2,3,19,28,29</sup>. Finally, emerging evidence suggests that many Infants, Toddlers, and Pre-schoolers do not meet the new 24-hour movement behavior guidelines, and non-compliance with at least some of the guidelines may vary markedly by socio-economic status.<sup>30-34</sup> As childhood obesity is highly socially patterned in the UK and social patterning is increasing<sup>33</sup>, there is a need for 24-hour movement behavior guidelines in the UK to help reduce social inequalities in health.

As the evidence base improves, guidelines will evolve further. Guidelines are required now given the importance of the 24-hour movement behaviors in the early years to child health and development<sup>8,14,15</sup>. Gaps in the evidence in the Under 5s should also be seen in the context of these behaviors later in childhood and adolescence: there is a more substantial evidence base on the benefits of adequate physical activity and sleep, and risks of some sedentary behaviors in school-age children<sup>34-37</sup>; levels of these behaviors in the pre-school period are closely related to later levels in school-aged children, and time spent sedentary increases steadily after school entry. Some issues were beyond our scope. In particular, the *content* of screen time was not considered. There were also gaps and weaknesses in the evidence base. First, recommending precise amounts of all of the 24-hour movement behaviors was problematic. Second, time spent standing was not measured in most studies, it does not appear in the literature and may be misclassified in accelerometry studies. This misclassification may obscure associations with health outcomes, and produce biases in estimates of the levels of these behaviors. Our unpublished data from postural monitoring of pre-school children suggests that they typically spend around 3 hours per 24 hours standing. Third, while TV and DVD were the main sources of screen time for the Under 5s, at least until recently<sup>40</sup>, there is a need for more evidence on the impact of time spent using newer devices which have become more widely available recently: some forms of modern screen-based technology are potentially less harmful, and may bring greater benefits, than the kinds of sedentary behavior used to inform the 2019 UK recommendations.

Finally, there are some limitations in the ADOLPMENT process which are especially problematic for movement behavior guidelines. GRADE was originally intended for clinical research evidence, in particular RCTs. This methodology is less applicable to evidence from public health. GRADE methodology currently assigns an initial rating to each study design (high for RCT, low for observational studies – including longitudinal, cross-sectional, and even systematic reviews of observational studies). This rating is then modified (up or down) according to the risk of bias, inconsistency, indirectness, imprecision, publication bias, dose-response relationship, residual confounding or the size of the magnitude of any associations<sup>41,42</sup>. GRADE methodology therefore downgrades evidence from study types which would widely be regarded as highly informative and entirely appropriate to understanding relationships between movement behaviors and health, e.g. well-conducted longitudinal studies. This meant that UK recommendations and guidelines were rated as very/low quality in GRADE terms. In future this may be less of a problem for movement behavior guideline development as GRADE methodology is being adapted to other kinds of evidence (<https://www.gla.ac.uk/researchinstitutes/healthwellbeing/research/mrccsocialandpublichealthsciencesunit/programmes/policy/evidencesynthesis/grade/#/collaborators>).

In summary, the UK guideline development experience provides novel insights which should be useful in the development of future movement behavior guidelines. First, an efficient and rigorous process exists for developing guidelines (GRADE ADOLPMENT), and this could be used more widely, despite its limitations. Second, there are risks associated with developing guidelines when they are not owned by the guideline developers, with the UK experience likely to be of relevance to

many others in future. The fact that ownership of the guidelines resided with government in the UK both delayed the publication of the guidelines (by more than a year), and greatly altered the guideline content. Third, the UK experience showed that the effort made in deconstructing the original source GRADE Tables made a meaningful difference to adapting the source guidelines and so was worthwhile: novel recommendations could be made in relation to physically active play and MVPA. Finally, the UK process produced the first evidence-based recommendations for physical activity and sedentary behavior with sleep *as an outcome*.

## ACKNOWLEDGEMENTS

We acknowledge the help of the WHO, both for funding an updated literature review and appraisal using GRADE methodology in February 2018, and for agreeing to share the literature search results with the Under 5s Expert Working Group. The deconstructed GRADE Tables provided on this manuscript were derived from World Health Organization (2019) Guidelines on physical activity, sedentary behaviour and sleep for children under 5 years of age: web annex : evidence profiles. World Health Organization. <http://www.who.int/iris/handle/10665/311663>. We also thank the many stakeholders who took part in the online and face-to-face consultation meetings. The work was undertaken with the support of The Centre for the Development and Evaluation of Complex Interventions for Public Health Improvement (DECIPHer), a UKCRC Public Health Research Centre of Excellence. Joint funding (MR/KO232331/1) from the British Heart Foundation, Cancer Research UK, Economic and Social Research Council, Medical Research Council, the Welsh Government and the Wellcome Trust, under the auspices of the UK Clinical Research Collaboration, is gratefully acknowledged. AM was supported by the UK Medical Research Council (grant number MC\_UU\_12017/14) and the Scottish Government Chief Scientist Office (grant number SPHSU14). KRH is supported by the Wellcome Trust (107337/Z/15/Z).

## List of Tables

Table 1 Tasks in the guideline development process using the GRADE-ADOLOPMENT approach

Table 2 Choice of source guidelines from candidate guidelines

Table 3 Breakdown of exposure types for physical activity, sedentary behaviour, and sleep.

Table 4 Summary of evidence on the influence of time spent in sleep, sedentary behaviour, and physical activity on health and developmental outcomes

Table 5 Draft recommendations made by the Expert Working Group

Table 6 The UK physical activity guidelines for the Under 5s, 2019.

**Table 1. Steps in the guideline development process using GRADE-ADOLOPMENT<sup>18</sup>**

Tasks		Timeline
1	Decision and stakeholder approval of the 24-hour movement behaviour approach	January 2018
2	Identification of appropriate source guidelines	14 February 2018
3	Feedback and agreement on WHO literature search strategy (PICOS), and 'grading' of importance of outcomes	1 <sup>st</sup> March 2018
4	Review of GRADE Summary of Findings table from Canadian 2017 guideline	22 March 2018
5	Identification of appropriate source systematic reviews on sleep outcomes	22-26 March 2018
6	Assessment of need and decision for de novo systematic review on sleep outcomes	26 March 2018
7	Re-structuring the Canadian 2017 GRADE Summary of Findings table by outcome, movement behaviour and age group (infants, toddlers, pre-schoolers)	23 March – 13 June 2018
8	Inclusion of updated WHO systematic reviews to GRADE Summary of Findings table	29 March – 13 June 2018
9	Conducting de novo systematic review and evidence synthesis for the association of screen time, sedentary time and physical activity with sleep	17 April – 17 June 2018
10	Initial decision on adoption, adaptation and de novo creation of recommendations through consensus in April 2018	8 May 2018
11	Submission of progress report with a rationale as to whether and how the UK 2011 guidelines should change	15 May 2018
12	Final decision on adoption, adaptation and de novo creation of recommendations through Expert Group consensus	14-17 May 2018
13	Write-up of draft recommendations for scientific consensus meetings	7 June 2018
14	Add evidence from #10 to GRADE Summary of Findings table	17 June 2018
15	Revision of draft recommendations based on feedback at scientific consensus meeting	6 July – 5 September 2018
16	Submission of revised recommendations for UK-wide national consultation	6 September 2018
17	Revision of draft recommendations based on UK-wide national consultation	26 October 2018
18	Consideration of UK 24-Hour Movement Behaviour Guidelines for the Under 5s by the UK Health Departments (Chief Medical Officers)	30 November 2018

**Table 2 Choice of Source Guidelines from Candidate Guidelines, Adapted from Okely et al<sup>3</sup>**

<b>Criterion</b>	<b>Canadian Guideline 2017</b>	<b>Australian Guideline 2017</b>	<b>US Physical Activity Guideline for Americans 2018</b>
<b>Published in last 5 years</b>	<b>Yes</b>	<b>Yes</b>	<b>Not yet published as a guideline, just the evidence synthesis</b>
<b>Followed GRADE</b>	<b>Yes</b>	<b>Yes</b>	<b>No, but used an analogous process</b>
<b>Addressed Clear Questions</b>	<b>Yes</b>	<b>Yes</b>	<b>Yes, but not the same questions or range of questions required by the UK process</b>
<b>Assessed Harms/Benefits</b>	<b>Yes</b>	<b>Yes</b>	<b>No</b>
<b>Assessed Using AGREE</b>	<b>Yes</b>	<b>Yes</b>	<b>No</b>
<b>Suitable for Updating</b>	<b>Yes</b>	<b>Yes</b>	<b>Yes</b>
<b>Access to evidence tables and summaries</b>	<b>Yes</b>	<b>Yes</b>	<b>Yes</b>
<b>Had risk of bias assessment</b>	<b>Yes</b>	<b>Yes</b>	<b>Yes</b>
<b>Were integrated (24 hours)</b>	<b>Yes</b>	<b>Yes</b>	<b>yes</b>

**Table 3: Different Exposures by Type within the 24-Hour Movement Behavior Framework**

Physical Activity	Sedentary time	Sleep
Total Physical Activity Light physical activity intensity Moderate physical activity intensity Moderate-to-vigorous physical activity intensity Vigorous physical activity intensity Active/Outdoor/Indoor/Exercise Play Prone position Outdoor PA (incl. bike riding, walking, active transport) Home/Leisure/extracurricular physical activity Aerobic physical activity Organised sport/sport participation Weight bearing activity	Screen time Evening screen time Device measured sedentary time	Sleep duration (total daily sleep) Night time sleep duration Sleep restriction Nap duration Increasing hours of sleep per bout Cortisol awakening response Sleep Trajectories

**Table 4. Summary of Evidence Quality, Quantity, and Generalisability**

Type of Evidence	Generalisability & Directions of Associations with Outcomes	Comments on Evidence
<b>Physical Activity (PA)</b>		
<p><b>Experimental/quasi experimental studies:</b> 14 RCT (n 4,199); 3 cross-over trials (n 182); 11 non randomised controlled trials (n 1,654)</p> <p><b>Observational studies:</b> 9 case control (n 2,404); 16 longitudinal (n 18,354; )63 cross-sectional (n 77,452)</p>	<p>High generalisability to UK-evidence largely from high-income western countries</p> <p><b>More PA is associated with improved: adiposity</b> (infants); <b>motor development</b> (infants, toddlers, pre-schoolers); <b>cognitive development</b> (infants, pre-schoolers); <b>fitness</b> (pre-schoolers); <b>bone/skeletal health</b> (pre-schoolers); <b>cardiometa-bolic health</b> (pre-schoolers).</p>	<p>Evidence for specific amounts/types of PA not clear /conclusive for all populations, but clear that ‘more is better’.</p> <p>New evidence for benefits of higher intensity (MVPA) in pre-schoolers, and ‘dose’ of tummy-time in infants, and active/outdoor play.</p>
<b>Sedentary Behavior (SB)</b>		
<p><b>Experimental/quasi experimental studies:</b> 2 RCT (n 482)</p> <p><b>Observational studies:</b> 7 case-control (n 2,374); 34 longitudinal (n 78,100); 79 cross-sectional (n 167,946)</p>	<p>High generalisability to UK-as noted above for PA.</p> <p><b>More SB is associated with: higher adiposity</b> (infants, toddlers, pre-schoolers); poorer <b>motor development</b> (toddlers), poorer <b>cognitive development</b> (infants, toddlers, pre-schoolers); poorer <b>psychosocial health</b> (pre-schoolers).</p>	<p>Most of the evidence is on screen time (duration), mainly TV/DVD viewing. Evidence for specific amounts inconclusive, but clear that ‘less is better’.</p>
<b>Sleep</b>		
<p><b>Experimental/quasi-experimental studies:</b> 2 RCT/controlled trials (n 67); 3 cross-over trials (n 45)</p> <p><b>Observational studies:</b> 3 case-control (n 810); 27 longitudinal (n 98,340); 48 cross-sectional (n 90,834)</p>	<p>High generalisability to UK-as noted above for PA.</p> <p><b>Shorter sleep duration is associated with: higher adiposity</b> (pre-schoolers); <b>poorer emotional regulation</b> (infants, toddlers, pre-schoolers); <b>poorer cognitive development</b> (pre-schoolers).</p>	<p>Increased sleep duration within a currently recommended range seems to have little evidence of harm.</p> <p>Evidence largely on duration of sleep rather than related behaviors (e.g. sleep environment and routine). Evidence for specific amounts inconclusive</p>

**Table 5 The UK 24-Hour Movement Behaviour Recommendations for the Under 5s, 2018**

**Infants (less than 1 year)** For infants, a healthy 24 hours includes:

- Being physically active several times in a variety of ways, including interactive floor-based activity *e.g. crawling. For infants not yet mobile, this includes at least 30 minutes of tummy time<sup>Footnote1</sup> spread throughout the day while awake (and other movements such as reaching and grasping, pushing and pulling)*; more is better.
- Minimising the amount of time restrained (e.g., in a pram or high chair). Screen time is not recommended. When sedentary, engaging in pursuits such as reading and storytelling with a caregiver is encouraged.
- 14 to 17 hours (for those aged 0-3 months) or 12 to 15 hours (for those aged 4-11 months) of sleep, including naps.

**Toddlers (1-2 years)** For toddlers, a healthy 24 hours includes:

- At least 180 minutes spent in a variety of physical activities at any intensity, including active and outdoor play, spread throughout the day—more is better.
- Not being restrained (e.g., in a pram/buggy or high chair) or sitting for extended periods (except when sleeping). Sedentary screen time should be no more than 1 hour; less is better<sup>Footnote2</sup>. When sedentary, engaging in pursuits such as reading and storytelling with a caregiver is encouraged.
- 11 to 14 hours of good-quality sleep<sup>Footnote3</sup>, including naps, with consistent bedtimes and wake-up times, avoiding use of screens for at least one hour before bed-time.

**Pre-schoolers (3-4 years)** For pre-schoolers, a healthy 24 hours includes:

- At least 180 minutes spent in a variety of physical activities spread throughout the day, including active and outdoor play,—more is better; the 180 minutes should include at least 60 minutes of moderate-vigorous intensity physical activity (MVPA).
- Not being restrained (e.g. in a buggy or car seat) or sitting for extended periods. Sedentary screen time should be no more than 1 hour; less is better<sup>Footnote2</sup>. When sedentary, engaging in pursuits such as reading and storytelling with a caregiver is encouraged.
- 10 to 13 hours of good-quality sleep<sup>Footnote3</sup>, which may include a nap, with consistent bedtimes and wake-up times, avoiding use of screens for at least one hour before bed-time.

**Footnote 1.** Tummy time may be unfamiliar to babies at first, but can be increased gradually—starting from a minute or two at a time—as the baby becomes used to it. Babies should not sleep on their tummies.

**Footnote 2** The historical evidence on screen time was largely from studies of the duration of screen time exposure to TV and DVD screens. These studies tend not to measure the type of content, nor the nature of the child's engagement with it. While it is generally assumed that the child is sedentary during screen time, some research suggests this is not always the case. There was a lack of evidence on the health and developmental impact of more recent screen-based technology, especially that which involves or requires interaction with other individuals (e.g. family members). The Expert Working Group felt that accompanied/interactive screen-time had less potential for harm and greater potential for benefit than solitary or sedentary screen time.

**Footnote 3** Good quality sleep is not excessively restless or broken by long periods of wake. Note children normally have brief wakings during the night but learn to settle themselves back to sleep within a few minutes.

**Table 6 The UK 2019 Physical Activity Guidelines for the Under 5s**

**Infants.** Being physically active several times in a variety of ways, including interactive floor-based activity e.g. crawling. For infants not yet mobile, this includes at least 30 minutes of tummy time<sup>Footnote</sup> spread throughout the day while awake (and other movements such as reaching and grasping, pushing and pulling); more is better.

**Toddlers.** At least 180 minutes spent in a variety of physical activities at any intensity, including active and outdoor play, spread throughout the day—more is better.

**Pre-Schoolers.** At least 180 minutes spent in a variety of physical activities spread throughout the day, including active and outdoor play,—more is better; the 180 minutes should include at least 60 minutes of moderate-vigorous intensity physical activity (MVPA).

**Footnote.** Tummy time may be unfamiliar to babies at first, but can be increased gradually-starting from a minute or two at a time-as the baby becomes used to it Babies should not sleep on their tummies.

## REFERENCES

- 1.UK Department of Health. Start Active, Stay Active. A report on physical activity for health from the four home countries' Chief Medical Officers. 2011 London, UK.
- 2.Tremblay MS, Chaput JP, Adamo KB et al. Canadian 24-hour movement guidelines for the early years (0-4 years): an integration of physical activity, sedentary behaviour, and sleep. *BMC Publ Health* 2017; 17 (Suppl 5): 874.
- 3.Okely AD, Ghersi D, Hesketh KD et al. A collaborative approach to adopting/adapting guidelines-the Australian 24-hour movement guidelines for the early years (birth-5 years): an integration of physical activity, sedentary behaviour, and sleep. *BMC Publ Health* 2017; 17 (Suppl 5): 869.
- 4.Carson V, Lee EY, Hewitt Let al Systematic review of the relationships between physical activity and health indicators in the early years (0-4 years). *BMC Publ Health* 2017; (Suppl5) 17:854.
- 5.Poitras VJ, Gray CE, Janssen X et al. Systematic review of the relationships between sedentary behaviour and health indicators in the early years (0-4 years) *BMC Public Health* 2017 17(Suppl 5):868
6. Chaput JP, Gray CE, Poitras VJ et al. Systematic review of the relationships between sleep duration and health indicators in the early years (0-4 years):*BMC Public Health* 2017 17(Suppl 5):855
7. Kuzik N, Poitras VJ, Tremblay MS et al Systematic review of the relationships between combinations of movement behaviours and health indicators in the early years (0-4 years). *BMC Public Health* 2017 17(Suppl 5):849
8. Okely AD, Tremblay MS, Reilly JJ et al. Physical activity, sedentary behaviour, and sleep: movement behaviours in early life. *Lancet Child Adolesc Health* 2018; 2: 233-235.
9. Farooq A, Parkinson KN, Adamson AJ, Pearce MS, Reilly JK, Hughes AR, Janssen X, Basterfield L, Reilly JJ. Timing of the decline in physical activity in childhood and adolescence: Gateshead Millennium Cohort Study *Br J Sports Med* 2018; 52: 1002-1006.
- 10Tanaka C Reilly JJ, Huang WY.Longitudinal changes in objectively measured sedentary behavior and their relationship with adiposity in children and adolescents: systematic review and evidence appraisal. *Obes Rev* 2014; 15: 791-803.
- 11.Janssen X, Mann K, Basterfield L et al. Development of sedentary behavior across childhood and adolescence: longitudinal analysis of the Gateshead Millennium Study *Int J Behav Nutr Phys Act* 2016; 13:88

12. Cooper AR, Goodman A, Page AS et al. Objectively measured physical activity and sedentary time in youth: the International Children's Accelerometry Database (ICAD). *Int J Behav Nutr Phys Act* 2015; 12:113.
13. Reilly JJ. When does it all go wrong?: longitudinal studies of changes in MVPA across childhood and adolescence. *J Exerc Sci Fitness* 2016; 14:1-6.
14. WHO Ending Childhood Obesity (ECHO) 2016. <http://www.who.int/end-childhood-obesity/publications/echo-report/en/>
15. WHO Ending Childhood Obesity (ECHO) Implementation Report 2017. <http://www.who.int/end-childhood-obesity/news/draft-implementation/en/>
16. South African 24-hour Movement Guidelines manuscript- in this JPAH series.
17. WHO 24-hour Movement Guidelines manuscript-in this JPAH series.
18. Schunemann HJ, Wiercioch W, Brozek J. GRADE evidence to decision (EtD) framework for adoption, adaptation, and de novo adolopment of trustworthy recommendations: GRADE-ADOLPMENT. *J Clin Epidemiol* 2017; 81: 101-110
19. Reilly JJ, Martin A, Hughes AR. Early life obesity prevention: critique of intervention trials during the first 1000 days *Curr Obes Rep* 2017; 6:127-133.
20. Mindell JA, Williamson AA. Benefits of a bedtime routine in young children: Sleep, development, and beyond. *Sleep Med Rev* 2018; 40: 93-108.
21. Janssen X, Hughes AR, Hill C, Martin A, Hesketh K. Systematic review of associations between physical activity, sedentary behaviour, and sleep in the early years. *Sleep Medicine Reviews*, under review.
22. Brussoni MS, Gibbons R, Gray CE. What is the Relationship between Risky Outdoor Play and Health in Children? A Systematic Review. *Int J Env Res Publ Health* 2015; 12: 6423-6454.
23. Gray CE, Gibbons R, Larouche R et al. What Is the Relationship between Outdoor Time and Physical Activity, Sedentary Behaviour, and Physical Fitness in Children? A Systematic Review *Int J Env Res Publ Health* 2015; 12: 6455-6474.
24. Janssen I. Active play: an important physical activity strategy in the fight against childhood obesity. *Can J Publ Health* 2015; 105: e22-27.
25. Prince S, LeBlanc AG, Colley RC, Saunders TJ. Measurement of sedentary behaviour in population health surveys: a review and recommendations. *PeerJ* 2017; DOI:10.7717/peerj.4130
26. Riazi N, Ramanathan S, O'Neill M, Tremblay MS, Faulkner G. Canadian 24-hour movement guidelines for the early years (0-4 years): exploring the perceptions of stakeholders and end users regarding their acceptability, barriers to uptake, and dissemination. *BMC Publ Health* 2017; 7 (Suppl 5): 841
27. Faulkner G, White L, Riazi N, Latimer-Cheung AE, Tremblay MS Canadian 24-Hour Movement Guidelines for Children and Youth: Exploring the perceptions of stakeholders regarding their acceptability, barriers to uptake, and dissemination» *Applied Physiol Nutr Metab*, 2016, 41(6 (Suppl. 3)): S303.
28. De Craemer M, McGregor D, Androustos O et al. Compliance with 24-hour movement behaviour guidelines among Belgian pre-school children: The ToyBox Study. *Int J Env Res Publ Health* 2018; 15: 2171.
29. Carter PJ, Taylor BJ, Williams SM, Taylor RW. Longitudinal analysis of sleep in relation to BMI and body fat in children: the FLAME Study. *Br Med J* 2011; 342: d2712

30. Baird J, Hill CM, Harvey NC et al. Duration of sleep at three years of age is associated with fat and fat-free mass at 4 years of age: the Southampton Women's Study. *J Sleep Res* 2016; 25: 412-418.
31. Cliff DP, McNeill J, Vella SA et al. Adherence to 24-hour movement guidelines in the early years and associations with social and cognitive development among Australian pre-school children. *BMC Publ Health* 2017 (Suppl 5): 851.
32. Chaput JP, Colley RC, Aubert S et al. Proportion of pre-school aged children meeting the Canadian 24-hour Movement Guidelines and associations with adiposity: results from the Canadian Health Measures Survey. *BMC Publ Health* 2017 (Suppl 5): 829.
33. Hesketh KD, Downing KL, Campbell K, Crawford D, Salmon J, Hnatiuk J. Proportion of infants meeting the Australian 24-hour Movement Guidelines for the Early Years: data from the Melbourne InFANT Program. *BMC Publ Health* 2017 (Suppl 5): 850.
34. Santos R, Zhang Z, Pereira JR, Sousa-Sa E, Cliff DR, Okely AD. Compliance with the Australian 24-hour movement guidelines for the early years: associations with weight status. *BMC Publ Health* 2017 (Suppl 5): 867.
35. Stamatakis E, Zaninotto P, Mindell J, Head J. Time trends in childhood and adolescent obesity in England 1995-2010 and projections of prevalence to 2015. *J Epidemiol Comm Health* 2010; 64: 167-174.
36. Poitras VJ, Gray CE, Borghese MM et al. Systematic review of the relationship between objectively measured physical activity and health indicators in school-aged children and youth. *Appl Physiol Metab Nutr* 2016; 41 (Suppl 3): s197-239.
37. Carson V, Hunter S, Kuzik N et al. Systematic review of sedentary behaviour and health indicators in school-aged children and youth: an update. *Appl Physiol Nutr Metab* 2016; 41 (Suppl 3): s240-265.
38. Chaput JP, Gray CE, Poitras VJ et al. Systematic review of the relationships between sleep duration and health: indicators in school-aged children and youth. *Appl Physiol Nutr Metab* 2016; 41 (Suppl 3): s266-282.
39. Saunders TJ, Gray CE, Poitras VJ et al. Combinations of physical activity, sedentary behaviour and sleep: relationships with health indicators in school-aged children and youth. *Applied Physiol Nutr Metab* 2016, 41(6 (Suppl. 3)): S283-287.
40. Chen W and Adler JL. Assessment of screen exposure in young children, 1997-2014. *JAMA Pediatr*, 2019; In press.
41. Balshem H, Helfand M, Schünemann HJ, Oxman AD, Kunz R, Brozek J, et al. GRADE guidelines: 3. Rating the quality of evidence. *J Clin Epidemiol*. 2011;64(4):401-406.
42. Guyatt GH, Oxman AD, Sultan S, Glasziou P, Akl EA, Alonso-Coello P, et al. GRADE guidelines: 9. Rating up the quality of evidence. *J Clin Epidemiol*. 2011;64(12):1311-1316