

Assessing population levels of physical activity and sedentary behaviour in the UK - what we do currently and recommendations for future approaches.

Summary Document

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Outline

This document summarises the recommendations for the surveillance of physical activity (PA) and sedentary behaviour (SB) in the UK, developed by the Implementation and Surveillance Group as part of the 2018 UK guidelines review process. This summary is presented as a basis for discussion; any decisions will depend on the updated guidance, and will require the approval from the UK Chief Medical Officers. Those financing and managing the current surveys will also need to be involved in the process.

The appendices to this document contain an overview of the current methods for PA guideline surveillance in the UK, alternative methods used by other countries or large surveys, and more detailed discussion of the current challenges and potential solutions.

Brief overview of current surveillance in the UK

- Data on all the recommendations are collected as part of larger surveys using questionnaires.
- These are mostly interviewer-led, computer assisted household based surveys. The exceptions are some school-based surveys for children, and the Active Lives survey in England where respondents complete the survey on mobile devices or computers.
- There is considerable variation between the home nations in the questionnaires used for adult and child moderate to vigorous PA (MVPA) making comparisons difficult.
- When measured, the methods for muscle strength, balance, and SB are more comparable amongst the surveys that measure these recommendations.

Detailed descriptions of the UK surveillance methods are include in appendices.

Identified issues with the current surveillance methods

Adult MVPA

- Not comparable between all four home nations or with international data.
- Very few investigations of validity and/or reliability.
- 16-18 year olds are included in the estimates from some surveys.

Child MVPA

- Questionnaires and data processing methods not comparable between home nations.
- Aside from the Health Behaviour in School Aged Children (HBSC) survey, the data are not internationally comparable.

- With exception of HBSC, there have been limited validity and reliability investigations on the questionnaires.
- Only one survey reports on the under 5s recommendation; 16-18 year olds often included in adult MVPA estimates.

Adult Muscle Strengthening and Balance and Coordination Activities

- In the three surveys that measure compliance to these recommendations, the estimates for both are based on the reported frequencies of certain sport and exercise activities (Health Survey for England, Scottish Health Survey, Health Survey for Northern Ireland).
- The validity and reliability of these methods are hard to assess without greater epidemiological evidence to understand what should count, and whether the relevant activities should be distinct from those counting towards compliance to the MVPA recommendation.

Child Muscle Strengthening Activities

- Currently not measured by any survey.

Adult and Child Sedentary Time

- The current method of deriving total SB as a sum of component behaviours is the type of questionnaire that performs the worst for estimating total SB.
- No survey measures the patterning of SB.

Greater discussion of these issues, and others identified, are include in the appendices.

Main recommendations

Firstly, we call on the relevant Expert Groups from this review process to provide clarity on issues where this is hindering surveillance. These include

- The preferred method to analyse the child MVPA recommendation
- What should be measured for the child muscle strength recommendation
- What should count towards the adult muscle strength and balance recommendations and should they be in addition to MVPA activities?
- What is it about SB that we need to measure?

Secondly, we recommend that this Expert Group works with those involved in the national surveys to assess whether improvements can be made to the current surveillance methods.

Thirdly, we recommend that a group is established to consider the longer term issues that we have identified. Harmonising the self-report questionnaires between the home nations and with international data would be advantageous for cross-country comparisons, but would need to consider factors such as the other priorities of the surveys and the disruption of trend data. It is also important that the advantages and disadvantages of including device-based measures as part of PA and SB surveillance are considered. In the appendices, we highlight some of the many issues that will need to be debated, explaining why this decision is not possible to take at this time.

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Appendices

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Overview

This document provides an overview of the national surveys measuring compliance to the PA and SB recommendations in the UK. For each recommendation, we provide a summary of the current surveillance methods used to monitor compliance to the relevant recommendation(s), an overview of methods used by other nations and large surveys, and a discussion of the issues with current surveillance methods and potential future directions.

1. Overview of the UK surveys

Table 1 presents an overview of the UK surveys that have been used to monitor trends in the prevalence of one or more of the PA or SB recommendations, at a home nation population level.

Table 2 provides an overview of which recommendations are monitored in each survey.

The surveys are usually commissioned by the Government/devolved administration department and are contracted out to social research companies. Some only ask about PA, others include a range of other topics, and some do not include PA and/or SB every year. Most are interviewer-led computer assisted personal interviews, but some are administered by telephone or various methods of self-completion. Weighting variables matched to nationally representative demographic characteristics are often used to account for unequal selection probabilities and non-response biases.

Table 1. Administration of the UK surveys that report on prevalence of the PA guidelines in 2018.

Country	Survey	Commissioners	Contracted to	Survey method
England	Active Lives Survey [1]	Sport England with some additional funding from other bodies	Ipsos MORI	Mobile or desktop completion, sent paper questionnaire if non-response
	Health Survey for England [2, 3]	Department of Health	National Centre for Social Research	Computer assisted personal interviewing
Northern Ireland	Health Survey for Northern Ireland [4]	Department of Health	Central Survey Unit of the Northern Ireland Statistics and Research Agency	Computer assisted personal interviewing
	Young Persons' Behaviour and Attitudes Survey [5]	Department of Health	Central Survey Unit of the Northern Ireland Statistics and Research Agency	Self-complete personal interviewing (now uses tablets)
Scotland	Scottish Health Survey [6]	The Scottish Government	Scottish Centre for Social Research	Computer assisted personal interviewing
Wales	National Survey for Wales [7]	Welsh Government	Office for National Statistics	Computer assisted personal interviewing
Scotland, England, Wales	Health Behaviour in School-Aged Children [8]	Supported by World Health Organization and other partners	Undertaken by a consortium of academics from different countries	School-based, self-completion questionnaires, varying methods of administration.

Table 2. Overview of recommendations monitored by each survey.

Country	Survey	Recommendation measured						
		Adult/ older adult MVPA	Adults/ older adult muscle strength	Older adult balance	Adult/ older adult SB	Child MVPA	Child muscle strength	Child SB
England	Active Lives [1]	✓*				**		
	Health Survey for England [2, 3]	✓*	✓	✓	✓	✓***		✓
Northern Ireland	Health Survey for Northern Ireland [4]	✓	✓	✓	✓			
	Young Persons' Behaviour and Attitudes Survey [5]					✓		****
Scotland	Scottish Health Survey [6]	✓	✓	✓	✓	✓		✓
Wales	National Survey for Wales [7]	✓				✓		****
England, Scotland, Wales	Health Behaviour in School-Aged Children					✓		****

*Official statistic provided by Active Lives Survey not the Health Survey for England.

** This is being considered for future surveys <https://www.sportengland.org/media/11479/active-lives-faqs-website.pdf>

***Also reports on recommendation for under 5s separately to that for older children.

****Some measure of a specific behaviour or domain, most commonly TV/screen time.

2. Moderate-to-vigorous PA for adults and older adults

The recommendation

Adults (aged 19-65) and older adults (aged 65+) should aim to be active daily.

Over a week, activity should add up to at least 150 minutes (2½ hours) of moderate intensity activity in bouts of 10 minutes or more – one way to approach this is to do 30 minutes on at least 5 days a week. Alternatively, comparable benefits can be

achieved through 75 minutes of vigorous intensity activity spread across the week or a combination of moderate and vigorous intensity activity [9].

The abbreviation '150 mins' will be used to refer to this recommendation in the remainder of this section.

Measurement of the '150 mins' recommendation in the UK

Table 3 provides an overview of the UK surveys' current questionnaires for assessing compliance to 150 mins, and a brief overview of past methods of measuring aerobic PA.

The Health Survey for Northern Ireland (HSNI) and the Health Survey for England (HSE) use identical questionnaires and methods of administration (interviewer-led computer assisted personal interview). The Scottish Health Survey (SHeS) only differs on occupational activity and the number of sports prompted. The Active Lives Survey (ALS) is structured differently in terms of what and how activities are prompted (e.g. no occupational activity). It is a self-complete survey (computer, mobile, or paper) rather than being interviewer-led. The National Survey for Wales (NSW) questionnaire is entirely different: it has a seven day (as opposed to four week) recall period, and does not ask about specific activities in such detail. It is, however, administered in a comparable way to the other home nations' health surveys. All surveys have a method of distinguishing between moderate and vigorous intensity activities so that the total weekly durations can be calculated separately. This enables recommendation compliance to be appropriately calculated for those undertaking a combination of intensities.

There have been few direct assessments of the validity and reliability of these questionnaires, the exceptions being those carried out by Scholes and colleagues on the HSE questionnaire (which is the same as the HSNI). Scholes et al. (2016) showed that the HSE questionnaire produces lower prevalence estimates than the IPAQ-short by approximately 10-20 percentage points depending on the age/sex/resting heart rate/body mass index sub-group [10]. The demographic patterns in prevalence were similar between the measures. An earlier study by Scholes et al. (2014) found that correlations between the mean daily minutes of MVPA derived from the HSE questionnaire with uni-axial accelerometry were not strong, but in the range of typical values seen when self-reported instruments are compared with devices [11]. The SHeS questionnaire is very similar to the HSE and HSNI: the main differences are in the number of sport and exercise activities displayed on the show card prompts, and in the measurement of occupational activity [12]. The HSE and HSNI have a series of six questions that interrogate the physical nature of the respondent's occupation, and are used to derive total minutes of MVPA at work per week. In contrast, the SHeS asks a single question asking whether respondents feel they are 'very', 'fairly', 'not very' or 'not at all' physically active at work. Those that respond 'very active' are then allocated 40 or 20 hours of MVPA per week dependent on whether they are full or part time, minus any work sedentary time they reported. Strain et al. (2016) have queried the validity of this method [13].

Alternative methods from other countries or large studies

Table 4 shows alternative methods used by other nations and/or large studies. The majority have used questionnaires, which typically measure moderate and vigorous physical activity and sometimes include specific domains such as walking. The most common recall period is 7 days, although some use the previous month, and some American surveys allow the respondent to choose the recall period. We detailed five examples of surveys/studies where device based measurements have been included: FinHealth (Finland), UK Biobank, Fenland and Whitehall II studies (UK), and the National Health and Nutrition Examination Survey (NHANES; USA).

Current challenges and future directions

Given that the estimates from the current questionnaires used in UK surveillance have either been shown to be, or are assumed to be, similar to those derived from other questionnaires, there is no major pressure to change them. Any change would have to result in benefits that outweighed the disruption of trend data.

Harmonisation between home nations and/or with global surveillance projects using the IPAQ or the GPAQ to enable comparisons could be one such benefit (However, it is worth acknowledging that the priorities of researchers using the data may not be the same as the survey contractors' or commissioners'.

As part of the work of this Expert Group, we have been in touch with almost all national survey contractors. The SHeS were the only survey that informed us that they were considering changing their adult MVPA questionnaire. This was due to the need to reduce the questionnaire length as this section takes up a disproportionate amount of time compared to other health topics surveyed (approximately 7-9 minutes of a 45-60 minute interview which is intended to cover other health topics such as other lifestyle behaviours, medical history, and anthropometric measurements).

One model could be the HSE approach, which only includes its 'long' questionnaire every four years but sometimes includes a variation on the IPAQ-short in intervening years. This allows researchers to adjust for MVPA when undertaking other analyses, but the data are not used for PA prevalence estimates. This may not be a satisfactory solution for the SHeS, however, because the local authority estimates they produce require the combination of different survey years.

It is important to note that the responses to the adult MVPA questionnaire in the SHeS, HSE, and the HSNI are also used to derive compliance to the adult muscle strength and balance recommendations. More details of this method are provided in Section 4 of this report, but it is relevant to mention at this point as any change to the adult MVPA questionnaire would affect the surveillance of other recommendations.

Also, the responses to the SHeS adult MVPA questionnaire are used to monitor other PA related outcomes, such as domain-specific participation rates, that make up the Active Scotland Outcomes Framework [14]. The requirements for such detailed MVPA data must be considered when proposing alternative surveillance methods.

The definition of adults used in the surveys varies, and crucially, often varies from the age range of the 2011 CMO UK PA guidelines. For example, the HSE, SHeS, and HSNI ask 16-18 year olds the

adult questionnaire and include them in their adult prevalence estimates. According to the guidelines, they should be included in the child estimates.

As Table 4 shows, it is now technologically feasible to undertake large-scale surveillance of aerobic activity using devices. The UK Biobank has demonstrated that it can be done on a large scale [15], and two UK child cohort studies (the Growing Up in Scotland Study [16] and Millennium Cohort Study [17]) have administered accelerometers following a household interview. Previously, practical and cost issues were prohibitive but as prices drop and expertise increases in terms of managing fieldwork and processing data, further discussion around the advantages and disadvantages of these methods is warranted, many of which are detailed in Matthews et al. (2012) [18] and Bassett (2012) [19].

One key issue is over the appropriateness of using devices to measure compliance to the 150 mins recommendation that has been derived from data based on self-reported PA. Trioano et al. (2014) addressed this issue directly stating that the 'evaluation of PA guideline adherence based on accelerometer outcomes is inappropriate because the behavioural metrics used to develop the guidelines differ conceptually from device-based measures of MVPA'. It may therefore be premature to introduce device-based surveillance methods before the development of new recommendations expressed in the relevant metric. However, one could argue that the development of such recommendations would require data from large scale surveillance studies. This may be more of a priority for researchers than the national surveys themselves. However, collecting such data now would mean that trends could be retrospectively established when a suitable recommendation has been developed.

On the issue of trend data, it will be important to consider how improvements to devices, device components, and software capabilities would be incorporated into surveillance methods whilst maintaining comparability with previously collected and analysed data. One only has to look at the experience of the NHANES survey for an example of such challenges: four survey 'sweeps'/waves collecting accelerometry used different devices and/or placements for each one (uni- and tri-axial accelerometers, hip and wrist placement).

It will also be important to consider the representativeness of people willing and able to wear a device for a given period of time, as compliance with wear protocols may increase this lack of representativeness [20].

As noted when considering alternative self-report questionnaires, any changes to the current surveillance of adult MVPA may have knock-on effects for other aspects of PA that are measured. Currently, no devices can identify muscle strengthening or balance activities. Also, the optimal choice of device may not be the same for each recommendation. Wrist accelerometers may be a viable option for MVPA measurement, but its ability to derive SB is still to be established. Most devices are currently unable to assess the type or setting of PA, which, as noted earlier, is often used within Government or devolved administrations.

This is not intended to be a comprehensive list of the issues that will need to be considered before device-based surveillance of adult MVPA could be introduced. These issues alone highlight the

complexity of the decision and justify our recommendation that an Expert Group needs to be formed to make long term strategic decisions about the future of PA surveillance in the UK.

In summary, we recommend that

1. The Expert Group communicates with national surveys to see whether 16-18 year olds can be asked the child MVPA questionnaire.
2. Assistance is given to the SHeS to address immediate concerns of the measurement of occupational MVPA and the length of the questionnaire.
3. An Expert Group is formed to consider the longer term future of UK adult MVPA surveillance both in terms of the harmonisation of self-report questionnaires across the home nations and with global surveillance initiatives, and to consider whether devices assessing objectively measured PA should be introduced and if so, how.

Table 3. Overview of 150 mins surveillance methods of the UK national surveys

Country	Survey	Current questionnaire	Brief historical notes
England	Active Lives	<ul style="list-style-type: none"> • Four week recall period. • Frequency of sessions, duration of average session. • Walking, cycling, sport and exercise activities, dance, gardening. 	<ul style="list-style-type: none"> • Pre-2015 it was the Active People Survey (telephone survey). Some questionnaire differences compared to present version.
	Health Survey for England	<ul style="list-style-type: none"> • Four week recall period. • Frequency of sessions, duration of average session. • Walking, heavy housework, gardening/manual, sport and exercises, six items on occupational activity. 	<ul style="list-style-type: none"> • Occupational activity questions introduced in 2008. • Accelerometers (uniaxial) piloted in 2008. • IPAQ-short (a variation of) included in 2013, 2017, 2018 (and planned for 2020-2024) but will not be reported on. • No measure in 2009-11, 2014-15 surveys.
Northern Ireland	Health Survey for Northern Ireland	<ul style="list-style-type: none"> • Four week recall period. • Frequency of sessions, duration of average session. • Walking, heavy housework, gardening/manual, sport and exercises, six items on occupational activity. 	<ul style="list-style-type: none"> • A mixture of questionnaires since 2010 including a variant on the IPAQ-short and then the actual IPAQ-short. • No measure in 2014/15.
Scotland	Scottish Health Survey	<ul style="list-style-type: none"> • Four week recall period. • Frequency of sessions, duration of average session. • Walking, heavy housework, gardening/manual, sport and exercises, single item on occupational activity. 	<ul style="list-style-type: none"> • Minor changes to questionnaire in 2011 on number of sports prompted and older adult walking pace.
Wales	National Survey for Wales	<ul style="list-style-type: none"> • Seven day recall period. • Specific daily durations of walking, moderate, vigorous intensity activity. • Only asked of a sub-sample (in some survey years at least). 	<ul style="list-style-type: none"> • Pre-2015 it was the Welsh Health Survey. • This included self-report paper self-complete questionnaire comparable to IPAQ-short.

Alternative methods of measurement from other countries or large studies

Table 4. Alternative methods from other countries/large studies.

Country/ Region	Measurement instrument and survey	Brief description	Source
Australia	Questionnaire in the National Health Survey	16-item (plus some sub-questions), walking, moderate, vigorous. 7 day recall.	Australian Bureau of Statistics. http://www.abs.gov.au/AUSSTATS/abs@.nsf/DatailsPage/4364.0.55.0012014-15?OpenDocument
Canada	Physical Activities-Adults (PAA) used in Canadian Health Measures Survey (Cycle 5) and Canadian Community Health Survey. Actical used in Canadian Health Measures Surveys (2007-2009, unclear model currently in use).	~14-item (plus some sub-questions), moderate, vigorous, some activity/domain specific. 7 day recall period. Hip-worn, tri-axial, 7 day wear period.	http://www23.statcan.gc.ca/imdb-bmdi/instrument/5071_Q1_V5-eng.pdf http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getMainChange&Id=251160 https://www.statcan.gc.ca/pub/82-003-x/2011001/article/11396-eng.htm
European region	European Health Interview Survey-Physical Activity Questionnaire	8-item, domain-specific questionnaire. 7 day recall.	Finger JD, Tafforeau J, Gisle L, Oja L, Ziese T, Thelen J, Mensink GBM, Lange C. Development of the European Health Interview Survey - Physical Activity Questionnaire (EHIS-PAQ) to monitor physical activity in the European Union. Archives of Public Health 2015;73:59.

Finland	<p>Monitor in the Health 2011 Survey.</p> <p>ActiGraph GT9 Link used in FinHealth 2017.</p>	<p>Hookie AM 20. Waist-worn tri-axial accelerometer, 7 day wear.</p> <p>Wrist-worn, other details unclear.</p>	<p>http://www.ukkinstituutti.fi/filebank/1037-hepa-jaana.pdf</p> <p>Husu P, Suni J, Vähä-Ypyä H, Sievänen H, Tokola K, Valkeinen H, Mäki-Opas T, Vasankari T. Objectively measured sedentary behavior and physical activity in a sample of Finnish adults: a cross-sectional study. BMC Public Health 2016;16:1:920.</p> <p>https://thl.fi/documents/10531/3194911/Health+Profile+FinHealth+2017.pdf/a1dadf8e-8256-4187-b5c5-05d6c5d3c3ba3</p>
United Kingdom	<p>Questionnaires in the UK Biobank.</p> <p>Axivity AX3 used in the UK Biobank.</p> <p>Acti-heart used in Fenland (Phase 2) Study.</p> <p>GeneActiv used in Fenland</p>	<p>6-item variant (different order) on the IPAQ-short.</p> <p>~25-item questionnaire with some similarities to the RPAQ.</p> <p>Wrist-worn (dominant hand) tri-axial accelerometry .</p> <p>Combined heart rate and chest-worn movement sensor.</p> <p>Wrist-worn (non-dominant hand) tri-axial</p>	<p>http://biobank.ctsu.ox.ac.uk/crystal/docs/TouchscreenQuestionsMainFinal.pdf</p> <p>http://biobank.ctsu.ox.ac.uk/crystal/docs/TouchscreenQuestionsMainFinal.pdf</p> <p>Doherty A, Jackson D, Hammerla N, Plötz T, Olivier P, Granat MH, White T, van Hees VT, Trenell MI, Owen CG et al. Large Scale Population Assessment of Physical Activity Using Wrist Worn Accelerometers: The UK Biobank Study. PLOS ONE 2017;12:2:e0169649.</p> <p>Brage S, Brage N, Franks PW, Ekelund U, Wareham NJ. Reliability and validity of the combined heart rate and movement sensor Actiheart. European journal of clinical nutrition 2005;59:4:561-570.</p> <p>White T, Westgate K, Wareham NJ, Brage S.</p>

	<p>(Phase 2) Study and Whitehall II Study.</p> <p>Global Positioning System Receiver used in Fenland (Phase 2) Study.</p>	<p>accelerometry.</p> <p>Waist-worn with option of using Annotation Tool afterwards to provide further detail.</p>	<p>Estimation of Physical Activity Energy Expenditure during Free-Living from Wrist Accelerometry in UK Adults. PLOS ONE 2016;11:12:e0167472.</p> <p>Sabia S, van Hees VT, Shipley MJ, Trenell MI, Hagger-Johnson G, Elbaz A, Kivimaki M, Singh-Manoux A. Association Between Questionnaire- and Accelerometer-Assessed Physical Activity: The Role of Sociodemographic Factors. Am J Epidemiol 2014;179:6:781-790.</p> <p>http://www.mrc-epid.cam.ac.uk/research/studies/fenland/fenland-phase-2-measurements/ https://www.youtube.com/watch?v=aTgO0KsuJV8&feature=youtu.be</p>
United States	<p>Questionnaire in National Health and Nutrition Examination Survey (NHANES)</p> <p>Actigraph GT3X used in NHANES 2011/13 and 2013/14</p> <p>Questionnaire in National Health Interview Survey (NHIS).</p> <p>Questionnaire in 2015 Behavioural Risk Factor Surveillance System (BRFSS).</p>	<p>15-item (plus 1 sedentary time), moderate and vigorous at work and leisure, active travel. 7 day recall period.</p> <p>Wrist-worn non-dominant hand tri-axial. 7 day requested wear.</p> <p>8-item, moderate and vigorous leisure time only. Flexible recall period.</p> <p>5-item (more if report >1 activity), leisure-time only, activity-specific. Flexible recall period.</p>	<p>https://wwwn.cdc.gov/nchs/data/nhanes/2017-2018/questionnaires/PAQ_J.pdf</p> <p>https://wwwn.cdc.gov/nchs/data/nhanes/2011-2012/manuals/Physical_Activity_Monitor_Manual.pdf</p> <p>ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Survey_Questionnaires/NHIS/2018/english/qadult.pdf</p> <p>https://www.cdc.gov/brfss/questionnaires/pdf-ques/2015-brfss-questionnaire-12-29-14.pdf</p>

Other	International Physical Activity Questionnaire Short Form (IPAQ-SF) used in many international studies.	6-item (plus 1 sedentary time), moderate, vigorous, walking. 7 day recall.	https://sites.google.com/site/theipaq/questionnaire_links/IPAQ_English_self-admin_short.pdf?attredirects=0&d=1
	International Physical Activity Questionnaire Long Form (IPAQ-Long)	25-item (plus 2 sedentary time), domain-specific. 7 day recall.	https://sites.google.com/site/theipaq/questionnaire_links/IPAQ_English_self-admin_long.pdf?attredirects=0&d=1
	Global Physical Activity Questionnaire (GPAQ) used by the World Health Organization.	15-item (plus 1 sedentary time), domain specific. Recall period 'typical day/week'	http://www.who.int/ncds/surveillance/steps/GPAQ%20Instrument%20and%20Analysis%20Guide%20v2.pdf
	Recent Physical Activity Questionnaire (RPAQ) used in Fenland study.	9 main questions, but ~60 sub-questions, domain-specific, detailed activities. Recall period 4 weeks.	http://www.mrc-epid.cam.ac.uk/wp-content/uploads/2014/08/RPAQ.pdf

3. MVPA for children and young people

The recommendations

Children of pre-school age (under 5s) who are capable of walking unaided should be physically active daily for at least 180 minutes (3 hours), spread throughout the day [9].

All children and young people (aged 5-18 years) should engage in moderate to vigorous intensity PA for at least 60 minutes and up to several hours every day [9].

Measurement of child MVPA in the UK

There is considerable variation between the methods and questionnaires used by the national surveys to measure compliance to the MVPA recommendation among children (see Table 5). The SHeS and HSE use relatively long detailed domain-specific questionnaires, while the Young Persons' Behaviour and Attitudes Survey (YPBAS) and the Health Behaviour in School-Aged Children (HSBC) surveys use very similar single-items. The NSW is an extended version of this single item – asking for a summary duration of MVPA for each day of the previous week. The administration setting also varies: HSE, SHeS and NSW are household-based interviews where the parents proxy report for the younger age groups. The YPBAS and HSBC are self-complete questionnaires undertaken in a school setting. The age ranges also differ between surveys (see Table 5). The SHeS and the HSE ask 16-18 year olds the adult questionnaire and include this age group in their adult prevalence estimates. The prevalence estimates derived from the SHeS stand out from the other surveys as they have been over 70% meeting the recommendation since 2008 [21]. Surveys such as the HSE and HBSC usually estimate prevalence to be <30%, dependent on age and sex sub-groups [22-24]. Williamson, Kelly, and Strain recently undertook analyses that established the majority of the difference in these estimates was attributable to different analysis methods (*work currently under consideration in BMC Pediatrics*). The SHeS considers children that achieve an average of ≥ 60 mins per day in the previous 7 days to meet the recommendation; other surveys require children to achieve ≥ 60 mins on every day. Up until now, the SHeS questionnaire could only be analysed in that way because the frequencies of activities were reported as a weekly average rather than specific to each day. The response options to the questions were changed in 2017 to allow for the data to be analysed in a more comparable way to other surveys. However, personal communication with the SHeS team has indicated that this has increased the complexity of questionnaire and respondents may be confused. It also increases the length of the survey, which clashes with competing interests to reduce it. The only survey to monitor the MVPA recommendation in the under 5s is the HSE. Parents of children this age are asked the same questionnaire as for 5-16 year olds. Compliance is then monitored by setting the threshold at 180 mins per day rather than 60. There is, however, a slight contradiction in this approach: the assumption for the 5-15-year-old recommendation is that all activity reported is MVPA but the under 5s recommendation could include light intensity activities, which is thus not recorded in the questions.

Table 5. Overview of the UK national surveys that measure compliance to the child MVPA recommendation.

Country	Survey	Current questionnaire	Brief historical notes
Scotland	Scottish Health Survey [6]	<ul style="list-style-type: none"> • Domain-specific, including activity at school. • 7 day recall period. • Activities are reported on specific days*. Asked of all 2-15 years, expected parent proxy report for younger children. 	<ul style="list-style-type: none"> • Prior to 2017, activities were reported as a weekly frequency, not on specific days.
England	Health Survey for England [3]	<ul style="list-style-type: none"> • Domain-specific, including activity at school. • 7 day recall period. • Activities are reported on specific days. • Asked of all 2-15 years, proxy report up to age 12. • 2-4 year olds analysed separately against the under 5s recommendation. 	<ul style="list-style-type: none"> • Pre-2008, the HSE questionnaire was the same as the version used in the SHeS between 2003-2016. • In 2008, the HSE changed the organisation of the domains, activities were reported on specific days, activity at school was removed. • In 2015, the HSE added in questions on activity at school.
Northern Ireland	Young Persons' Behaviour and Attitudes Survey [5]	<ul style="list-style-type: none"> • Single-item question asking how many days in last 7 days undertaken ≥ 60 mins MVPA. • Also questions to give greater detail on specific activity participation over 7 day/12 month time period. • 11-16 year olds, school-based survey. 	<ul style="list-style-type: none"> • Same questions used in 2007, 2010, 2013, and 2016 surveys.
Wales	National Survey for Wales [7]	<ul style="list-style-type: none"> • Proxy-report for all ages (only asked of those aged 3-7) from parent. • Duration of any MVPA reported for each day in last 7 days. 	<ul style="list-style-type: none"> • Current questionnaire in use since 2016-17 survey. • Similar style of questioning used in previous Welsh Health Survey prior to that.
Scotland, England, Wales	Health Behaviour in School-Aged Children [8]	<ul style="list-style-type: none"> • Single-item question where respondents report the days in last 7 when undertaken ≥ 60 mins MVPA. • 11, 13, 15 year olds, school-based survey. 	<ul style="list-style-type: none"> • Repeated using same questionnaire every 4 years.

* Personal communication. Questionnaire will be available on publication of the 2017 report (Autumn 2018).

Alternative methods of measurement from other countries or large studies

Table 6. Alternative methods of measuring child MVPA from other countries or large studies.

Country	Measurement Method(s) (Nationally representative data unless otherwise indicated)	Brief Description	Source
Australia	Pedometers and self-report	<p>G-Sensor pedometer, daily step count (and non wear time) recorded with 7 day diary.</p> <p>Self-report 7 day recall, different questions for 2-4 year olds (focus on active play), 5-17 year olds includes a question comparable to HBSC single-item plus additional domain/activity-specific.</p>	<p>Australian Bureau of Statistics, Australian Health Survey: Physical Activity, 2011–12 2013: Catalogue No. 4364.0. Canberra: Australian Bureau of Statistics. http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/4363.0.55.0012011-13?OpenDocument</p> <p>Cancer Council Victoria, National Secondary Students' Diet and Activity (NaSSDA) survey, 2012-13: Available from: http://www.cancer.org.au/news/media-releases/increase-in-teenagers-screen-use-a-new-threat-to-long-term-health.html.</p>
	Self-report	Self-report question comparable to the HBSC single-item.	Katzmarzyk, P, Barreira, T, Broyles, S, Champagne, C, Chaput, J, Fogelholm, M, Hu, G, Johnson, W, Kuriyan, R, Kurpad, A, Lambert, E, Maher, C, Maia, J, Matsudo, V, Olds, T, Onywera, V, Sarmiento, O, Standage, M, Tremblay, M, Tudor-Locke, C, Zhao, P, and Church, T, The International Study of Childhood Obesity, Lifestyle and the Environment (ISCOLE): Design and methods. BMC Public Health, 2013. 13: p. 900. 47.
	Accelerometers at a regional level with 9-11-year olds.	Actigraph GT3X, hip worn, 7 day requested wear.	Telford, R, Bass, S, Budge, M, Byrne, D, Carlson, J, Coles, D, Cunningham, R, Daly, R, Dunstane, D, English, R, Fitzgerald, R, Eser, P, Gravenmaker, K, Haynesk, W, Hickman, P, Javaid, A, Jiang, X, Lafferty, T, McGrath, M, Martin, M, Naughton, G, Potter, J, Potter, S, Prosser, L, Pyne, D, Reynolds, G, Saunders, P, Seibel, M,

	Pedometers at a regional level.	Pedometers (model AT; New-Lifestyles, US), Pedometer, 7 day requested wear.	Shaw, J, Southcott, E, Srikusalanukul, W, Stuckey, D, Telford, R, Thomas, K, Tallis, K, and Waring, P, The lifestyle of our kids (LOOK) project: outline of methods. Journal of Science and Medicine in Sport, 2009. 12: p. 156-163. http://dx.doi.org/10.1016/j.jsams.2007.03.009
Belgium	Face-to-face questionnaire and via accelerometry	Nationally representative sample, yet quite small (n=488 for 3- to 5-year-old children, n=575 for 6- to 9-year-old children, and n=964 for 10- to 17-year-old adolescents). Actigraph GT3X+, 7 days plus log book for wear time. Adolescents asked Flemish Physical Activity questionnaire (domain-specific, typical week recall period).	Bel S, Van den Abeele S, Lebacqz T, et al. Protocol of the Belgian food consumption survey 2014: objectives, design and methods. Arch Public Health. 2016;74(20) 4. Bel S, De Ridder K, Lebacqz T, Ost C, and Teppers E. Report 3: Physical activity and sedentary behavior (Dutch: Rapport 3: Lichaamsbeweging en sedentair gedrag). Voedselconsumptiepeiling 2014-2015. 2016.
Brazil	Self-report questionnaire	Questionnaire based on Global School-based Student Health Survey and the Youth Behavioural Risk Surveillance System, adapted to the Brazilian setting. Completed on smartphone in classroom setting.	Brazil Ministry of Health, Brazilian Institute of Geography and Statistics. 2012 National Survey of School Health. Rio de Janeiro, Brazil: Author; 2013. Barbosa Filho VC, de Campos W, Lopes Ada S. Epidemiology of physical inactivity, sedentary behaviors, and unhealthy eating habits among Brazilian adolescents: a systematic review. Cien Saude Colet. 2014;19(1):173–193.
Canada	Self-report questionnaire	7 day recall, domain-specific.	Canadian Health Measures Survey (CHMS; goo.gl/dnZ41C)
Denmark	Self-report questionnaire	Self-complete form asking about daily durations of certain activities, longer term frequencies of others.	Region Hovedstaden. Forskningscenter for Forebyggelse og Sundhed. Sundhedsprofil for region og kommuner. årgang 2013. Glostrup: Region Hovedstaden, Forskningscenter for Forebyggelse og Sundhed; 2014:258 sider, illustreret (nogle i farver).15. https://www.regionh.dk/fcfs/sundhedsfremme-og-forebyggelse/Documents/NY-Sp+%C2%A9rgeskema%20Unge_TRYKKLAR.pdf

	Accelerometers at a regional level with 9-11-year olds.	Hip-worn accelerometry, 7 day requested wear.	Troelsen J, ed. Space - rum til fysisk aktivitet: Samlet evaluering af en helhedsorienteret, orebyggende indsats for børn og unge. Kbh.: Center for Interventionsforskning, Institut for Idræt og Biomekanik, Syddansk Universitet; 2014.
England	Self-report questionnaire Self-report questionnaire Accelerometry	Understanding Society (Longitudinal Panel Survey) single item question on frequency of participation in sports, aerobics or other keep fit activities. Self-complete form including question comparable to HBSC plus two additional questions on frequency and duration of more intense activity outside of school hours. Actigraph GT1M units used to assess 2008-2009 PA levels of 7-year olds within the Millennium Cohort Study.	McAloney K, Graham H, Law C, Platt L, Wardle H, Hall J. Fruit and vegetable consumption and sports participation among UK youth. Int J Public Health. 2014;59:117–121. Ipsos MORI. Health and wellbeing of 15 year olds in England: Findings from the What About YOUth? Survey 2014. Health and Social Care Information Centre; 2015. http://www.hscic.gov.uk/catalogue/PUB19244/what-about-youth-eng-2014-rep.pdf . Griffiths LJ, Cortina-Borja M, Sera F, et al. How active are our children? Findings from the Millennium Cohort Study. BMJ Open. 2013;3(8). doi: 10.1136/bmjopen-2013-002893.
Finland	Accelerometers at a regional level	Hip worn Actigraph GT1M and GT3X.	Tammelin T, Kulmala J, Hakonen H, Kallio J. School Makes You Move and Sit Still. Finnish Schools on the Move research results from 2010 to 2015. LIKES - Research Center for Sport and Health Sciences / Finnish Schools on the Move programme; 2015.
Ireland	Accelerometers at a regional level.	Hip worn Actigraph (different models used; i.e., GT1M, GT3X, GT3X+). 9-days of wear requested.	Belton S, O'Brien W, Issartel J, McGrane B, Powell D. Where does the time go? Patterns of physical activity in adolescent youth. J Sci Med Sport, 2016; 19, 921-925.
New Zealand	Self-report questionnaire and accelerometer data.	Self-report using the Multimedia Activity Recall for Children and Adolescents (MARCA). 1-day recall in 5 min time-slices completed on computer, generates estimates of energy expenditure. Actigraph data from 1812 of 2503 participants.	Maddison R, et al. A national Survey of Children and Young People's Physical Activity and Dietary Behaviours in New Zealand: 2008/09. 2010. Clinical Trials Research Unit, The University of Auckland: Auckland, New Zealand.

Portugal	Accelerometry (10-17 year olds).	Actigraph GT1M hip worn, 4 consecutive day requested wear (2 weekday, 2 weekend)	Baptista F, Santos DA, Silva AM, et al. Prevalence of the Portuguese population attaining sufficient physical activity. <i>Med Sci Sports Exerc.</i> 2012;44(3):466–473
South Africa	Regional self-report data	Physical activity questionnaire (PAQ) – participation across six different domains.	McVeigh J, Meiring R. Physical activity and sedentary behaviour in an ethnically diverse group of South African school children. <i>J Sports Sci Med.</i> 2014;13:371–378.
Spain	Accelerometers at a regional level	MTI (Actigraph) accelerometer (model 7164), hip worn, 4 consecutive days requested wear including 2 weekday and 2 weekend days.	Riddoch C, Edwards D, Page AS, et al. The European youth heart study—cardiovascular disease risk factors in children: rationale, aims, study design, and validation of methods. <i>J Phys Act Health.</i> 2005;2:115–129
Sweden	Accelerometer data	Uniaxial monitors (Actigraph or ActiTrainer models used), 3 days requested wear including one weekend day.	Kovacs E, Siani A, Konstabel K, et al. Adherence to the obesity-related lifestyle intervention targets in the IDEFICS study. <i>Int J Obes.</i> 2014;38(Suppl 2):S144–S151
United States	Accelerometers and self-report Self-report questionnaire	The 2003–2006 cycles of the National Health and Nutrition Examination Survey (NHANES) collected waist-worn accelerometer (AM-7164, ActiGraph, LLC, Pensacola, FL, USA) data on a subsample of participants that included children. Self-report single item comparable to HBSC question asked of children/parents of children. Single-item comparable to HBSC plus additional questions on PE class attendance and sport team participation.	Publically available data from the 2003–2004 NHANES and the 2005–2006 NHANES data collections are downloadable from the Centers for Disease Control and Prevention website. Centers for Disease Control and Prevention (CDC). Youth Risk Behaviour Surveillance System. https://www.cdc.gov/healthyyouth/data/yrbs/pdf/2017/2017_yrbs_standard_hs_questionnaire.pdf

Alternative methods from other countries

Table 6 shows alternative methods used by other nations. A range of self-report tools have been used, which have largely been developed by each country. Many surveys include single item questions comparable to the HBSC question (i.e. asking directly on how many days in the last week children have undertaken at least 60 minutes of physical activity), even when further domain-specific questions are asked. There are many examples of accelerometry data collection, although these are mostly at a regional/research study level with NHANES being the only example of repeat national surveillance (i.e., monitoring on annual cycles of 2003-2006; 2011-2014). It is worth noting that both the device and the protocol employed during the 2003-2006 and 2011-2014 cycles did differ.

Current challenges and future directions

A major challenge of current UK surveillance is the lack of a standardised approach to data collection and analysis of the children's PA recommendations. This includes the questionnaires used, administration methods, the different analysis approach taken by the SHeS, and the discrepancies between the age ranges of the guidelines and those monitored. Some of these issues will not be possible to resolve as they relate to the overall survey design. Also, as with adult MVPA, the benefits of harmonising methods may come at a cost of disrupting trend data.

However, the issue of the SHeS analysis method could be resolved through communication between the relevant Expert Groups and survey teams as part of this review process. We also recommend that discussions with the HSE, SHeS, and HSNi are started to investigate whether it is feasible to ask 16-18 year olds the child MVPA questionnaire to allow for their inclusion in the prevalence estimates. We also recommend that in the short-term, the SHeS follows the example of the HSE and reports on the under 5s separately from those aged 5-15 years. We recommend that this is derived from responses to the current questionnaire: the proportion of the under 5s who undertake 180 minutes of MVPA per day.

In line with our recommendations for adult MVPA, we recommend that an Expert Group is created to consider the longer term future of child MVPA surveillance. The two main issues are similar to those raised under adult MVPA: can comparable self-reported data be collected from the different national surveys, and, should objective measures be introduced? Many of the issues relating to the introduction of objective measures that were discussed in the previous section also apply to the measurement of child MVPA, and indeed there may be many other issues specific to this age group (e.g., recall bias). These need to be considered in detail before further recommendations on their introduction can be made.

4. Muscle strengthening and balance activities.

The recommendations

Adults and older adults should also undertake PA to improve muscle strength on at least two days a week [9].

Older adults at risk of falls should incorporate PA to improve balance and coordination on at least two days a week [9].

Children and young people are also advised that vigorous intensity activities, including those that strengthen muscle and bone, should be incorporated at least three days a week [9].

No national survey collects data relating to the children and young people's muscle strengthening guideline, therefore this section will focus on the adult and older adult recommendations.

Measurement of adult and other adult muscle strengthening and balance activities in the UK

In terms of measuring participation in muscle strengthening activities, this has been approached in several different ways. In England, Northern Ireland and Scotland, for each sport and exercise activity that a respondent reported undertaking, they were asked "During the past four weeks, was the effort of [*name of activity*] usually enough to make your muscles feel some tension, shake or feel warm? Yes/No". For some potentially ambiguous sport and exercise activities, data from this question was used to confirm whether it was muscle strengthening. These surveys also include questions on how much time respondents have spent doing a range of non-sport and exercise activities that would typically be considered muscle strengthening activities including heavy housework, gardening, and DIY or building, although responses to these questions are not included when calculating the frequency of muscle strengthening activity.

In Scotland, a panel of experts was convened in 2011 to determine whether each of the activities listed in the SHeS could count towards the muscle strengthening and balance guidelines [6]. Each activity was coded by the experts based on its contribution to strengthening muscles and improving balance. This classification system has also been applied to the HSE and the HSNI, in order to report against the full PA recommendations including the aerobic, muscle strengthening and balance components [4, 25].

Alternative methods from other countries

We undertook a review of the surveillance tools used to measure PA prevalence in 114 countries. The PA prevalence estimates for 74 countries were taken from the WHO 2014 Global Status Report on Non-communicable Diseases[26]. This report included comparable estimates of PA prevalence across many countries, but based only on achievement of the aerobic recommendation of 150 minutes per week, not the full recommendations including muscle strengthening and balance

activities. For the other 40 countries, a range of national and international surveys were used. In total, these 40 countries used 38 different surveillance surveys (see Table 7).

Each tool was reviewed to determine whether it included questions on muscle strengthening and balance activities. For example we reviewed all questions in each of the surveys to determine whether they included questions such as 'do you regularly undertake activities to strengthen your muscles?', 'do you regularly undertake activities to improve your balance?', and/or whether they included questions about participation in activities which are known to increase strength or improve balance, such as weight lifting or one leg stands. We also considered whether each survey would elicit a detailed list of activities that respondents had taken part in, which would inform judgements about their level of participation in muscle strengthening and balance activities. No requirement was set in terms of eliciting the frequency, intensity, time, or type of muscle strengthening and balance activities, simply that at least one question was asked about these types of activities.

Only two countries (in addition to England, Northern Ireland and Scotland) included a question explicitly asking about muscle strengthening activity (Puerto Rico and Guam), yet neither of these surveys systems asked specific questions related to balance activities. In the Behavioural Risk Factor Surveillance Survey conducted in Puerto Rico and Guam, respondents were asked by the interviewer "During the past month, how many times per week or per month did you do physical activities or exercises to STRENGTHEN your muscles? Do NOT count aerobic activities like walking, running, or bicycling. Count activities using your own body weight like yoga, sit-ups or push-ups and those using weight machines, free weights, or elastic bands". Response options were: '(free text) times per week'; '(free text) times per month'; 'never'; 'don't know/not sure'; and 'refused'.

Whilst not explicitly asking about activities that strengthen muscles and improve balance, several other surveys have the capability of estimating the prevalence of muscle strengthening activities due to capturing a detailed list of the types of activities that respondents undertake. These include the national surveillance systems in Barbados, Canada, Israel, and the Netherlands. Eliciting a detailed list of the activities undertaken would allow an assessment against the full PA recommendations by adopting a similar coding system to that utilised in England, Northern Ireland and Scotland, however to date, such categorisation has not been applied to these tools.

Table 7. Alternative methods of measuring muscle strengthening and balance activities.

Region / Country	Survey name	Asks explicitly about muscle strengthening activities	Asks about activities which typically contribute to muscle strengthening	Asks about balance activities	Elicits detail which would allow categorisation of activity types
European region					
Austria	Eurobarometer 80.2, 2013				
Croatia	Eurobarometer 80.2, 2013				
England	Health Survey for England, 2012	X	X		X
Germany	Eurobarometer, 2005				
Greece	Eurobarometer 80.2, 2013				
Greenland	Local Survey, 2005-2009				
Israel	Israeli Ministry of Health, 2011-2012				X
Macedonia	Local Survey, 2012-2013				
Netherlands	Health Interview Survey, 2013				X
Northern Ireland	The Health Survey for Northern Ireland, 2013-2014	X	X		X
Norway	Dyrstad et al (2014) Med Sci Sports Exerc, 46: 99-106				
Scotland	Scottish Health Survey, 2013	X	X		X
Turkey	Turkey Chronic Diseases Prevalence and Risk Factor Study, 2012				
Wales	Wales Health Survey, 2013				
Eastern Mediterranean Region					
Bahrain	Non-Communicable Disease Risk Factors Survey, 2007				
Jordan	Stepwise Survey, 2007				
Lebanon	Sibai et al (2013) BMC Public Health, 13:1002				
Qatar	Stepwise Survey, 2012				
Region of the Americas					
Aruba	Steps, 2006				
Barbados	The Barbados Health of the Nation Survey, 2015				X

Bermuda	Steps, 2014				
Canada	Canadian Fitness and Lifestyle Research Institute, Physical Activity Level of Canadians, 2014				X
Cayman Islands	Steps, 2012				
Chile	National Health Survey, 2009-2010				
Colombia	ENSIN National Survey, 2010				
Cuba	National Survey, 2014				
Dominica	Steps, 2008				
Grenada	Steps, 2010-2011				
Paraguay	First Survey of Risk Factors for Non-Communicable Chronic Disease in the General Population, 2012				
Puerto Rico	Behavioural Risk Factor Surveillance Survey, 2013	X			
St Kitts and Nevis	Steps, 2008				
St Lucia	Steps, 2012				
St Vincent and the Grenadines	Steps, 2013-2014				
Uruguay	Second National Survey on Risk Factors for Non-Communicable Disease, 2013				
Venezuela	Physical Activity and Cardiovascular Risk Factors Survey, 2006				
South-East Asia Region					
Thailand	Thailand Physical Activity Surveillance System, 2014				
Western Pacific Region					
Australia	Australian Health Survey, 2011-2012				
Guam	Local Survey, 2013	X			
Hong Kong	Physical Activity Surveillance System, 2012				
New Zealand	New Zealand Health Survey, 2012-2013				

Current challenges and future directions

Based on existing surveillance systems, the best approach for measuring all aspects of the PA recommendations (including aerobic, muscle strength, and balance activities) using a self-report tool appears to be the approach which was developed in Scotland and has subsequently been applied in England and Northern Ireland. However, some important questions need answering: 1) to ensure this system is fit for purpose and 2) to inform its application in national surveillance. The questions that we call on the Expert Groups involved in this review process to consider are:

- What is the strength of the evidence for muscle strengthening and balance activities?
- Are muscle strengthening and balance activities as important for health as aerobic activity?
- Which activities contribute to muscle strength?
- Which activities contribute to improving balance?
- To what extent are the activities which contribute to strength and balance the same as the activities which lead to aerobic fitness benefits?
- Are the muscle strength and balance guidelines 'in addition' to the aerobic recommendation if undertaking activities which benefits multiple components of fitness?
- Are the balance guidelines only applicable to 'older adults at risk of falls' or do all adults stand to benefit from undertaking these activities?

We also recommend that the recommendation for children and young people is clarified to enable surveillance instruments to be developed.

We also recommend that the Expert Groups consider bone health:

- It is an area of health that is not explicitly addressed in the current PA recommendations. Research indicates that weight bearing and impact activities such as jumping, gymnastics, and dance have beneficial effects on bone health throughout the life course. The primary goal for adults and older adults in relation to bone health is to maintain bone mass, helping to prevent osteoporosis, and minimising the risk of fracture, especially among older adults at risk of falls. The review of the PA recommendations should consider the evidence on PA and bone health, as well as the amount and type of activity required to maintain healthy bones. The assessment of these types of activities should also be incorporated into national surveillance.

Longer term, we recommend consideration of objective measures:

- Strength and balance are relatively easy to measure objectively, for example via a handgrip dynamometer and single-leg balance test. These tests provide a direct measure of fitness, which is more robust than self-reported measures of behaviour. It may be appropriate to incorporate direct measures of strength and balance into national surveillance systems.
- Also, as mentioned in previous sections, we note the importance of considering the measurement of muscle strength and balance activities if changes to the MVPA questionnaires are made.

5. Sedentary behaviour

Recommendation

All children, young people, adults and older adults should minimise the amount of time spent being sedentary (sitting) for extended periods [9].

Note that the wording is slightly different for the under 5s: they should minimise the amount of time spent being sedentary (being restrained or sitting) for extended periods (except time spent sleeping).

A statement on minimising SB was first included in the 2011 guidelines, but in the absence of sufficient evidence, was provided without guidance as to how much (or how little) SB should be undertaken or what constituted an extended period of sitting.

How should we talk about measuring SB?

The term sedentary behaviour has had multiple meanings in the past, including being defined as a lack of adequate PA, which can be confusing and means any retrospective assessment needs to pay attention to the definition that was used.

SB is currently defined as

Any waking behaviour characterised by an energy expenditure ≤ 1.5 metabolic equivalents (METs) while in a sitting, reclining or lying posture [27].

In self-report measures of SB, questions usually ask about time spent sitting, which is a limited subset of the full definition of SB, but is a clear term that most people understand. Accompanying text may clarify that reclining and lying postures are included, and the examples of sedentary behaviour provided generally suggest that sitting without excessive exertion is to be measured. There are many different self-report tools used to measure SB, and this report adopts the TASST framework [28] to describe the composition of the questions. The TASST framework consists of four domains which fully describe each questionnaire (Figure 1).

Objective measures of SB are usually obtained from body-worn monitors. In general, these either measure a lack of activity (worn at hip or wrist), or they measure posture (through thigh inclination). Although both low energy expenditure and posture form part of the definition of SB, objective measures of SB tend to measure one or the other. Measuring the postural element of sitting leads to the best agreement with direct observation, and should be considered the gold standard [29].

Overview of adult sedentary behaviour measurement in the UK

Questions used to report on the SB of adults in the four national surveys over the last ten years are documented in Table 9. In general, inclusion of questions on SB in the national surveys of the U.K. has been inconsistent. In some cases, such as the Welsh Health Survey and the National Survey for Wales, questions about SB have only been asked once in the last 10 years. The most consistent

measurement of SB has been in the SHeS, which has asked the same set of questions annually since 2012. Both the HSE and HSNI, have asked different SB questions in different years.

Reporting of SB in the annual reports from the national surveys is more sporadic than the inclusion of measurement questions. For example, the SHeS has included SB questions every year since 2012, but only reported on them in 2012 and 2015. Additionally, when reporting on SB, the SHeS only reported on leisure time SB, and did not include time spent sitting at work in the reported statistics. Despite this, there is a large amount of consistency in the type of SB questions asked, falling in to two broad groups. The first group asks a single item direct question about total sitting time (reported in hours and minutes), with a previous week recall period asking about week days only (a version of the IPAQ short [28]). This question has been asked in the HSE, the HSNI and the Welsh Health Survey. The second group asks a composite measure as a sum of three behaviours: work; TV viewing; and other (described in the question as not work and not TV). The questions were asked for the last four weeks (a long recall period). Two of these behaviours (TV and other) were asked separately for week and weekend days, whereas one behaviour (work) asked about the work day. This means that assumptions must be made about work days being week days when combining the items to form a sum of total sitting time [30]. This is the version used in the SHeS. When used in the HSE and the HSNI, the work question asked about time spent sitting and time spent standing in the same question, meaning it cannot be reliably used to isolate time in SB, and meaning that total sitting time cannot be assessed.

It is clear that there currently is some consensus, but only limited commitment, to both record and report on SB in national surveys. This is likely to be due to pressures on surveys to limit the number of questions, and lack of guidance as to how best to measure SB.

Overview of child sedentary behaviour measurement in the UK

Questions used to report on the SB of children in the four national surveys over the last ten years are documented in Table 9. For children, questions about SB have been asked less frequently, and less completely than for adults. As with adults, the SHeS has been the most consistent of the national surveys, asking the same SB question annually since 2012. The HSE has included questions for children on SB in three years with enhanced PA modules, although this is not always the same year as for adults. In addition, children were included in the objective monitoring sub-sample in 2008. Children have not been asked about time spent in SB in the last 10 years in either Wales or Northern Ireland.

In terms of content, in both SHeS and HSE, questions ask only about leisure time sitting, as a sum of time spent watching TV and other sitting. Time spent sitting at school is expressly excluded, and there is no provision to ask about this elsewhere in the survey (as there is for work for adults). The surveys differ in the recall period used (unanchored for SHeS, previous week for HSE), which is in turn different from those used in the adult questions (longer recall period, previous 4 weeks).

Questions have been asked in both Wales and Northern Ireland about screen time, but in each case this is not explicitly while sitting. The types of screen time considered in the National Survey for Wales included devices which cannot be assumed to be used predominantly when sedentary, for example smartphones and hand held games players. It is therefore difficult (and potentially not feasible) to use such questions as proxy measures of time spent in SB.

Figure 1: The TAxonomy of Self-reported Sedentary behaviour Tools (TASST) framework for development, comparison and evaluation of self-report tools [21]

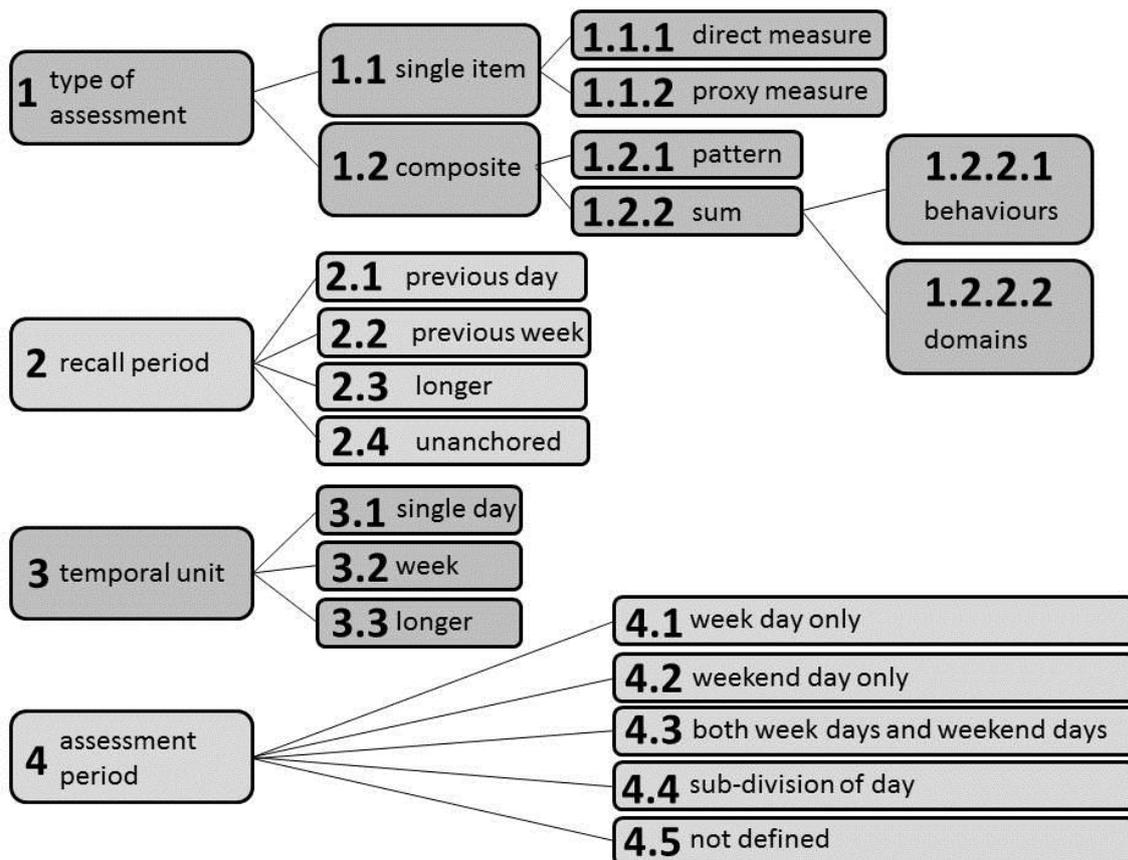


Table 8. Self-report questions used in U.K. national surveys to report SB in adults and children described in terms of the TASST framework [28].

The Taxonomy of Self-reported Sedentary behaviour Tools (TASST)				
Domain name	Type of Assessment	Recall Period	Temporal Unit	Assessment Period
A ¹	1.2.2.1 Sum of Behaviours: work; TV; other (not work, not TV).	2.3 longer (previous 4 weeks)	3.1 day	4.3 both week and weekend days. <i>NOTE: work asked for work (not week) days</i>
B ^{2,3}	1.2.2.1 Sum of Behaviours: work; TV; other (not work, not TV). <i>NOTE for work, asked about sitting and standing in the same question</i>	2.3 longer (previous 4 weeks)	3.1 day	4.3 both week and weekend days. <i>NOTE: work asked for work (not week) days</i>
C ¹	1.2.2.1 Sum of Behaviours: TV; other (not school, not TV).	2.4 unanchored (asks about an average week)	3.1 day	4.3 both week and weekend days.
D ²	1.2.2.1 Sum of Behaviours: TV; other (not school, not TV).	2.2 previous week	3.1 day	4.3 both week and weekend days.
E ^{2,3}	1.1.1 Single item direct measure (i.e. total time spent sitting)	2.2 previous week	3.1 day	4.3 both week and weekend days.
F ⁴	1.1.1 Single item direct measure (i.e. total time spent sitting)	2.2 previous week	3.1 day	4.1 week days only.
G ¹	1.1.2 Single item proxy measure (TV)	2.3 longer (previous 4 weeks)	3.1 day	4.1 week day only

Question used in: ¹ the Scottish Health Survey; ² the Health Survey for England; ³ the Health Survey for Northern Ireland; ⁴ Welsh Health Survey.

Alternative methods of measuring child sedentary behaviour from other countries or large studies

A selection of alternative methods of measuring the SB of children (Table 10) and adults (Table 11), from other countries or large studies are provided. For adults, only a few national surveys (Australia, United States) have used self-report measures of SB. Questions used are similar to those in U.K. surveys, being either a sum of three behaviours (work, TV and other) or a single direct item of sitting. Whilst objective measurement has been employed in large studies and national surveys, this has been limited to monitors mounted at the hip or wrist, which can only measure low activity and not postural sitting.

For children, a greater number of national surveys (eighteen countries) have reported on SB using self-report methods. In general these are predominantly based around screen-based SB, and many do not report on time spent sitting at school. Some countries also reported on SB in children using objective assessments from various devices, yet these are generally on non-representative samples, and are worn at the hip or wrist which can only measure low activity and not postural sitting.

Table 9. Questions on sedentary behaviour for adults and children in national surveys since 2008.

Country	Survey	Population	Year									
			2017	2016	2015	2014	2013	2012	2011	2010	2009	2008
Scotland	Scottish Health Survey	Adults		A	A	A	A	A	X	G	X	G
		children		C	C	C	C	C	X	X	X	G
England	Active Lives Survey/ Active Peoples Survey	Adults		X		X	X	X	X	X	X	X
		children		X		X	X	X	X	X	X	X
	Health Survey for England	Adults		B	E	E	E	B	X	X	X	B*
		children		X	D	X	X	D	X	X	X	D*
Northern Ireland	Health Survey for Northern Ireland	adults	B	E	X	B	?	X	X			
	Young Persons' Behaviour and Attitudes Survey	children		S			S			S		
Wales	Welsh Health Survey	adults			F	X	X	X	X	X	X	X
		children			X	X	X	X	X	X	X	X
	National Survey for Wales	adults	X									
		children	S									

Notes: Surveys crossing successive years (e.g. 2015-2016) are reported under the second year. Cells with a cross indicate survey not conducted in that year, or years when the National Survey for Wales did not include questions on health. Blank cells are where the questionnaires have not yet been published in repositories/archives. Questionnaires for adults apply to those aged 16+, questionnaires for children apply to those aged 2 to 15.

KEY (see table 8 for full description of questions): A: Sum of Behaviours [work; TV; other (not TV not work)], long recall period; B: Sum of Behaviours [work [SIT AND STAND]; TV; other (not TV not work)]; long recall period; C: Sum of Behaviours [TV; other (not TV, not school)], unanchored recall period; D: Sum of behaviours [TV; other (not TV, not school)], previous week recall period; E& F: Single Item Direct Measure; previous week recall period; G: Single Item Proxy Measure [TV]; long recall period (previous 4 weeks); S: asked questions about screen time, which cannot be directly ascribed to sitting; X: no questions asked about SB; * additionally, piloted objective measurement, using hip-worn ActiGraph (not a postural measure of sitting); ?: items on PA missing in archived questionnaire.

Alternative methods of measuring child sedentary behaviour from other countries or large studies

Table 10. Alternative methods of measuring child sedentary behaviour from other countries or large studies.

Country	Measurement Method(s) (Nationally Representative Data unless otherwise indicated)	Source
Australia	Self-Report ^{1,2}	<p>¹Australian Bureau of Statistics, Australian Health Survey: Physical Activity, 2011–12 2013: Catalogue No. 4364.0. Canberra: Australian Bureau of Statistics.</p> <p>²Cancer Council Victoria, National Secondary Students' Diet and Activity (NaSSDA) survey, 2012-13: Available from: http://www.cancer.org.au/news/media-releases/increase-in-teenagers-screen-use-a-new-threat-to-long-term-health.html.</p>
Belgium	<p>Face-to-Face Questionnaire (using a computer-assisted personal interviewing technique) and via accelerometry (Actigraph GT3X+)^{3,4}</p> <p style="text-align: center;"><u>Note</u></p> <p>A nationally representative sample, yet quite small (n=488 for 3- to 5-year-old children, n=575 for 6- to 9-year-old children, and n=964 for 10- to 17-year-old adolescents)</p>	<p>³Bel S, Van den Abeele S, Lebacq T, et al. Protocol of the Belgian food consumption survey 2014: objectives, design and methods. Arch Public Health. 2016;74(20) 4.</p> <p>⁴Bel S, De Ridder K, Lebacq T, Ost C, and Teppers E. Report 3: Physical activity and sedentary behavior (Dutch: Rapport 3: Lichaamsbeweging en sedentair gedrag). Voedselconsumptiepeiling 2014-2015. 2016.</p>
Brazil	Self-Report Questionnaire ⁵	⁵ Brazil Ministry of Health, Brazilian Institute of Geography and Statistics. 2012 National Survey of School Health. Rio de Janeiro, Brazil: Author; 2013.
Canada	<p>Self-Report Questionnaire^{6,7*}</p> <p style="text-align: center;"><u>Note</u></p> <p>*Assessment of communication-</p>	<p>⁶Freeman JG, King M, Pickett W. <i>Health Behaviour in School-Aged Children (HBSC) in Canada: Focus on Relationships</i>. Ottawa, ON: Public Health Agency of Canada; 2016.</p> <p>healthycanadians.gc.ca/publications/science-research-sciences-recherches/health-behaviour-children-canada-2015-comportements-sante-jeunes/alt/health-behaviour-children-canada-2015-</p>

	and media-based sedentary behaviours ⁷	comportements-sant%C3%A9- unes-eng.pdf ^{*7} Leatherdale ST, Harvey A. Examining communication- and media- based recreational sedentary behaviors among Canadian youth: results from the COMPASS study. <i>Prev Med.</i> 2015; 74:74–80.
Columbia	Self-Report Questionnaire ⁸	⁸ Instituto Colombiano de Bienestar Familiar. Encuesta Nacional de La Situación Nutricional En Colombia ENSIN. Bogotá. 2010.
Denmark	Self-Report Questionnaire ⁹ <p style="text-align: center;"><u>Note</u></p> Accelerometers used in smaller, unrepresentative intervention studies.	⁹ Inchley J, Currie D. Growing up unequal: Gender and socioeconomic differences in young people's health and well-being: Health behaviour in school-aged children (HBSC) study: International report from the 2013/2014 survey. WHO, 2016. Health policy for children and adolescents. 2016(7).
England	Self-Report Questionnaire ^{10,11*} *Currently no guidelines for sedentary behaviour	¹⁰ Ofcom. Children and parents: Media use and attitudes report. 2015. http://stakeholders.ofcom.org.uk/binaries/research/media-literacy/children-parents-nov-15/childrens_parents_nov2015.pdf ^{11**} Sandercock GRH, Ogunleye A, Voss C. Screen time and physical activity in youth: thief of time or lifestyle choice? <i>J Phys Act Health.</i> 2012; 9:977–984. **Limited to East Anglia
Estonia	Self-Report Questionnaire ¹² (Regional data using accelerometers; e.g., ¹³)	¹² Aasvee K, Rahno J. <i>Eesti Koolilaste Tervisekäitumise Uuring. 2013/2014.</i> Õppeaasta. Tabelid [Health Behavior in School-Aged Children(HBSC) Study 2013/2014]. Tallinn: National Institute of Health Development; 2014. ¹³ Children's Physical Activity Study. University of Tartu, Institute of Sport Sciences and Physiotherapy. Unpublished data; 2015.
Finland	Self-Report Questionnaire ¹⁴⁻¹⁶ Parental reports of screen-use ¹⁷ <p style="text-align: center;"><u>Notes</u></p> Accelerometers at a regional	¹⁴ Ministry of Education and Young Finland Association. Recommendations for the Physical Activity of School-aged Children. Finnish report, abstract in English. Helsinki: Reprotalo Lauttasaari; 2008. ¹⁵ Kokko S, Hämylä R. The Physical Activity Behaviours of Children and Adolescents in Finland. Results of the LIITU study. Finnish report, abstract in English. Publications of the National Sports Council; 2015:2

	level ¹⁸	<p>¹⁶Tammelin T, Laine K, Turpeinen S. Physical Activity of School-aged Children. LIKES Research Reports on Sport and Health 272. Finnish report, abstract in English. Jyväskylä, Finland: LIKES - Foundation for Sport and Health Sciences; 2013</p> <p>¹⁷Sääkslahti A. Taitavat tenavat results. Unpublished information; 2016.</p> <p>¹⁸Husu P, Vähä-Ypyä H, Vasankari T. Objectively measured sedentary behavior and physical activity of Finnish 7- to 14-year-old children- associations with perceived health status: a cross-sectional study. <i>BMC Public Health</i>. 2016;16(1):338</p>
Ireland	Self-Report Questionnaire ¹⁹⁻²²	<p>¹⁹Economic and Social Research Institute Trinity College Dublin and the Office of the Minister for Children and Youth Affairs. Growing Up in Ireland Infant Cohort Wave 3. 2013.</p> <p>²⁰Gavin A, Keane E, Callaghan M, Molcho M, Kelly C, Nic Gabhainn S. The Irish Health Behaviour in School-aged Children (HBSC) Study 2014. Galway, Ireland: Health Promotion Research Centre at the National University of Ireland. Galway: NUIG; 2015.</p> <p>²¹Belton S, O'Brien W, Issartel J, McGrane B, Powell D. Where does the time go? Patterns of physical activity in adolescent youth. <i>J Sci Med Sport</i>, 2016; 19, 921-925.</p> <p>²²Inchley J, Currie D. Growing up unequal: gender and socioeconomic differences in young people's health and well-being. Health Behaviour in School-aged Children (HBSC) study: International report from the 2013/2014 survey. World Health Organization; 2016.</p>
Netherlands	Self-Report Questionnaire ^{23,24}	<p>²³Hildebrandt VH, Bernaards CM, Hofstetter H. <i>Trend Report Exercise and Health 2000/2014</i>. TNO Leiden; 2015. [<i>Trendrapport Bewegen en Gezondheid 2000/2014</i>]. [screen time]</p> <p>²⁴Van der Klauw M, Verheijden MW, Slinger JD. Report Monitor Covenant Healthy Weight 2013. (Determinants of) exercise-and eating behavior of children (4-11 years, youth (12-17 years) and adults (18+ age) [Rapport Monitor Convenant Gezond Gewicht 2013. (Determinanten van) beweeg- en eetgedrag van kinderen (4-11 jaar), jongeren (12-17 jaar) en</p>

		volwassenen (18+ jaar)]. Netherlands Organization for Applied Scientific Research; 013.publications.tno.nl/publication/34617176/.../klauw-2013-monitor.pdf
New Zealand	Self-Report Questionnaire ^{25,26}	<p>²⁵New Zealand Secondary School Sports Councils. <i>New Zealand Secondary School Sports Census</i>. 2015. http://www.nzsssc.org.nz.</p> <p>²⁶Sport New Zealand. <i>KiwiSport: 2009–2014 Report</i>. Wellington, New Zealand: Sport New Zealand; 2015.</p>
Northern Ireland	Self-Report Questionnaire ²⁷	²⁷ University of London, UCL Institute of Education, Centre for Longitudinal Studies. Millennium Cohort Study: Fifth Survey. 6th ed. Colchester, Essex: UK Data Archive; 2012.
Poland	Self-Report Questionnaire ^{28,29}	<p>²⁸Mazur J. <i>Zdrowie i Zachowania Zdrowotne Młodzieży W Polsce Na Tle Wybranych Uwarunkowań Socjodemograficznych. Wyniki Badań HBSC 2014</i>. Warsaw: Instytut Matki i Dziecka; 2015.</p> <p>²⁹Mazur J, Oblacińska A, Jodkowska M, et al. <i>Aktywność Fizyczna Młodzieży Szkolnej W Wieku 9 - 17 Lat</i>. Warsaw: Institute of Mother and Child; 2013.</p>
Portugal	Self-Report Questionnaire ³⁰	<p>Matos MG, Simões C, Camacho I, Reis M. Relatório do Estudo HBSC 2014—A Saúde dos Adolescentes Portugueses em Tempos de Recensão—Dados Nacionais do Estudo HBSC de 2014. Lisboa: Centro de Malária e Outras Doenças Tropicais/IHMT/UML and Faculdade de Motricidade Humana; 2015.</p> <p>³¹Baptista F, Santos DA, Silva AM, et al. Prevalence of the Portuguese population attaining sufficient physical activity. <i>Med Sci Sports Exerc</i>. 2012;44(3):466–473.</p>
	<u>Note</u> Accelerometers at a regional level with 10-year olds – e.g., ³¹	
South Africa	Self-Report Questionnaire ³²	³² A Survey of Time Use, 2010 / Statistics South Africa. Pretoria: Statistics South Africa, 2013. http://www.statssa.gov.za/publications/Report-02-02-00/Report-02-02-002010.pdf
Spain	Self-Report Questionnaire ³³	³³ Nacional de Salud E. (ENSE) 2011/12. Madrid: Ministry of Health, Social Services and Equality; 2014. [Spanish national health survey (ENSE) 2011/12] [website]. http://www.msssi.gob.es/estadEstudios/estadisticas/encuestaNacional/encuesta2011.htm

Sweden	Self-Report Questionnaire ³⁴ Parental self-report ³⁵	³⁴ The Public Health Agency of Sweden. <i>The Health Behaviour in school-aged Children in Sweden</i> . Stockholm, Sweden; 2013-2014. ³⁵ Kovacs E, Siani A, Konstabel K, et al. Adherence to the obesity- related lifestyle intervention targets in the IDEFICS study. <i>Int J Obes</i> . 2014;38(Suppl 2): S144–S151.
United States	Self-Report ³⁶	³⁶ Centers for Disease Control and Prevetion. National Health and Nutrition Examination Survey. Hyattsville, MC: United State Department of Health and Human Services; 2003-2006.

Alternative methods of measuring adult sedentary behaviour from other countries or large studies

Table 11. Alternative methods of measuring adult sedentary behaviour from other countries or large studies

Country/Region	Measurement instrument and survey	Brief description	Source
Australia	Questionnaire in the National Health Survey	Sum of behaviours (work, TV, other), unanchored recall period, day temporal unit, work and non-work days assessment period.	Australian Bureau of Statistics. http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/4364.0.55.0012014-15?OpenDocument
Canada	Actical used in Canadian Health Measures Surveys (2007-2009, unclear model currently in use).	Hip-worn, tri-axial, 7 day wear period. Measures low activity rather than postural sitting.	https://www.statcan.gc.ca/pub/82-003-x/2011001/article/11396-eng.htm

<p>Finland</p>	<p>Monitor in the Health 2011 Survey.</p> <p>ActiGraph GT9 Link used in FinHealth 2017.</p>	<p>Hookie AM 20. Waist-worn tri-axial accelerometer, 7 day wear.</p> <p>Wrist-worn, other details unclear. Careful consideration required as to whether wrist worn monitors adequately assess SB.</p>	<p>http://www.ukkinstituutti.fi/filebank/1037-hepa-jaana.pdf</p> <p>Husu P, Suni J, Vähä-Ypyä H, Sievänen H, Tokola K, Valkeinen H, Mäki-Opas T, Vasankari T. Objectively measured sedentary behavior and physical activity in a sample of Finnish adults: a cross-sectional study. BMC Public Health 2016;16:1:920.</p> <p>https://thl.fi/documents/10531/3194911/Health+Profile+FinHealth+2017.pdf/a1dadfbc-8256-4187-b5c5-05d6c5d3c3ba3</p>
<p>United Kingdom</p>	<p>Questionnaires in the UK Biobank.</p> <p>Axivity AX3 used in the UK Biobank.</p>	<p>Proxy measures (TV and home computer use), unanchored recall period, day temporal unit, assessment period not defined. Note also asks about time spent driving, which could be considered as a SB (but TV and driving on their own do not form a coherent sum of behaviours to assess total SB). Standing/walking at work also asked; some may use to infer a sedentary occupation.</p> <p>Wrist-worn (dominant hand) tri-axial accelerometry. Careful consideration required as to whether wrist worn monitors adequately assess SB.</p>	<p>http://biobank.ctsu.ox.ac.uk/crystal/docs/TouchscreenQuestionsMainFinal.pdf</p> <p>Doherty A, Jackson D, Hammerla N, Plötz T, Olivier P, Granat MH, White T, van Hees VT, Trenell MI, Owen CG et al. Large Scale Population Assessment of Physical Activity Using Wrist Worn Accelerometers: The UK Biobank Study. PLOS ONE 2017;12:2:e0169649. PLOS ONE 2016;11:12:e0167472.</p>

United States	<p>Questionnaire in National Health and Nutrition Examination Survey (NHANES)</p> <p>Actigraph GT3X used in NHANES 2011/13 and 2013/14</p>	<p>Single item direct measure, unanchored recall period, day temporal unit, assessment period not defined.</p> <p>Wrist-worn non-dominant hand tri-axial. 7 day requested wear. Careful consideration required as to whether wrist worn monitors adequately assess SB.</p>	<p>https://www.cdc.gov/nchs/data/nhanes/2017-2018/questionnaires/PAQ_J.pdf</p> <p>https://www.cdc.gov/nchs/data/nhanes/2011-2012/manuals/Physical_Activity_Monitor_Manual.pdf</p>
Other	<p>International Physical Activity Questionnaire Short Form (IPAQ-SF) used in many international studies.</p> <p>International Physical Activity Questionnaire Long Form (IPAQ-Long)</p> <p>Global Physical Activity Questionnaire (GPAQ) used by the World Health Organization.</p> <p>Recent Physical Activity Questionnaire (RPAQ) used in Fenland study.</p>	<p>Single item direct measure, previous week or unanchored recall period, day temporal unit, weekdays only assessment period.</p> <p>Single item direct measure, previous week or unanchored recall periods, day temporal unit, both week and weekend days assessment period.</p> <p>Single item direct measure, unanchored recall period, day temporal unit, both week and weekend days assessment period</p> <p>Sum of behaviours, longer recall period, day temporal unit, both weekday and weekend days assessment period.</p>	<p>https://sites.google.com/site/theipaq/questionnaire_links/IPAQ_English_self-admin_short.pdf?attredirects=0&d=1</p> <p>https://sites.google.com/site/theipaq/questionnaire_links/IPAQ_English_self-admin_long.pdf?attredirects=0&d=1</p> <p>http://www.who.int/ncds/surveillance/steps/GPAQ%20Instrument%20and%20Analysis%20Guide%20v2.pdf</p> <p>http://www.mrc-epid.cam.ac.uk/wp-content/uploads/2014/08/RPAQ.pdf</p>

For an extensive list of self-reported SB instruments categorised according to the TASST, see Rivière, Aubert [31].

What should we measure?

The current CMO guidelines for SB do not have a recommended value of SB to achieve. Without wishing to prejudice the findings of the SB EWG being conducted in parallel, there may still be insufficient evidence for consensus on a recommended value. It is therefore preferable for national surveillance to measure the total volume of SB, and report this value annually. Prevalence estimates could then be reported, either prospectively or retrospectively, as guidance is updated.

Total SB should be reported across the whole (waking) day. Whilst there is some debate as to whether specific behaviours might be associated with other detrimental health behaviours (e.g. TV viewing may be associated with snacking [32]), there is no evidence that the health effects of sitting at work are different from sitting for leisure. Additionally, for many working age adults, sitting while at work is considerable, and represents a large proportion of the daily sitting (e.g. [33]). Only reporting on SB in part of the day can distort trend data, leading to erroneous conclusions. For example, in the SHeS, when including SB at work those aged 45-54 are the most sedentary segment of the population, whereas when only reporting leisure time SB it is the oldest age group who are the most sedentary [30]. The assessment of SB across the whole day should also apply to children, and time spent sitting at school should be included in total sitting time estimates. This may have implications for the prioritisation of policy.

The current CMO guidelines recommend not sitting for extended periods. Having a higher number of breaks in sitting has been associated with favourable health, and breaking up extended periods of sitting time is often used as a suggestion to improve SB [34]. If breaking up prolonged sitting forms part of the guidelines, then it should, in principle, be assessed in national surveys. However, compared with total SB, the evidence of an association with health for breaking up SB is weaker and more limited [35], and surveillance of this aspect should be considered a secondary priority.

Although total time spent in SB in a day is the most appropriate way to assess the CMO guidelines for SB, the context in which sitting is conducted may have policy implications. For example, assessing specific behaviours (e.g. tracking screen time), or tackling SB in particular domains (e.g. work or transport). As these are related to policy drivers, they may change over time, and should be assessed in addition to, rather than instead of or as part of, total SB. This allows for flexibility with changes in policy and decisions to be made on how much space can be allocated to such policies, without compromising continuous annual assessment of total SB.

How should we measure SB?

Measuring SB using self-report and objective measures produce widely different values. Whilst there are limitations to the objective measurement of SB using body-worn sensors, a postural method of measurement can be considered as gold standard compared to direct observation [29]. Self-reported SB can differ by several hours (e.g. seven hour underestimate to a four hour overestimate) compared with objectively measured postural sitting in the same population [36].

However, self-report measures are easier to implement within existing U.K. surveillance structures, and are likely to form the basis of national surveillance of SB going forward. Whilst there is a wealth of

literature assessing the performance of individual self-report tools compared either to a second self-report tool or to an objective measure of SB, such assessment is rarely undertaken in a systematic manner. A recent large (n=700) validation study in older adults used the TASST framework to assess the effect of two domains (type of assessment n=6, recall period n=3) in a systematic manner (in a 6 by 3 grid, testing 18 combinations), against an objective postural measure of SB [36]. Using this methodology allowed for generalisable statements to be made as to the optimal method of assessing self-reported SB. Accuracy of measurement was poor for all combinations, and it was recommended that a correction factor be added to the self-reported SB to adjust the population mean value. Assessing the 18 combinations for precision and data loss (missing or infeasible data) identified that using a visual analogue scale (VAS) of the proportion of the waking day spent sitting was the best type of assessment. Although using a VAS scale was the best measure, asking other single item assessments (i.e. a direct question about time spent sitting) performed nearly as well, meaning it can also be recommended for use in surveillance. Asking about SB as a sum of time spent in individual behaviours (such as commonly used in national surveys) was the type of assessment that performed worst. The recall period used (previous day, previous week, or unanchored) did not make a great difference to performance.

Objective measurement of SB would provide a more accurate assessment of SB than using self-report measures, however objective surveillance on a regular basis requires commitment and funding. Large scale studies (e.g. UK biobank [15]), have demonstrated the feasibility of using objective measures of SB, however these require time and investment [20]. National surveys with direct contact to researchers, through interviewer-led surveillance (e.g. computer assisted personal interviewing) or anthropometric/physical measurements, provide a platform suitable for effective distribution of monitors, although collection would need additional investment. One clear question to be addressed concerns the type of monitor used. Those that are generally considered most suitable for wide distribution (worn at the wrist or hip) are unable to assess the postural element of sitting [37]. Monitors that assess postural sitting have been used in large studies [38], but not in national surveys. Additionally, how objective assessment of SB integrates with measurement of PA is also important, as using a single monitor to assess both is preferable.

The growth and popularity of wearable technologies to track activity and health may provide a mechanism to objectively assess PA in the future, potentially through (consented) access to data stored in respondents own devices. This could potentially include devices marketed as activity trackers (e.g. Fitbit), as well as data from smart phone accelerometers and applications. Assessment of SB using such devices would need to be carefully considered, especially in regard to what is actually measured by such technology, how the output is interpreted, and how unequal distribution of use may affect weighting of the dataset. Developments in this technology should be monitored to identify an appropriate time and mode for inclusion.

Assessing breaks in sedentary behaviour is difficult using self-report, and has only been attempted in a small number of self-report tools, often in limited contexts (e.g. at work [39]). In the systematic validation of self-report tools in older adults [36], breaks in sitting performed extremely poorly. It is

likely that breaks in sitting can only be adequately assessed using objective methods of measurement.

Current challenges and future directions

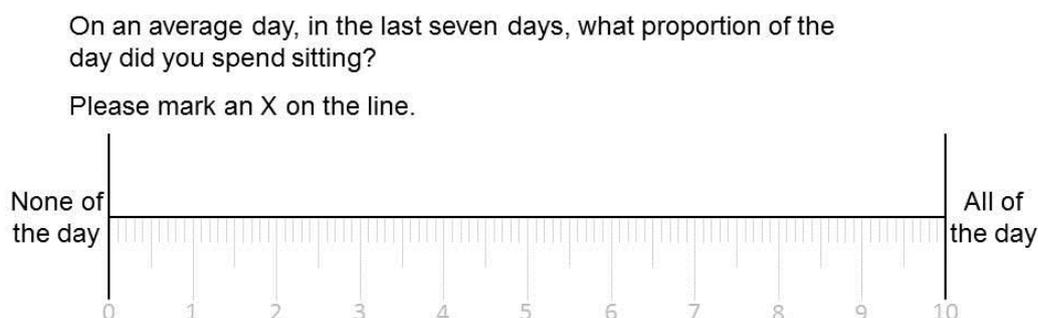
In general, surveillance of, and reporting on, the SB of adults and children in the United Kingdom in the last ten years has been intermittent, and has not always been measured consistently within national surveys. We conclude the following recommendations:

- That total SB across the whole day be assessed and reported annually in national surveys.
- That this is achieved using a single question (a single item direct measure of total time spent sitting). The recall period could be adapted such that is consistent with that used for MVPA.
- Questions should be preceded by a brief description of SB, e.g.:

We are going to ask you about your sedentary behaviour, which is any time you spend sitting, reclining or lying down. Please don't count the time asleep at night.
- Current evidence suggests a Visual Analogue Scale response is optimal (see Figure 2 below, for an example using a previous week recall period). We recommend that work is undertaken to see if it is feasible for use in a UK national health survey context.
- If a VAS scale is impractical, then the following text is recommended (provided for a previous week recall period):

How long in total did you spend sitting on an average day in the last seven days?
- Additional questions should be asked on time spent in SB in specific behaviours and contexts as required by the individual policy requirements of the surveys, or to provide historical comparison with previous survey questions. These additional questions should not be used to provide a sum of time spent sitting, and should not be used as an alternative to the single annual question on total SB.
- Objective measurement of SB would provide a more accurate assessment than self-report, and should be considered in future in conjunction with the potential objective assessment of PA.

Figure 2. Example of single direct item of sitting asked as a visual analogue scale, for a previous week recall period.



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