Expert Working Group Working Paper

Older Adults Working Group

UK physical activity guidelines: Review and recommendations for Older Adults (aged 65+ years)

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BACKGROUND

UK Physical Activity Guidelines

The first UK physical activity guidelines were produced in 1996 following the 1994 Ascot Meeting of UK and international experts, who agreed recommendations for adults (1, 2). These recommendations were then extended to include new recommendations for children and young people in 1998 (3). These recommendations included suggestions about the frequency, intensity and time of aerobic physical activity needed for each age group but also included the first recommendation for muscle strengthening, flexibility and bone health for children and young people only. In 2004 the English Chief Medical Officer formally endorsed these recommendations and thus began a continuing relationship with their production and dissemination that has continued to today. At the same time Scotland and Wales had adopted similar guidelines and following the publication of the 2008 USA physical activity guidelines (4), the UK CMOs harmonised and produced the current physical activity guidelines, published in 2011 (5). These included, for the first time, recommendations for Under 5s and for all age groups, sedentary behaviour (6).

Benefits of physical activity for Older Adults

A healthier old age includes good physical and mental function, opportunities for social interaction and a sense of control over, and responsibility for one's own health and well-being as well as managing or coping with disease symptoms and functional limitations. Participation in regular physical activity or exercise contributes to all five of these inter-related determinants of health (7, 8). Regular physical activity plays an important part in enabling older adults to remain above critical functional thresholds by managing disease symptoms, reducing falls risk factors and morbidity, preserving and restoring function, and maintaining both psychological and cognitive health (5, 7-9).

Older adults are assets to society as, for example, grandparents provide up to 40% of childcare (10), there are over 1 million carers over the age of 65 years in the UK and most carers over the age of 70 years are providing over 60 hours care a week (11). In terms of paid employment, 1 in 5 workers do not expect to retire until they are over 70 years old (12). Yet, more than 50% of our older population report early disability and increasing dependency, with substantial personal and public health implications. Targeting the increase of physical activity and the reduction of sedentary behaviour has a major role to play in the prevention of chronic disease, the maintenance of functional status, and the preservation of physical independence as we age and therefore should be encouraged across the lifespan (6).

The key aim/objective of this working paper is to present recommendations for potential changes to the existing 2011 UK CMO Physical activity guidelines for older adults. This working paper presents the findings of the Older Adults Expert Working Group (EWG). The document

answers a set of questions about potential changes to current physical activity guidelines, by expert scrutiny of the most up to date scientific reviews and other national guidelines.

Outline of CMO Process

This work was conducted in three phases (summarised in Figure 1). Phase One established each EWG, selected international experts, conducted formal purposive systematic reviews of the existing and new evidence, developed a website for a national consultation on the current UK CMO Guidelines and their implementation, and production of working group papers. All Chairs and Expert Panel members completed a statement of their declarations of interest.

In Phase Two, draft working papers were developed (this being one of the six papers). The draft papers were circulated to participants attending two Scientific Consensus Meetings (SCM) in Edinburgh and London, during June and July of 2018, respectively. This document has been revised in two ways: i) to reflect the feedback received from both consensus meetings; ii) in response to the updated evidence base.

Phase Three will include a second national consultation on draft physical activity recommendations, and a final round of review and revision. CMO EWGs will then produce a final technical report for UK CMOs with final recommendations for new physical activity guidelines. If the CMOs sign off the suggested recommendations, then the CMO Guidelines Writing Group supports the production of a final CMO Physical Activity Guidelines Report.

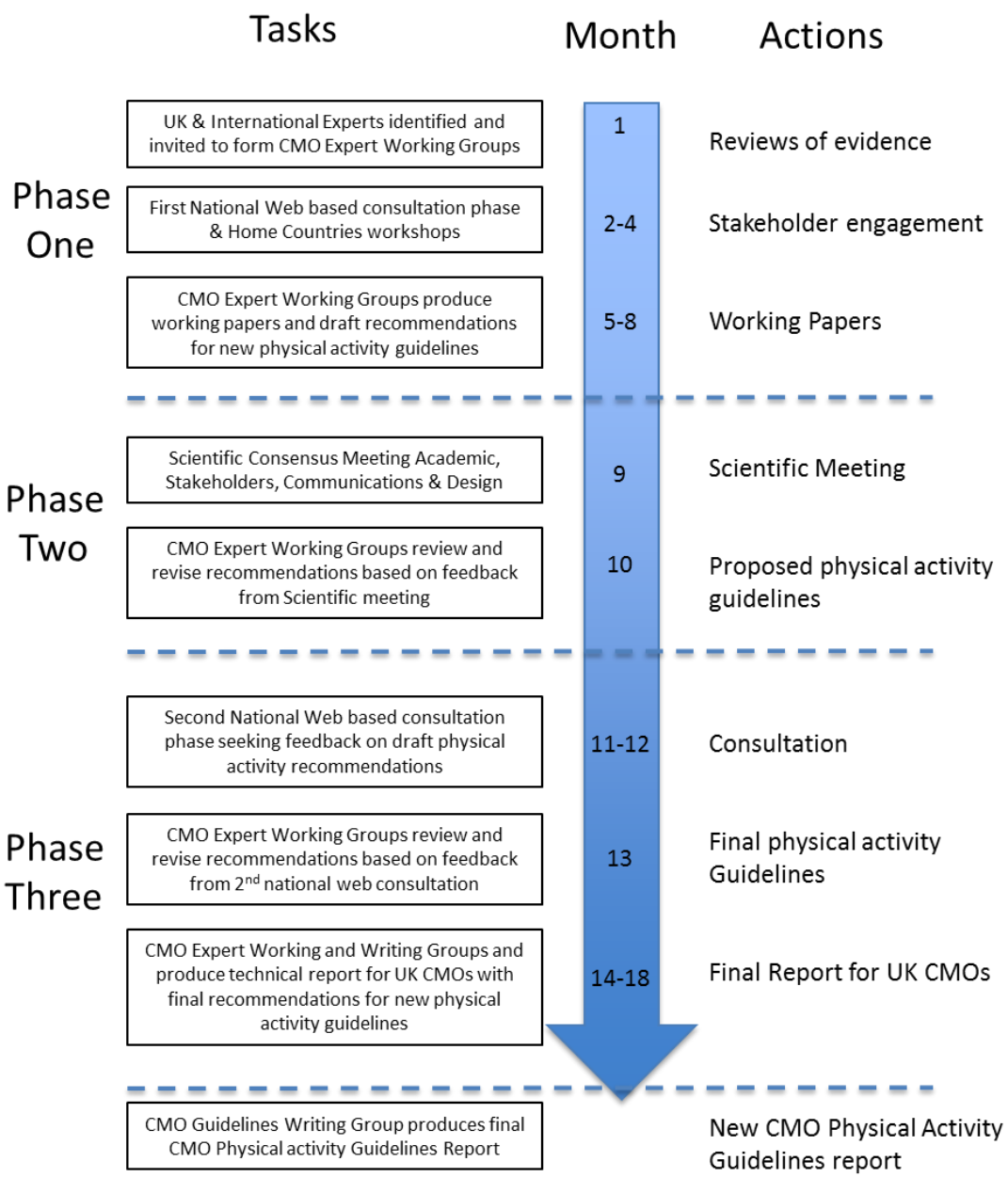

Figure 1. 2018 UK Physical activity guidelines review process

Methods for CMO Physical Activity Guidelines Update

Based on the experience of updating guidelines in 2011, as well as resources and time it was deemed impractical to undertake a full review of the primary literature. It was agreed by the EWG Chairs that to identify a set of key review documents to be the primary sources of evidence underpinning the UK review work.

The process to update the 2011 CMO physical activity guidelines drew upon three types of evidence: (A) recent published evidence reviews used to construct or update international physical activity guidelines; (B) the most recent pooled analyses, meta-analyses and systematic reviews from prospective and randomised controlled trial (RCT) research published since the most recent reviews used to update international guidelines; and (C) any additional relevant papers identified by each EWG. In addition, comments and suggestions about the current 2011 CMO physical activity recommendations were identified for each EWG from our first round of National Consultation.

Each EWG adopted the same principle, namely, to identify if there was any new evidence that justified a change to the existing 2011 guidelines. The current 2011 UK physical activity guidelines were constructed to advise the general population about the recommended frequency, intensity, time and types of physical activity required to prevent major chronic disease and to maintain health. In the UK, disease refer specifically to premature and all-cause mortality, years of life lost and the disease burden (coronary heart disease, stroke, heart failure, diabetes mellitus type 2, chronic obstructive pulmonary disease (COPD), breast cancer, colorectal cancer, lung cancer, osteoarthritis, dementia and cognitive decline, and depression and depressive symptoms). The guidelines also focus on preventing premature (or all-cause) mortality and fractures, disabilities in the elderly, injuries and, in children, attention deficit hyperactivity disorder (ADHD) symptoms. We also included key risk factors, which have a causal relationship with these chronic diseases i.e. systolic blood pressure, low density lipoprotein (LDL) cholesterol, body weight, adiposity, insulin sensitivity and cardiorespiratory fitness.

The specific steps that were followed to address items A-C that were highlighted above are described in detail below.

A. Identifying recent national evidence reviews used to construct or update physical activity guidelines

We searched for published international evidence reviews of physical activity, used to construct national physical activity guidelines and recommendations (published since 2010) using Google and targeting public health bodies (i.e. National Centre for Health and Care Excellence, Centre for Disease Control). We also contacted international experts to identify further examples of relevant reviews from the United States, Australia, Canada and The Netherlands. We identified the most relevant and up to date high quality reviews from these sources and made summations of the effectiveness of the evidence across their health outcomes.

B. Identifying the most recent pooled analyses, meta-analyses and systematic reviews from prospective and RCT research

We undertook purposive searches to identify review level relevant literature on the relationship between physical activity and health outcomes. Our searches primarily focused on review-level evidence for longitudinal cohort studies examining the relationship between physical activity and health outcomes. We also examined review level evidence from RCTs in order to identify from systematic reviews and meta-analyses what types of physical activity were considered in effectiveness studies. We searched PubMed using a tailored set of broad MeSH terms (Medical Subject Headings) to capture the most current studies published, relevant to the needs of each EWG. For example, "resistance training", "muscle", "bone', "balance" AND "physical activity" AND "adults". Full search terms for each EWG are presented in Table 1.

Table 1. Search Terms for Older Adults

Mortality	Breast Cancer	Sedentary Behaviour
Morbidity	Lung Cancer	Sitting
Health Outcomes	Prostate Cancer	Screen Time
Coronary Heart Disease	Mental Health	
Cardiovascular Disease	Dementia	Adults
Stroke	Cognitive	Young Adults
Heart Failure	Depression	Older Adults
Diabetes	Quality Of Life	
Chronic Obstructive Pulmonary	Happiness	English
Disease	Sleep	Review
Osteoarthritis	Attention Deficit Hyperactivity	Meta Analysis
Sarcopenia	Disorder	Systematic Review
Strength	Blood Pressure	Individual Patient
Function	Hypertension	Data
Anxiety	Cholesterol	
Brain	Obesity	
Behaviour	Insulin Sensitivity	
Academic Performance	Body Weight	
Fractures	Body Composition	
Accidents	Fat Mass	
Falls	Aerobic	
Disability	Resistance	
Injury	Balance	
Cancer	Strength	
Colorectal Cancer	Fitness	
	Muscle	
	Bone	

The terms of the searches and their dates reflected the searches used in the most recent international evidence review from the Netherlands and the USA. For example, the searches used for the Dutch guidelines were truncated at 1 October 2016 so searches for this report include all publications from January 1st 2016 (in case of delayed archiving) to 1st January 2018.

A total of 38 papers were identified using this process (13-50). EWGs reviewed these papers and made summations of the effectiveness of the evidence across their health outcomes.

C. Identifying any additional relevant papers by each EWG

In addition to the above search strategy, each EWG member was asked to identify any relevant outcomes and primary papers from their own sources and networks. EWG members identified the most relevant and up to date high quality reviews from these sources and made summations of the effectiveness of the evidence across their health outcomes and whether the evidence suggested that any element of the 2011 guidelines for adults should be altered. A further 111 papers were identified by expert working group members (51-163).

Key Questions

Question 1: Does the scientific evidence continue to support the current physical activity guidelines for older adults?

Statement 1: The evidence broadly supports the current guidelines, but there are some changes required following new evidence. The recommendation for a minimum bout length (i.e. at least 10 minutes) is no longer be necessary for the optimal health message. Growing evidence supports the importance of light intensity activity to health, which should be communicated particularly with those currently inactive or frailer/disabled, as a way to encourage transition to meeting the guidelines. Growing evidence further supports the 'be active daily' guideline as frequency of trips from home has emerged as an independent predictor of newly diagnosed disease. Evidence suggests that moderate volumes of activity (measured by steps per day) is predictive of reduced risk of mortality. Given the very low levels of physical activity in this population, small increases in volume of daily physical activity can produce important health benefits. Strength and balance activities (multi-component or multi-modal exercise with flexibility included) at least twice a week remain important for health. 'Walk and rest for a minute' may be a useful strategy for adults in this age group, particularly those currently inactive or frailer. It is important to recognise that becoming less active as we age leads to reduced function and health and any benefits of an intervention or activity are lost once stopped. Activity involvement, in whatever form is possible, is vital irrespective of age or medical conditions.

Commentary 1: There is a changing role of PA in older adults as for some it is more about the maintenance of independence and management of symptoms of disease (secondary disease prevention) rather than primary disease prevention. Moderate intensity physical activity (MVPA) can reduce by 50% the relative risk of developing functional limitations or disability. The risk of progression of disability in basic activities of daily living is almost halved in those who undertake regular moderate level PA compared to those with a low PA level (58). The value of light activity in maintenance of health in older age is now clear (see Question 4).

Six large cohort studies suggest that steps per day are associated with reduced mortality and morbidity in older adults. A review and meta-analysis (59-61, 164, 165) of pedometer and accelerometers research on health recommends 4500-5500 steps a day for improved health related quality of life, >7000 steps a day for better immune function, and 8000-10000 steps a day for an effect on metabolic syndrome and maintenance of weight. The evidence suggests that 30 minutes of daily MVPA accumulated in addition to habitual daily activities in healthy older adults is equivalent to taking approximately 7,000-10,000 steps/day. A longitudinal study examined the associations between volume and intensity of older adults' PA, with their subsequent health service usage over the following four to five years (n=240) (60). Using objectively measured PA and lower limb function, minutes of MVPA per day predicted subsequent numbers of prescriptions. Steps taken per day and MVPA also predicted unplanned hospital admissions. There was a dose response relationship with those who either managed

more than 4196 ± 574 steps (medium group) or more than 7065 ± 1936 steps (high group) per day reporting lower number of prescriptions and unplanned hospital admissions than those reporting 2067 ± 784 steps per day. A further analysis with the same participants highlighted that steps per day were significantly predictive or mortality with mortality risk being 36% lower for every 1,000 steps taken (61). A large prospective cohort study in men aged 71-92 years concluded that each additional 1000 steps per day was associated with a fully adjusted hazard ratio of mortality of 0.86. There was no evidence for a threshold effect, nor for setting a specific target goal for mortality, simply that more steps were associated with lower risk of mortality (85). Another prospective cohort study following older adults for 9.8 years, reported a reduction in mortality in the top quartile of steps (>~8000) however they acknowledge that the study lacked power to detect other effects (164). Finally, a 10 year follow up of adults aged 58.8 years at baseline found a higher daily step count at baseline was linearly associated with lower all-cause mortality (adjusted hazard ratio 0.94 per 1 000 steps) (165). These studies highlight that small increases in physical activity can produce significant health benefits. Given the low levels of PA of this diverse population setting steps/MVPA targets that are progressive and tailored to the individual could produce important benefits for the individual and the society. Low levels of MVPA and few trips from home were associated with a diagnosis of new diseases, reinforcing the 'be active every day' message.

Adequate muscle strength is necessary for good mobility and for every 25 newton (N) increase in lower extremity muscular strength, individuals aged 50-85 years have a 14% reduced risk of residual-specific death (deaths not from the major nine causes of death) (hazard ratio = 0.86) (62). A loss of muscle strength in advancing age is the primary limiting factor for functional independence (63). The WHO framework on Healthy Ageing suggests "intrinsic capacity" as an appropriate concept to assess the integrated care needs of older adults, as it includes common clinical manifestations of declining physical and mental capacities as strong predictors of mortality and care dependence in older age (64). Many of the chronic diseases associated with ageing are also the result of the superimposed negative effects of lack of activity and the resulting diminished homeostatic adaptive capacity may underlie both clinical frailty and its adverse outcomes (65). Good balance and mobility are essential to the successful performance of most activities of daily living as well as being able to take part in recreational activity, indeed those with compromised balance are often weaker in key independence muscles as they avoid activity. Poor balance predicts a higher rate of cognitive decline (66) and predicts higher all-cause mortality (67). In older adults, using the Short Physical Performance Battery (SPPB) as a marker for physical function, there is a linear relationship with mortality (68) with a threshold SPPB score of less than 10 predictive of all-cause mortality. Keevil's study suggests that the association of physical function with mortality is visible as young as mid-life (69). Although higher training intensities are superior to lower intensities in terms of maximal strength per se (70), the intensity appears less important for improving physical function, where multimodal activities that mimics activities of daily living, such as sit to stands, and functional repetitive movements using body weight and resistance, confers the greatest benefits on function (71). Multi-component strength and balance activities performed 2-3 times per week conferred the

best benefits to physical function (23). From a public health perspective, reducing sedentary behaviour (see Sedentary Behaviour Panel report) and engaging in regular sit to stands (72, 73), stair climbing (74), embedding strength and balance activities into everyday life tasks (75), and walking may be a more feasible and less challenging approach to increase strength and balance in frailer older adults than taking part in more strenuous activities in order to promote health (76).

Question 2: Is there sufficient evidence to require separate Physical Activity Guidelines for older adults?

Statement 2: Older adults should be the target for a specific set of guidelines appropriate for their future health and should have specific messaging and health promotion strategies to improve their uptake and adherence to the guidelines. This is reinforced by the 2018 USA Physical Activity Guidelines Committee assessment (9). Encouragingly, there is strong evidence from systematic reviews of RCTs and meta-analyses that physical activity contributes to increased physical function, reduced disability, independent living, and improved quality of life in both healthy and frail older adults. There is also strong evidence that physical activity in later life can help treat and offset the symptoms of a range of chronic conditions (e.g. depression, cardiovascular disease (CVD), Parkinson's disease).

Older adults also experience different life stages to middle-age adults such as retirement, having grandchildren for the first time and are more likely to become a carer bringing with it a new set of challenges in terms of physical activity participation (128). Strategies to overcome these are likely to be different compared with younger or middle-aged adults. Taken collectively the evidence supports discrete focused guidance on physical activity in older adults.

Commentary 2: Improvements in lifestyle, health and social care mean that the proportion of the UK population who are over 65 years is increasing (currently 18% aged 65 years and over and 2.4% aged 85+) (157). This is projected to rise to 25% by 2046 for people aged over 65. Importantly here, UK adults over the age of 65 years constitute one of the most inactive populations in society with commensurate poor health. Older adults have a high level of absolute risk for mortality, are more likely to experience a range of chronic health problems (over half of the population aged 65+ years have two or more chronic diseases) and as a result of age-related decline in physical function (e.g., strength, gait speed, balance) are at greater risk of falls and subsequent trauma-related hospital admissions compared to younger adults. As a society, increasing physical activity in those over 65 years will help minimise the burden on health and social care. For example, people aged 65 years or over account for approximately one in six of the population but one in two hospital bed days and a third of all outpatient attendances.

Support for this statement is based on evidence synthesised from national and international policy documents, studies describing the epidemiology of the current UK populations (147-149,

157), a review of how existing physical activity guidelines from 17 countries categorise physical activity for older adults (including the USA physical activity guidelines assessment of multiple systematic reviews of RCTs and meta-analyses (9)), and finally multiple systematic reviews of RCTs and meta-analyses that specifically explored the impact of physical activity on older adults (24, 49, 78-80, 114). Moderate PA reduces the risk of stroke in older adults (81). Those older adults who self-report moderate or vigorous activity at least once a week have less chance of being frail at 10 year follow up (82). Multi-component group exercise programmes are effective at reducing frailty or postponing frailty (83) though further work is needed on optimum frequency and duration. Finally, many of the life-course events that affect ability to be active occur in older age (retirement, caring responsibilities, hospitalisation) and it is important that older adults are encouraged to maintain or increase activity in these times (128).

Finally, there is a need for specific guidelines to focus awareness on the decline in those meeting the aerobic and the strength guidelines with increasing age. In fact, 34% of men and 39% of women aged 65+ years do no MVPA (159) and 84% of men and 91% of women over the age of 75 years do no muscle strengthening sport and exercise activities (160). The proportion of the older population meeting the current balance activity guidelines decreases steadily with age, from 25% of men and 18% of women aged 65–69 years to 8% of men and 2% of women aged over 85 years (160). Average self-reported sedentary time is 7.4 hours a day in the over 75s (73, 162). Domestic activity and walking are the most prominent activities reported by the over 65s and these rarely have any effect on strength and balance and are rarely performed briskly or at moderate intensity (159). However, when movements specifically prescribed to improve balance or increase strength are embedded within everyday activities significant reductions in falls rates by as much as 30% over 12 months have been observed (75). In the LiFE study strategies to improve balance included “reduce base of support”, so, for example, a prescribed activity incorporating this strategy involved a tandem stand while working at the kitchen bench, and over time could be upgraded to working while standing on one leg. Strategies to increase strength included “bend your knees”, and a prescribed activity incorporating this strategy might involve squatting instead of bending at the waist to close a drawer, and this could progress to picking things up from the floor (75).

Older adults have a very wide range of physical function and mobility and as such there will be wide variations in activity levels they achieve currently or could achieve in the future. The 2011 PA guidelines were supported by a series of resources aimed at interpreting the PA guidelines (149). *Active* older adults are those who are already active either through daily walking, an active job and/or who are engaging in regular recreational or sporting activity. Older people *in transition* describes people whose function is declining due to low levels of activity and too much sedentary time, who may have lost muscle strength and/or are overweight but otherwise remain reasonably healthy. *Frailer* older adults are those who are identified as being frail or have very low physical or cognitive function, perhaps as a result of chronic disease such as arthritis, dementia or advanced old age. Those *in transition* and *frailer* are less likely to meet guidelines but should be encouraged to sit less and move more and build up their activity

gradually (e.g. to cope with fatigue) as for these groups any increase in activity has some health benefits (166).

Question 3: What is the available evidence related to the accumulation of physical activity in multiple short periods (10 min bouts) in older adults?

Statement 3: Emerging evidence from cross sectional and prospective studies indicates that bouts of any length of MVPA contribute to the health benefits associated with accumulated volume of physical activity. The recommendation for a minimum bout length (i.e. at least 10 minutes) is therefore no longer necessary for the optimal health message. This seems particularly important in older adults given the sporadic nature of accumulated MVPA in this population.

Commentary 3: The evidence for this statement was primarily taken from the 2018 USA Physical Activity Guidelines Committee (9) assessment of 25 papers that reported on 23 original research studies, of which nine were RCTs, two were prospective cohort studies, 11 were cross-sectional studies, and one used a non-randomised design. In addition, the EWG reviewed ten recent papers based on prospective cohort studies that investigated patterns of accumulation of device-measured PA (including bout length and sedentary breaks) in relation health outcomes and mortality in middle-aged to older adults (85, 86, 90, 164, 167-172).

Summary of the evidence from the USA report: The randomised studies reported only on bouts that were at least 10 minutes. These studies demonstrated that intermittent bouts resulted in similar or enhanced effects when compared to continuous bouts of physical activity of longer duration for outcomes of weight and body composition, blood pressure, blood lipids, or glucose or insulin. However, these studies did not provide information to evaluate bouts of physical activity of less than 10 minutes in duration.

Evidence of overall health benefits resulting from bouts of physical activity less than 10 minutes in duration was provided by studies that used a cross-sectional or prospective design. Physical activity accumulated in bouts less than 10 minutes in duration is favourably associated with body mass index, body fatness, blood pressure, blood lipids, glycaemic control, metabolic syndrome, inflammatory markers, Framingham Cardiovascular Disease Risk Score, and mortality.

Evidence from other recent prospective cohort studies: One prospective population-based cohort study of men recruited from 24 UK General Practices (85) found that the Hazard ratio (mortality) for accumulating 150 min MVPA/week in sporadic minutes (achieved by 66% of men) was 0.59 (95% CI 0.43 to 0.81) and, similar, 0.58 (95% CI 0.33 to 1.00) for accumulating 150 min MVPA/week in bouts lasting ≥10 min (achieved by 16% of men). Another analysed data from the NHANES 2003-2006 survey, with a 6.6 year follow up, examined the associations between objectively-measured PA accumulated with and without a 10-minute bout criterion and all-cause mortality in a representative sample of US adults 40 years and older (n=4840) (86).

Increased length of MVPA bout did not result in additional risk reductions for mortality, suggesting mortality risk reductions associated with MVPA are independent of how activity is accumulated. The prospective cohort studies of Lee et al. (87) and LaMonte et al. (90) also indicate that a higher volume of device-measured, non-bouted MVPA is associated with a reduced risk of mortality in older women. Simmonds et al. (60) looked at a follow up of older adults (PA objectively measured) and found that both volume of activity (including lower limb function) and amount of MVPA (independently) were associated with diagnosis of new disease, even if accumulated in bouts shorter than 10 minutes. Fox et al. (61) found that older adults who took part in high levels of moderate PA (>23 mins per day) had less unplanned hospital admissions and number of prescription medications. A large prospective cohort study in men aged 71-92 years with a median follow up of five years did not find a lower mortality rate in those accumulating >150 minutes MVPA in bouts of 10 minutes or more compared with those accumulating >150 minutes MVPA in bouts of 1 minute or more (164). Papers published since the US PAGAC report have also failed to find associations between bouts of MVPA lasting 10 minutes or more in relation to the following outcomes: presence of peripheral arterial disease, subclinical vascular disease (168), markers of cardiac injury (169), markers of inflammation and haemostasis (170), levels of adiposity (171) and markers of chronic kidney disease (172).

Limitations of findings: None of the randomised studies reported on the effects of physical activity accumulated in bouts of less than 10 minutes. Such studies would be beneficial for informing potential cause and effect rather than simply associations. There is still insufficient evidence to determine whether the relationship between physical activity accumulated in bouts with a duration of less than 10 minutes and health outcomes varies by age, sex, race/ethnicity, or socioeconomic status.

Question 4: Is there enough evidence to suggest sufficient health benefits for light intensity activity?

Statement 4: There is emerging evidence to recommend that for inactive older adults, replacing sedentary behaviour with light-intensity PA is likely to produce some health benefits. Specifically, for individuals who perform no or little moderate-to-vigorous PA, replacing sedentary behaviour with light-intensity PA (such as walking at 2 miles per hour, dusting or polishing furniture, or easy gardening) reduces the risk of all-cause mortality, cardiovascular disease incidence and mortality, and the incidence of type 2 diabetes. It would be a missed opportunity in this revision not to highlight the potential of light intensity PA to benefit the health of older adults. That would be particularly important for older adults for whom moderate-intensity PA might not be a feasible option. Making up the deficit of MVPA with light-intensity movement in daily routines could bring important health benefits at a population level.

Commentary 4: Existing guidelines do not explicitly recommend light intensity PA due to the lack of evidence at the time of their development, just inclusion of the recommendation '*be*

active every day'. However, the use of wearable devices to objectively measure PA of community-dwelling individuals during daily life activities in addition to exercise has provided a growing evidence base that supports the beneficial role of light-intensity PA to favourable health benefits, independent of those provided by MVPA (88, 89). A review of 37 cross-sectional and 3 longitudinal studies on the benefits of light intensity PA suggests that light activity is associated with a range of health benefits including lower risk of obesity and all-cause mortality as well as improved markers of lipid and glucose metabolism (91) in adults and older adults. Further, for individuals who perform little or no MVPA, adding a small and comfortable amount of light- to moderate-intensity activity, such as walking an additional 5 to 15 minutes 2 to 3 times per week, has a low risk of injury or adverse events. A prospective study of accelerometry measured by light PA in relation to all-cause mortality, CVD mortality and cancer mortality provides evidence that light activity is related to lower risk of mortality (90). A variety of other health outcomes appear to be related to higher levels of light PA including lower pulse wave velocity and carotid intima media thickness (168), lower levels of markers of cardiac injury (169), lower levels of inflammatory markers (170) and lower levels of BMI, waist circumference, fasting serum insulin and fat mass index (171). Some initial meta-analytic evidence suggests that protective benefits accrue for older adults at levels of PA well below current recommendations (92), but this needs further examination in those with and without comorbidity or frailty.

The results invariably show a reduction in mortality risk when sedentary behaviour is replaced with higher intensity activities. Models in which an equivalent duration of sedentary behaviour is replaced with light-intensity PA predict a reduction in mortality, and models in which sedentary behaviour is replaced with MVPA predict an even greater reduction in mortality. Because the models are "isotemporal" (in the same time frame) it cannot be determined whether the increase in predicted benefit is due to the higher intensity of the PA per se or the higher volume of energy expended (93).

Limitations of findings: The most recent systematic review and meta-analysis of 72 studies (including 27 experimental studies, 28 cross-sectional studies and 17 prospective studies) (89) together with the evidence base presented in the US PAGAC report (9) highlight that important gaps in knowledge still remain and more studies determining the role and contribution of light-intensity PA alone or in combination with MVPA to health outcomes are required.

Question 5: Is the evidence sufficient to support a separate guideline for muscle-strengthening activity, a separate guideline for flexibility activities, and/or a separate guideline for balance activities? If so, what should be considered, and should these guidelines differ for adults and older adults?

Statement 5: The evidence suggests that the recommendations should include 'all adults and older adults should undertake a programme of activity at least twice per week that includes resistance activities (lifting weights, using resistance bands or other equipment to provide

resistance etc.), some impact activities (running, jumping, skipping etc.) and balance activities (standing on one leg, backwards walking, activities that involve three dimensional movement etc.) (94). The specific exercises included and the volume of activity per session should be tailored to individual fitness and physical function' (95). The guideline should include specific examples of resistance activities and other relevant activities. These examples should reflect key principles of progression, volume, intensity, frequency, multi joint, multi modal (e.g. bodyweight, free weights, resistance machines, elastic bands, support options for challenging balance activities etc.) and prescriptions for strength and balance activities and training for different starting levels of experience and activity. Other examples from everyday living to develop or maintain strength could also be presented (74, 75, 163).

There is little evidence to suggest a separate guideline on flexibility. However, flexibility and movements to increase range of movement should be part of these multi-component activities as the majority of the evidence-based interventions included flexibility in the cool down element of the intervention.

Commentary 5: A detailed commentary exists from the Adult EWG Panel (Question 4). Essentially, this statement comes from two rapid reviews of the evidence base for strength and balance activities (94, 95).

Perhaps the most well-known and accepted benefits of flexibility (muscle stretching) exercises are improved or maintained range of motion, alignment of bones and joints, and strengthening of connective tissues, all elements that optimise performance. The PAGAC 2018 report (section on older adults) states 'insufficient evidence is available to determine the effects of flexibility training on physical function' (9). Although some evidence exists that flexibility training favours reduction in contractures, where 5 out of 7 seven studies that assessed active stretching programmes for healthy older people reported statistically significant effects on joint mobility (96). However, a systematic review of 22 studies concluded the information regarding the relationship between functional outcomes with flexibility interventions was conflicting. A meta-analysis of three studies of flexibility training found a non-significant effect of flexibility training on gait speed (9). This limited evidence precludes the offering of guidance as to a flexibility intervention related to maintaining or improving functional ROM for older adults (97, 98). However, all interventions reviewed within the Hillsdon and Foster review (95) included a flexibility element within the training (warm up or cool down components) and so this should be explicit in the updated guideline for multi-component strength, balance and flexibility recommendation. Flexibility is a key part of multicomponent interventions shown to be effective at improving physical function in a recent umbrella review (99).

Question 6: What is the evidence for high intensity interval training (HIIT) on clinical/health outcomes in older adults?

Statement 6: There is currently limited evidence to support HIIT in older adults. Insufficient evidence is available to determine whether the effects of HIIT on cardiometabolic risk factors are influenced by age, sex, race/ethnicity, or socioeconomic status.

Commentary 6: Although evidence indicates that high intensity interval training (HIIT) can effectively improve insulin sensitivity, blood pressure, and body composition in adults, there is a paucity of data for older adults. These HIIT-induced improvements in cardiometabolic disease risk factors are comparable to those resulting from continuous, moderate-intensity aerobic exercise and are more likely to occur in adults at higher risk of cardiovascular disease and diabetes, compared to healthy adults. Insufficient evidence is available to determine whether a dose-response relationship exists between the quantity of HIIT and several risk factors for cardiovascular disease and diabetes. The evidence for this statement was taken from the 2018 USA Physical Activity Guidelines Committee assessment (9) of three systematic reviews and/or meta-analyses of intervention studies (100-102). The majority of HIIT studies have been done in younger healthy adults, and those (fewer) studies that have involved older adults have typically focussed on a specific chronic condition. Indeed, the EWG only identified two small (N<60) RCTs exploring the effects of HIIT on cardiometabolic health outcomes in a non-clinical older adult population (103, 104). Therefore, although the EWG agrees with the USA Committee's assessment of HIIT and acknowledges that it is an approach to accumulating vigorous-intensity physical activity, it recognises the need for more research in older adults specifically.

Limitations of findings: There is a paucity of data on the effects of HIIT on hard clinical end-points (e.g. all-cause and CVD mortality, CVD and type 2 diabetes incidences). The outcomes of the Generation 100 study are eagerly awaited in this regard (105). As indicated above, there is also limited evidence on the benefits and harms of HIIT in the non-clinical older adult population. An additional limitation is that most HIIT intervention periods have been less than 12 weeks, which may be insufficient time for clinically-meaningful changes in specific cardiometabolic health outcomes to occur. The willingness and ability of older adults to adhere to HIIT programmes is also poorly understood.

Question 7. Based on the current scientific evidence, how should the Physical Activity Guidelines address physical activity and weight management?

Statement 7: Evidence on physical activity and weight management in older adults is lacking. In adults, strong evidence demonstrates a relationship between greater amounts of PA and attenuated weight gain in adults, with some evidence to support that this relationship is most pronounced when PA exposure is above 150 minutes per week and moderate to vigorous in nature. However, there is some limited evidence that suggests that the relationship varies by age, with the effect diminishing with increasing age. Given the scale of the problem of overweight adults and obesity, the importance of PA and the need for restricting energy intake simultaneously should be emphasised. Moreover, the role of PA in maintaining weight after

weight loss and the health benefits of reduced body fat should be highlighted. Weight maintenance, loss or gain may be particularly important for certain health conditions (e.g. type II diabetes, frailty, depression) and should be considered in context. The value of PA to these conditions is covered elsewhere.

Commentary 7: The evidence for this statement was taken from the 2018 USA PA guidelines based on evidence from 33 original research studies (9). Out of those 33 studies, 6 studies analysed the data specifically by age, with the evidence suggesting attenuation of this association with increasing age in both men and women, however the pattern of results was inconsistent in the studies that included both men and women. Some studies suggest that the associations between physical activity and magnitude of weight gain are lost past mid-life (around 45-50 years) in men and women (106), in men (107, 108) and in women (109, 110). Others have shown no difference in associations with increasing age in men (111) and women (108). Exercise interventions in older adults with obesity showed improved physical function but no significant weight loss and combined dietary and exercise interventions appear to have better outcomes on weight in older adults (112).

Limitations of findings*:* RCT interventions to support the role of PA in reducing obesity in older adults are lacking. Insufficient evidence is available to determine whether the relationship between PA and weight is influenced by age, race/ethnicity, socioeconomic status or by initial weight status. A recent review looking at PA combined with dietary restriction on weight loss and musculoskeletal function in overweight and obese older adults with knee osteoarthritis found 2 trials and the narrative synthesis suggested differences in favour of reduced body weight and mobility but there is much more work needed in comorbid older adults (113).

Question 8: Based on the current scientific evidence, how should the Physical Activity Guidelines address physical activity preventive mental health benefits?

Statement 8: Strong evidence from multiple systematic reviews and meta-analyses supports the preventive mental health benefits of physical activity for older adults. In particular, evidence demonstrates that PA delays the onset of cognitive decline, anxiety disorders and symptoms, reduces the risk of experiencing depression and improves wellbeing. Activity with components of both aerobic and resistance-type training, of at least moderate intensity and at least 45 min per session, on as many days of the week as possible, is beneficial to cognitive function in older adults. Even low amounts of activity (<150 minutes per week) are associated with significantly reduced risk of depression (greater volume of physical activity is associated with larger effects). Bouts of 30 minutes per day of activity almost halve the odds of experiencing depression, which has particular public health, health care and economic impact. Moderate evidence supports the importance of maintaining PA for sustaining health-related quality of life (HRQoL) and overall quality of life (QoL) in late adulthood. Moderate evidence exists for multicomponent physical activity reducing fear of falling in older adults.

Commentary 8: Support for this statement is based on evidence synthesised from multiple systematic reviews of RCTs (114) and meta-analyses and from a review of existing PA guidelines from 17 countries, including the USA Physical activity guidelines assessment of multiple systematic reviews of RCTs and meta-analyses (9). The EWG reviewed additional systematic reviews that identified strong support for the role of physical activity in reducing the risk of cognitive impairment and dementia (20, 115) and improving cognitive function and quality of life (24, 49) and emerging support from a review exploring the protective role of PA in older adults from age-associated executive cognitive function declines (116). Clinical trials of both aerobic and resistance training activities show positive effects on executive function, attention, and processing speed, with inconsistent evidence for memory and other domains (45).

Physical activity in the form of aerobic exercise holds promise in terms of reducing the risk of cognitive impairment and dementia (20, 117). It is likely that this results from either a) attenuating progression of neurodegenerative processes and age-related loss of synapses and neuropil or b) via affecting cerebrovascular disease. Interventions of aerobic, resistance training, multicomponent training and tai chi were similarly effective, regardless of baseline cognitive status (49). The findings suggest that a programme with components of both aerobic and resistance-type training, of at least moderate intensity and at least 45 min per session, on as many days of the week as possible, is beneficial to cognitive function in older adults. The meta-analysis by Loprinzi et al. (116) suggest that 6000 to 8000 MET-min-month of MVPA may best protect older adults from age-associated executive cognitive function declines but will need to be confirmed with prospective and experimental work. More recently, it has been suggested that multicomponent exercise (strength, aerobic and balance) has the most positive effects on cognitive function (44).

Physical activity is efficacious at reducing depressive symptoms in older adults (118). Fear of falling can be reduced (at least immediately following intervention) with multicomponent exercise programmes (119). The meta-analysis by Windle et al. (114) suggests two sessions per week (walking programmes and group exercise), each of 45 mins duration is most effective at improving mental wellbeing, even in frailer older adults. However, PA interventions do not seem to confer benefits to participation in life roles (120).

There is also a sound empirical basis for the role of PA in improving HRQoL (NB: Physical HRQoL has received more attention that mental HRQoL) (24, 121, 122).

Limitations of findings: The body of literature pertaining to the preventive value of PA to mental health typically adopt self-report measures (varied) to assess PA. The same can be said for depression and depressive symptoms in terms of a lack of consistency of measurement. Further research is also required to understand to what extent overall and HRQoL outcomes derived from PA participation are modified by a number of social and economic factors (e.g. age, sex, socioeconomic status).

Question 9: What evidence is there to support PA and the prevention of dementia and Alzheimer's disease?

Statement 9: Strong evidence demonstrates that greater amounts of PA are associated with a reduced risk of developing dementia, including Alzheimer's disease and with improvement of other aspects of cognitive function. The high and rising prevalence of older adults and the financial and societal consequences of caring for people with dementia, stress the important role of PA as a prevention tool against dementia.

Commentary 9: The 2008 Scientific Report concluded that strong evidence demonstrated that PA delays the incidence of dementia and the onset of cognitive decline associated with ageing (4). Recent reviews point to a 28% reduced risk of developing dementia among physically-active older adults (20, 115, 123). Physical inactivity may be the most important preventable risk factor for Alzheimer's dementia, with the population-attributable fraction estimated to be around 20% (124).

Physical activity influences cognitive function across the lifespan, including both cognitively normal and impaired populations. The effects are consistent across a variety of methods for assessing cognition (e.g., academic achievement and dementia diagnoses). The 2018 Scientific Report (9) also demonstrates, for the first time, the positive effects of physical activity on biomarkers of brain health obtained from neuroimaging techniques (e.g., brain volume).

Moderate evidence indicates that PA interventions can improve cognition in individuals with dementia, including Alzheimer's disease (AD) (125, 126). For example, one meta-analysis of 18 RCTs from 802 dementia patients reported an overall effect size of 0.42. This effect was also significant for individuals with AD or non-AD dementias (126). These positive effects were found for interventions that included both high-frequency or low-frequency PA. A very recent study RCT (n=494) found that people with mild to moderate dementia can engage and comply with moderate to high intensity aerobic and strengthening exercise and improve physical fitness (measured with the 6-min walking test at 6 weeks only), these benefits did not translate into improvements in cognitive impairment, activities in daily living, behaviour, or health related quality of life (127). This 4-month group-based intervention with 12-month follow-up showed some cognitive worsening in the intervention group. The intervention had a strong and well-developed behavioural component which targeted the transition from group-based supervised to individual non-supervised activity. However, the intervention group did not continue with non-supervised activity after the end of the intervention. This study raises a more generic concern on how RCTs treat people with dementia when they are randomised to the intervention group and where after four months of establishing a positive routine and engaging socially with other people (especially in a group context) the intervention finishes and they return to their previous routines. From a psychological perspective, that could trigger strong negative responses not experienced in the control group who continued their normal routines during the trial. However, this is a speculation at this point which merits further investigation.

To summarise, given the heterogeneity in the assessment methods, insufficiently detailed description of the physical activity interventions, and moderate risks for bias, the strength of the evidence is rated as moderate. Consideration must also be given to the frequency and intensity of supervision and support as the dementia progresses (84).

Question 10: What evidence is there to support PA in delaying progression of Parkinson's disease?

Statement 10: There is strong evidence that increasing physical activity has a significant impact on cognition (general cognitive function and executive function) and physical function of people with Parkinson's disease (PD) (walking, balance, strength and disease specific motor scores).

Commentary 10: The evidence on physical function came from 20 systematic reviews published between 2004 and 2015 (detailed in (9)). Participants included in these studies were community-dwelling older adults between the ages of 57 and 88 years diagnosed with mild to moderate PD (based on Hoehn and Yahr scores of 1 to 3). The PA modalities were varied, ranging from conventional forms of training (aerobic (129) or resistance training) to activities such as dance, yoga, and tai chi (130). Significant improvements in mobility and disease progression were reported in people with PD after strength training (131) and aerobic exercise improved function (132).

Studies of PD also show significant improvements in cognition following exercise interventions, with the largest effect sizes in domains of general cognitive function and executive function (133).

Not fully recognized is the substantial accumulating evidence that long-term aerobic exercise might attenuate PD progression. Randomized controlled trial evidence will not be forthcoming due to many complicating methodological factors. However, extensive and diverse avenues of scientific investigation converge to argue that aerobic exercise and cardiovascular fitness directly influence cerebral mechanisms mediating PD progression. To objectively assess the evidence for a PD exercise benefit, a comprehensive PubMed literature search was conducted, with an unbiased focus on exercise influences on Parkinsonism, cognition, brain structure, and brain function. This aggregate literature provides a compelling argument for regular aerobic-type exercise and cardiovascular fitness attenuating PD progression (77).

Question 11: What is the evidence for the associations between physical activity and sleep?

Statement 11: There is strong evidence that habitual MVPA improves sleep outcomes in adults of all ages. There is moderate evidence for a dose-response relationship between the duration in minutes of the episode of PA (but not intensity or modality) and the size of the benefit. Improved sleep may occur immediately after a single acute bout of MVPA ('last bout effect'). Moderate evidence indicates improvement across all ages for all sleep outcomes with the

exception of sleep (onset) latency, i.e., the length of time between going to bed and falling sleep. There is moderate evidence for benefits of MVPA on sleep in adults reporting symptoms of insomnia and obstructive sleep apnoea.

Commentary 11: Sleep duration is associated with all-cause mortality (both short <6.5 hours and long >9.5 hours) and the strength of the association is greater in older adults with low PA levels (134). Low levels of activity are also associated with sleep disturbances (135) in older adults. A more recent cross-sectional study examining cognitive function and its association with PA and sleep found that PA is associated with better cognitive performance independently of sleep quality, and sleep efficiency is associated with better cognitive performance independently of PA (136). However, PA is not associated with sleep quality and thus PA and sleep quality may be related to cognitive performance through independent mechanisms.

The US Department of Health and Human Services PAGAC report (9) is the primary evidence source. The PAGAC drew upon six systematic reviews and nine meta-analyses which showed benefits of both regular and acute PA on a number of sleep outcomes including total sleep time, sleep efficiency, sleep onset latency, sleep quality (habitual only; insufficient information about acute effects for this outcome), and rapid eye movement sleep (acute only; insufficient information about habitual effects for this outcome). Acute bouts also shortened the time awake after falling asleep and decrease stage 1 sleep time. Acute bouts of sleep also improved depth of sleep and this effect was stronger in those who were habitually active. MVPA improves sleep in adults reporting symptoms of insomnia and obstructive sleep apnoea.

The committee also concluded that age does not moderate the relationship between greater amounts of regular PA and total sleep time, sleep efficiency, and sleep quality. However, there is a reduced benefit on sleep latency with age, with a 0.15 standard deviation decrease in benefit for every decile increase in mean age.

Limitations of findings: The evidence presented in PAGAC 2018 is applicable to adults of all ages. However, the proportion of reviews cited in the section on age as a specific factor and which specifically focus on PA and sleep in older adults compared with younger/ middle-aged adults is very limited.

Question 12: Does physical activity in older adults contribute to social isolation and low social support, social functioning, or social networks and can it help reduce loneliness?

Statement 12: There is limited evidence that physical activity improves social functioning in older adults. There is inconclusive evidence that physical activity helps to reduce social isolation and/or loneliness. There is insufficient evidence that PA improves social support, or social (support) networks important to help maintain PA. The number of reviews and meta-analyses focussing specifically on older adults is limited.

Commentary 12: This statement drew on 3 systematic reviews (2 included meta-analysis) and 2 observational studies. One systematic review and meta-analysis of community dwelling adults found that effective PA interventions for social functioning were those delivered by medical healthcare professionals, and among older adults with disease (compared with healthy older adults). Most studies assessed social functioning (as a subdomain of health-related quality of life) typically using the Short Form (SF-36) Health Survey, the World Health Organisation Quality of Life Assessment questionnaire (WHOQOLBREF), and the 12-item Short Form Health Survey. Meta-analyses targeting studies with social support and social networks as primary outcomes reported non-significant association. Meta-analysis of the effect of PA on loneliness and social isolation was not possible (137). The results of another review and meta-analysis of community dwelling adults (138) showed a significant effect of physical activity on social isolation/loneliness (measured as one construct) but this analysis included only four studies. However, the findings were supported by the narrative analysis. Studies reporting a positive effect of physical activity were group based. A further review included five interventions, all in older adults, which reported that physical activity reduced loneliness (139). However, two of the interventions also included healthy lifestyle advice and information. No meta-analysis was conducted due to few studies and their variability in terms of both outcome measures and the intervention protocols. One longitudinal study found loneliness to be associated with transitioning from physically active to inactive (140). In 8,688 adults aged 52 years and older from wave two in the English Longitudinal Study of Ageing (ELSA), social isolation and loneliness were associated with a greater risk of being inactive (141). Finally, the evidence surrounding the relationship between social support and PA in older adults suggests that people with greater social support for PA are more likely to do leisure time PA, especially when the social support comes from family members (142).

Limitations: Social health is complex and multifaceted and a characteristic of research in this field is the overlap between concepts (e.g., social isolation and loneliness historically used interchangeably). Thus, the same measurements may be applied to different outcomes as well as the wide range of available measurement scales and scores within each domain of social health. Further, definitions of social isolation and loneliness vary among studies making the comparison of findings challenging. Studies using self-reported physical activity data tend to report stronger associations between social isolation, loneliness and physical activity than studies employing objective measures (143, 144). However, studies employing objective measures of physical activity tend to examine mainly moderate to vigorous physical activity. As recent longitudinal evidence suggests that physical activity of any intensity is beneficial for older adults' physical health (60, 89, 145), the social health impact of activity at any intensity needs to be assessed. Further, non-exercise and non-leisure forms of PA per se (including daily errands and purposeful activities such as volunteering) need to be examined for their protective role in relation to social isolation and/or loneliness. Two of the three systematic reviews focussed on community dwelling older adults. It is likely that older adults from institutional settings (e.g. care homes) may be at increased risk of loneliness as it is reported to be a common problem (146). The systematic review which reported positive effects of physical activity on social

functioning also reported publication bias for this outcome (137). Well-designed, experimental and observational studies employing objective measures of physical activity and validated measures of loneliness, social isolation and social functioning are needed to advance the quality of evidence in relation to the relationship between physical activity and social isolation or social functioning, social networks and loneliness.

Question 13: Why not just have daily guidelines for PA in older adults?

Statement 13: The available evidence base strongly supports the message that older adults should be regularly active, with an emphasis on some activity is good but more is better. Whilst it is tempting to outline a daily prescription the extant literature does not provide sufficient evidence of how this should be achieved in all older adults. Moreover, even small increases in activity provide health benefits with no 'minimum' apparent threshold before benefits begin to occur and a daily target might not be helpful – especially for the least active. A daily prescription would also fail to take into account context, individual preferences and health profiles, which we know are central to the initiation, adoption and maintenance of physical activity. With this in mind, it is appropriate to simply outline that for older adults there is strong evidence that a combination across the week of muscle strength and balance activities, MVPA and light intensity activity helps maintain independence and manage symptoms of disease.

Commentary 13: This mix of PA can be easily incorporated into tasks of daily living (e.g. additional sit to stands to break up sitting, stair climbing for strength or cleaning teeth whilst standing on one leg as discussed earlier) or via structured exercise such as a gym. Older adults who are inactive should seek to replace sedentary behaviour with light-intensity physical activity where possible. At least twice per week, older adults should undertake activity that has a specific focus on strength and balance whereas MVPA and light intensity activity can be accumulated daily towards a target of 150 minutes per week. This could be achieved by undertaking 30 minutes on 5 days of the week but there is sufficient evidence to suggest that this can also be achieved via sporadic bouts of activity. Equivalent health benefit can be achieved from achieving >7000 steps per day but even 4000 steps per day has been shown to be beneficial to the health of older adults (85, 164, 165), with more steps being better.

Question 14: Is there sufficient evidence / knowledge of the risks associated with physical activity to inform a statement on the risks versus benefits of the Physical Activity Guidelines?

Statement 14: There is sufficient knowledge of the benefits associated with PA in older adults to state that they outweigh the risks. In older adults with frailty, moderate to severe dementia and those with a history of vertebral fractures or regular falls, it might be more appropriate for

any exercise interventions to be supervised by a trained professional, at least at the start, to ensure efficacy and safe technique to avoid injury from a fall.

Commentary 14: The CMO 2011 guidelines state that 'Engaging in physical activity carries very low health and safety risks for most older adults (5). The risk of activity-related injury is related to a person's usual amount of activity and the increase in volume or intensity of the activity performed'. They also state that 'small, gradual increases in the volume or intensity of activity will allow for adaptation with a low risk of injury. However, vigorous activity should be attempted only by those older adults who have been very active for some time and who have a high level of fitness'. The US Department of Health and Human Sciences Physical Activity Guidelines Advisory Committee (PAGAC) 2008 report (4) also concluded in the 'Adverse Events' section that the benefits of physical activity outweighed the risks but did not specify across different age groups. The Adverse Events section focuses on musculoskeletal injuries (most common) and sudden cardiac death (most severe). The 2008 report states that among older adults, inactive people report more (all-cause) injuries requiring medical attention compared with those who are active and that PA is associated with lower medical costs. Active older adults report lower musculoskeletal injury rates compared with younger adults which may be due to a 'confounding of age with exposure' i.e., older individuals can't and don't undertake activity at levels comparable with younger adults. The cardiovascular risks of light or moderate intensity physical activity are expected to be less, but information is limited. For older adults who are increasing their PA, the report also states that cardiovascular adaptation to an activity programme may take as long as 20 weeks or more. The most recent US evidence review (9) states that musculoskeletal injury is more common in activities which involve impact and is inversely associated with total volume of PA, but the relative contributions of frequency intensity and duration are unknown. Adverse cardiac events are rare and are inversely associated with volume of regularly performed vigorous activity. So, although greater exercise intensity increases cardiorespiratory fitness, it also carries greater risk of injury, especially in sedentary older adults.

Although there is little evidence of any muscle strength and balance activities being inherently unsafe, given the heterogeneity of the older population, the real question is what types of physical activity and which settings should be promoted within specific groups of older adults, particularly those who are frail, in order to maximise the benefits and reduce risk of adverse events (e.g. falls and fractures). A recent narrative review of adverse events documented in systematic reviews suggests that minor adverse effects (mainly transient musculoskeletal pain) were not uncommon but that serious adverse events were rare (84). Consideration of progression (start slowly and build gradually), tailoring and adaptation should apply in order to avoid poor technique, fatigue and an environment, which may increase the risk of falls and other adverse events.

Limitation of findings: The main source of information (PAGAC 2008 report) (4) is 10 years old (the 2018 report (9) concurs but does not provide an update on evidence for risk/benefit). The narrative review (84) was based on strength and balance only and was not systematic but did

include data from all Cochrane Reviews on strength and balance and other systematic review literature that reported adverse events. They reported that in this literature many studies did not report adverse events adequately.

Question 15: How applicable are the proposed changes to the current UK Physical Activity Guidelines for older adults with disability?

Statement 15: The proposed changes to the recommendations include a greater focus on replacing sedentary behaviour with light activities and this will help older adults with disability or frailty, who may have difficulty meeting MVPA guidelines, to understand the benefits to their health of moving more often, even if they are unable to be active at higher intensities due to their limitations. The proposed changes to the strength/balance/flexibility (multi-component) recommendations are more applicable to the exercise opportunities offered to older adults with disability in the UK and reduce progression of frailty and functional decline. We recommend that the guidelines are viewed in light of a persons' current activity level and ability, using the model designed to assist those who work with older people to interpret the UK physical activity guidelines into appropriate messages for differing current activity and functional levels (149).

Commentary 15: Disability is a wide term but the most likely causes of disability in old age include frailty and sarcopenia, or progressive neurological (e.g. Parkinson's) or CVD (e.g. heart failure). Multi-component activities at least twice a week (including aerobic work, strength, flexibility and balance) is feasible and effective in frailer older adults (150) and should be supplemented with being active everyday. Moderate PA reduced the progression of frailty in some age groups (particularly ages 65 and above) and vigorous activity significantly reduced the trajectory of frailty progression in all older adults (82)**.** However, the oldest and most frail older adults find it difficult to engage with and meet the PA guidelines of 150 mins of MVPA activity per week (151). Older adults with disability get fatigued easily and as such, do not move as safely. An example of this is the increased risk of falls during brisk walking in frailer older adults (152). We support the recognition of light activities and the promotion of any length of bout of moderate activity, as this can be linked with people getting out of their homes for any purpose. These messages could support efforts for effective physical activity promotion with older adults and enable better compliance with recommended levels of physical activity as proposed with these revised guidelines. There are three booklets designed to reflect the differences among the older population (active older adults, older adults in transition and frailer, older adults, those who are identified as being frail or have very low physical or cognitive function, perhaps as a result of chronic disease such as arthritis, dementia or advanced old age itself) (147-149).

Question 16: Would adoption of the proposed modifications to current UK Physical Activity Guidelines influence the difficulty of meeting Physical Activity Guidelines compared to the current Physical Activity Guidelines for insufficiently active older adults?

Statement 16: The proposed modifications, including a recognition of the benefits of light intensity PA, removal of the 10-min bout minimum, and a change to the description of strength and balance activity, may have implications for the proportion of adults meeting the guidelines. Due to a number of barriers, PA participation rates remain low among many older adults but the recognition of light activity and combining the individual strength and balance guidelines into one recommendation will likely lead to an increase in numbers meeting the guidelines.

Commentary 16: The PA of older adults differs in nature from younger adults, with a tendency for intermittent, sporadic or unstructured movement (153). What is more, PA in older age tends to be conducted as part of daily life and at a lower intensity than middle-aged adults. It is likely that self-reported measures that focus on activities at higher intensities might underestimate light and moderate intensity activities for this population (154) and therefore including surveillance on light activity, will increase documented participation rates. Since strength and balance activities are rarely reported within health surveys, the proposed changes are a chance to document participation rates in the future, without concern about changes to previous surveillance (161).

Question 17: What are the data limitations and implications for surveillance for this age group?

Statement 17: It is essential that robust, valid and reliable population-level survey data is available to track over time the percentage of people (including older adults) who engage in recommended amounts of activity. Importantly here, PA surveillance questionnaires used in general population surveys need to consider the nature of PA and the cognitive ability of older adults in their design. This is because PA in older age tends to be conducted as part of daily life and at a lower intensity and there are known interpretation issues for older adults, given changes in cognitive abilities and memory recall in later life. Surveillance data in older adults would benefit from objective physical activity monitoring and should also, ideally, include dimensions of PA related to strength training and balance through direct (e.g. handgrip dynamometer) or indirect (e.g. walking speed, chair rise, standing balance and the timed get up and go) assessments to be able to track the associations of activity with maintenance of physical function, given their association with health outcomes in older people.

Commentary 17: The monitoring and surveillance of PA has been the focus of substantial research attention over the past decade. This has led to valuable insight into the PA behaviour of the population, including older adults, to inform public health policy. In the UK, the transition of the PA guidance from bouts of 30 minutes on 5 days per week to total volume of PA of 150 minutes per week (2012) has had implications for the analysis and reporting of population data. Combined with a move away from postal towards internet-based collection methods this has

resulted in some longitudinal trend data from surveillance systems (e.g. Active Peoples Survey – Active Lives) being discontinued (155). It is essential that robust, valid and reliable population-level survey data is available to track over time the percentage of people (including older adults) who engage in recommended amounts of activity. Furthermore, whilst international efforts to increase PA have been reported within the adult or youth populations, the PA of older adults has arguably received less interest, meaning less is known the prevalence of various types of PA in older adults (78).

Previous studies exploring the reliability and validity of population surveys have demonstrated that participants often misunderstand PA concepts such as 'moderate' or 'vigorous' (156) and these issues of comprehension/interpretation appear particularly evident in older adults which is unsurprising given changes in cognitive abilities and memory recall in later life (157). The process of ageing also leads to changes in the metabolic cost of PA and as a result determining the energy expenditure of activities for older adults using standardised tables developed on younger populations is likely to be inappropriate (153). Objective physical activity monitoring would remove elements of interpretation and also allow more accurate quantification of the 150 minutes/week MVPA that may be accrued sporadically, which is likely by its nature harder to recall than activity in occurring in bouts >=10 minutes.

Although the data on total volume of PA is available, a key challenge in the area of surveillance is the omission of major dimensions of PA related to strength training and balance activities (121). A recent review found that only five national surveys (out of 139 countries) explicitly asked about muscle strengthening activity (155). Balance activities were considered even more rarely. Existing surveillance systems must include this aspect of PA.

Limitations of findings.

- We have not reviewed original research and limited our search to papers published in English.
- Papers identified in the literature searches, were reviewed by a single working group member.
- We used an ad hoc approach to the inclusion of papers beyond the identified systematic reviews, based on knowledge by group members.
- The nature of the evidence and in particular the reliance on self-reported PA assessed in specific domains and the heterogeneity in how PA is operationalized in the papers reviewed is likely to have influenced our conclusions.

Draft recommendations

Recommendation 1: The UK physical activity guidelines for older adults should start with a statement that PA is good for you and the more you do the better it is, for mental, physical and social health. They should continue to recommend a minimum of 150 minutes of moderate intensity physical activity per week but that these minutes can be accumulated sporadically. Further statements should make it clear that this volume of activity can be accumulated in different ways and a mixture of moderate, vigorous and high intensity activities (where appropriate) will provide similar health benefit. They should also make it clear, that events happen in older age that may temporarily halt ability to be active but people should try to develop strategies to re-engage and do a little more each day. Every bit of PA counts.

Recommendation 2: The guidelines should acknowledge that increasing volume and frequency of light activities and reducing sedentary behaviour are a place to start for the frailer or disabled older adult and contribute both towards health. There is a risk that this approach might persuade inactive or insufficiently active older people that they are doing enough so this must be carefully managed in the guidelines. Suggestions of strategies for increasing PA should be presented.

Recommendation 3: The UK physical activity guidelines should indicate that although optimal health benefits are likely to be derived from meeting the guidelines, they should continue to recognise the value of PA below (as well as above) the moderate intensity and 150 minute thresholds. This is particularly the case for older adults for whom moderate-intensity physical activity might not be a feasible option, or for whom frailty means they can no longer meet the guidelines, particularly as the greatest functional improvements are found for increments in activity within the lower end of the overall physical activity spectrum (166).

Recommendation 4: The UK physical activity guidelines should continue to recommend strengthening/resistance activities for major muscle groups on at least 2 days per week but should expand this recommendation to include high intensity activity, impact exercise, balance *and* flexibility activities. Further statements should include specific examples of resistance, balance and flexibility training and other relevant physical activities that may contribute (eg. Pilates, Yoga, Nordic walking, Tai Chi, aqua-aerobics, active travel). These examples should reflect key principles of progression, volume, intensity, frequency, multi joint, multi modal (e.g. bodyweight, free weights, resistance machines, elastic bands etc.) and prescriptions for strength/balance training for different starting levels of experience and activity. Other examples from everyday living to develop or maintain strength (e.g. sit to stands, stair climbing) should also be presented.

Recommendation 5: Although the physical activity guidelines for older adults are aimed at those aged 65+ years, they are relevant for younger people who have functional limitations or disabilities or have experienced functional decline, through ill health or periods of immobilisation.

Proposed recommendations:

Older adults who participate in any amount of physical activity gain some health benefits, including maintenance of good physical and mental health, wellbeing, and social functioning. It is recommended that all older adults aim to be active every day. Some physical activity is better than none, even light activity brings some health benefits compared to sedentary behaviour, and more physical activity provides greater health and social benefits.

Breaking up long periods of sitting with standing or light activity, and avoiding prolonged sitting has distinct health benefits for older people.

Older adults can maintain or improve their physical function if they undertake activities aimed at improving muscle strength, balance and flexibility on at least two [preferably non-consecutive] days a week. These could be incorporated within the same sessions with a mix of multi-component activities.

Building to 150 minutes (2½ hours) of moderate intensity aerobic activity over the week is recommended for maintenance of physical and mental health, and reduced risk of dementia and cognitive decline. Weight-bearing activities which create an impact through the body help maintain bone health. For those who are already regularly active a combination of moderate and vigorous aerobic activity brings greater benefit. Due to its intensity, 75 minutes of vigorous aerobic activity spread across the week can produce comparable benefits to 150 minutes of moderate intensity activity.

Research recommendations

The older adult EWG, based on their review and that of the 2018 US review (9) recommend the research in the following areas. Further research should:

- Define the 'equivalencies' of different combinations of duration and intensity (beyond energy expenditure) and explore possible difference in their health benefits.
- Determine the most appropriate methods for PA surveillance at population level particularly in older adults who may have memory problems.
- Explore the suggestion that the benefits of multi-component resistance activities might be gained from a lower frequency (1 day per week).
- Determine the dose response relationship between PA and health for different population groups including those with a disability and different ethnic groups, those with multiple long-term conditions, and frailer older adults (eg. trips from home), including any risks/harms associated. Research should explore this relationship across each PROGRESS-Plus population characteristic (173).
- Determine the effects of HIIT on hard clinical end points in older adults, which address in detail adherence, the harms (adverse events of all types) as well as the benefits.
- Understand to what extent overall and HRQoL, social, isolation, wellbeing and psychological outcomes derived from physical activity participation are dose- or mode-dependent (i.e. MVPA or multi-component) or modified by a number of social and economic factors (e.g. age, sex, socioeconomic status).
- Explore the impact of PA and SB on severe mental health illness.

All RCTs should address issues of dose response, last at least 6 months and have a considerable follow up period to address not only hard clinical end points (such as CVD and all-cause mortality) but also consider other end points such as independence in own home and functional outcomes as these are strongly associated with QoL in this population.

Next steps

A second national consultation on the draft physical activity recommendations will be undertaken. This report will then be reviewed and edited where appropriate. A final technical report will then be produced for the UK CMOs with final recommendations for new physical activity guidelines. If the CMOs sign off the suggested recommendations, then the CMO Guidelines Writing Group will support the production of a final CMO Physical Activity Guidelines Report.

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