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Review Article

A review of global surveillance on the muscle strengthening and balance elements of physical activity recommendations

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Abstract

Introduction: Despite the importance of muscle strengthening and balance activities for health, these elements of the physical activity recommendations are often omitted from communication campaigns and national surveillance systems. This paper reviews national physical activity surveillance systems to determine which tools assess muscle strengthening and balance activities. **Methods:** We reviewed each tool that was used to inform the Global Observatory for Physical Activity (GoPA) country card prevalence estimates. **Results:** Of the 139 countries with GoPA country cards, 21 countries reported having no physical activity prevalence data. The prevalence estimates for 74 countries came from the World Health Organization 2014 Global Status Report on Non-Communicable Diseases. For the remaining 44 countries, a range of national and international surveys were used. A limited number of tools sought to assess muscle strengthening activities, and even fewer assessed balance and coordination activities. **Discussion:** Several issues arise from this review, including the need to: verify the strength of the evidence to inform whether muscle strength and balance should be given equal prominence to the aerobic recommendation; establish which activities count towards different aspects of the guidelines; and confirm whether the muscle strengthening and balance components of the guidelines are 'in addition' to the aerobic component.

Keywords: Physical activity, Surveillance, GoPA, Strength, Balance

Introduction

Physical inactivity is now widely recognised as one of the major behavioural risk factors for Non-Communicable Diseases. Participation in regular physical activity reduces the risk of developing many chronic conditions including coronary heart disease, stroke, type 2 diabetes, cancer, obesity, and musculoskeletal conditions, and is also associated with improved mental health and wellbeing¹⁻³. Physical inactivity is responsible for 3.2 million deaths per year⁴, and is estimated to cost healthcare systems worldwide 53.8 billion (INT\$) annually⁵.

Undertaking strength training exercise is known to lead to increased muscle mass and improved muscle function⁶. Muscle mass is recognised as an important determinant of risk for chronic diseases such as osteoporosis and type 2 diabetes^{2,7} and increased muscle strength has been shown to be associated with a reduced risk of cardiovascular disease and premature mortality⁸⁻¹⁰. Muscle mass declines with age,

leading to reduced strength and contributing to functional impairment, disability, falls, and loss of independence in older adults¹¹. Undertaking muscle strengthening exercises is important for combatting the negative effects of the age-related decline in muscle mass¹². In addition, undertaking activities to improve balance and coordination, particularly among older adults, can help to reduce risk of falls^{13,14}.

The authors have no conflict of interest.

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African Region	Eastern Mediterranean Region	Western Pacific Region
Angola Uganda	Oman Palestine/ West Bank and Gaza Syrian Arab Republic	American Samoa French Polynesia Macao SAR, China New Caledonia Northern Mariana Islands Palau Tuvalu
Region of the Americas	European Region	
Antigua and Barbuda Bolivia Guyana Haiti Nicaragua Peru St Martin Virgin Islands	Switzerland	

Table 1. Countries reporting no physical activity prevalence data (n=21).

Given the importance of muscle strengthening and balance activities, the 2011 physical activity recommendations for the United Kingdom (UK) emphasised these elements of physical activity for health³. In addition to the ‘aerobic recommendation’ that adults and older adults undertake at least 150 minutes of at least moderate intensity activity per week, the guidelines state that adults and older adults should undertake physical activity to improve muscle strength on at least two days per week, and that older adults at risk of falls should incorporate physical activity to improve balance and coordination on at least two days per week. The recommendations to undertake muscle strengthening and balance activities are similar to those found in many other countries, as well as the Global Recommendations on Physical Activity for Health published by the World Health Organization (WHO)¹.

Despite explicit statements in national and international recommendations about the importance of muscle strengthening and balance activities, these elements of the physical activity recommendations are often omitted from public communication campaigns and national surveillance systems, which prioritise the aerobic ‘150 minutes’ component. As such, researchers have begun to refer to the muscle strengthening and balance recommendations as the ‘forgotten guidelines’¹⁵.

The aim of the current research was to undertake a review of the national physical activity surveillance systems used throughout the world to:

- 1) Determine the extent to which national surveillance systems measure muscle strengthening activities (in adults and older adults) and balance activities (among older adults);
- 2) Identify which national surveillance and reporting systems account for muscle strengthening and balance activities when reporting physical activity prevalence estimates for adults and older adults; and
- 3) Appraise the utility of existing surveillance questions on

muscle strengthening and balance activities in assessing physical activity against recommended levels.

Methods

In 2015 the Global Observatory for Physical Activity (GoPA) produced a set of ‘country cards’ which summarised demographic data and physical activity policy, surveillance and research indicators across 139 countries, representing a global coverage of 64.1% of the world’s countries and 85.4% of the world’s population in 2013¹⁶. The set of country cards was published in November 2016 as the ‘GoPA 1st physical activity almanac’ (<https://indd.adobe.com/view/f8d2c921-4daf-4c96-9eaf-b8fb2c4de615>). The development of each country card was supported by a contact in each of the participating countries who assisted in reviewing, revising and approving the accuracy of the content.

The surveillance indicator on the GoPA country cards summarises the physical activity prevalence in each country (among adults and older adults combined), by gender and overall. We decided to use the surveillance tools that were used in the development of the GoPA country cards as the basis for our global review, as these tools were considered by the country contacts to provide the most valid and respected physical activity prevalence estimate for the country. We attempted to obtain a copy of each survey that was used to inform the GoPA prevalence estimates. This was done by: 1) undertaking online searches using the Google search engine; 2) searching the GoPA archive which was created during the construction of the country cards; and 3) emailing the country card contacts to request a copy of their survey.

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 muscle strengthening activities?’, ‘do you regularly undertake activities to improve your

African Region	European Region	South-East Asia Region
Botswana Cameroon Ghana Kenya Mozambique Nigeria Rwanda Senegal Seychelles South Africa Swaziland Tanzania	Belgium Bulgaria Czech Republic Denmark Estonia Faeroe Islands Finland France Hungary Ireland Italy Kazakhstan Luxembourg Malta Moldova Poland Portugal Romania Russian Federation Slovakia Slovenia Spain Sweden Ukraine	Bangladesh Bhutan India Indonesia Maldives Myanmar Nepal Sri Lanka
Region of the Americas		Western Pacific Region
Argentina Brazil Costa Rica Dominican Republic Ecuador Guatemala Mexico Trinidad and Tobago United States of America		China Fiji Japan Kiribati Korea, Rep Lao People's Dem. Rep. Malaysia Marshall Islands Micronesia Mongolia Papua New Guinea Samoa Solomon Islands Tonga Vanuatu Vietnam
Eastern Mediterranean Region		
Arab Republic of Egypt Iraq Saudi Arabia Tunisia United Arab Emirates		

Table 2. Countries with data from the World Health Organization 2014 Global Status Report on Non-Communicable Diseases (n=74)¹⁷.

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. In addition, the calculation and reporting of each survey was reviewed to confirm whether achievement of the strength and balance recommendations was factored into the national prevalence estimates (i.e. whether the prevalence estimate was based on reported moderate to vigorous physical activity only or whether any attempt was made to incorporate self-reported muscle strengthening and/or balance activities into the calculation).

Of the 139 countries included in the GoPA 1st physical activity almanac, 21 countries reported having no physical activity prevalence data (see Table 1). The remaining 118

countries had prevalence data on physical activity and cited the survey that was used to generate the estimates. The physical activity prevalence estimates for 74 countries were taken from the WHO 2014 Global Status Report on Non-Communicable Diseases (see Table 2)¹⁷. This report includes comparable estimates of physical activity 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. Whilst other countries were also included in the WHO Global Status Report, some of the country contacts felt it was more appropriate to use data from a different survey on the GoPA country cards. This was usually the national health survey, due to the importance placed on these data within the country. For 44 countries, a range of national and international surveys were used and these are identified in Table 3. These 44 countries used 42 different surveillance surveys. We obtained copies of 26 surveys through online searches. A further ten surveys were identified through searching the archive of documents which were used in the creation of the GoPA country cards.

Table 3. Description of the national and international surveys used to generate the GoPA prevalence estimates (n=44 countries).

Region / Country	Survey name	Description
European region		
Austria	Eurobarometer 80.2, 2013	Eurobarometer 80.2 collected data on days and time per week of vigorous and moderate intensity activity and walking.
Croatia	Eurobarometer 80.2, 2013	Eurobarometer 80.2 collected data on days and time per week of vigorous and moderate intensity activity and walking.
England	Health Survey for England, 2012	Respondents were asked about their participation in different sport and exercise activities and for each activity they were asked about their level of muscular activity/fatigue. A coding system was applied to each activity to categorise it as aerobic, muscle strengthening, and/or contributing to balance. For activities which may or may not be muscle strengthening or balance-related, the response to the qualifying question(s) about muscle fatigue/activity specifics were used to determine inclusion. In addition, respondents were asked about the frequency and duration of non-sport and exercise activities that are typically considered to build strength including climbing stairs or ladders, carrying or lifting, heavy housework, gardening, DIY or building, although responses to these non-sport and exercise questions were not included in the prevalence calculation.
Germany	Eurobarometer, 2005	Eurobarometer 64.3 collected data on days and time per week of vigorous and moderate intensity activity and walking.
Greece	Eurobarometer 80.2, 2013	Eurobarometer 80.2 collected data on days and time per week of vigorous and moderate intensity activity and walking.
Greenland	Local Survey, 2005-2009	The Greenland national prevalence survey included questions from the International Physical Activity Questionnaire (IPAQ; long version) which collects data on days and time in the past 7 days undertaking moderate and vigorous activities across a range of domains including work, transport, at home, and in sport and leisure.
Iceland*	National Database, 2004	
Israel	Israeli Ministry of Health, 2011-2012	Participants were asked about their typical frequency and duration of vigorous and moderate intensity physical activity. Participants were then asked to report the time they devoted to specific activities (walking outdoors or on a treadmill; jogging; swimming; bike riding or stationary cycling; light exercise such as yoga, Feldenkrais, Alexander's method, light gymnastics; body shaping and strength training in a fitness room; any other activity).
Lithuania*	Health Behaviour among Lithuanian Adult Population Survey (year unknown)	
Macedonia	Local Survey, 2012-2013	The Macedonian cross-sectional population based study included questions from the Godin and Shepherd Leisure-Time Physical Activity Questionnaire, which assesses strenuous, moderate and light activity during leisure time in the past 7 days.
Netherlands	Health Interview Survey, 2013	This survey used the Short Questionnaire to assess health enhancing physical activity (SQUASH). This tool assesses days and time, as well as effort expended in commuting, leisure time activities, household activities, and activities undertaken at work or school. It does not explicitly ask about participation in muscle strengthening and balance and coordination activities, but it does generate a long list of activities, to which strength and balance codes could be assigned.
Northern Ireland	The Health Survey for Northern Ireland, 2013-2014	The 2013/14 Health Survey for Northern Ireland collected data in the same way as the 2012 Health Survey for England described above.
Norway	Dyrstad et al (2014) Med Sci Sports Exerc, 46: 99-106	These data are from the IPAQ Short form, which assesses days and time undertaking vigorous and moderate activity and walking in the past 7 days.
Scotland	Scottish Health Survey, 2013	The Scottish Health Survey, 2013 collected data in the same way as the 2012 Health Survey for England described above, with two exceptions: 1) the list of prompted sport and exercise activities was longer (40 versus 10) and 2) detailed questions on specific activities at work (climbing stairs, lifting) were not included.

Table 3. (Continuous from previous page).

Region / Country	Survey name	Description
Turkey	Turkey Chronic Diseases Prevalence and Risk Factor Study, 2012	This survey assessed days and time in the past week undertaking moderate and vigorous activity in leisure time and at work, whether people walk to work (yes/no and for less than or more than 30 minutes), and the number of flights of stairs climbed.
Wales	Wales Health Survey, 2013	This survey assessed the days (Monday - Sunday) on which respondents achieved at least 30 minutes of light, moderate and vigorous intensity physical activity during the past 7 days.
Eastern Mediterranean Region		
Bahrain	Non-Communicable Disease Risk Factors Survey, 2007	Assessed low, moderate and vigorous intensity activity at work, for travel, and during leisure time.
Jordan	Stepwise Survey, 2007	Assessed days and time in a typical week participating in moderate and vigorous physical activity at work, for travel and for recreation.
Lebanon	Sibai et al (2013) BMC Public Health, 13:1002	These data are from the IPAQ Short form, which assesses days and time undertaking vigorous and moderate activity and walking in the past 7 days.
Qatar	Stepwise Survey, 2012	These data are from the Global Physical Activity Questionnaire (GPAQ), which assesses days and time in a typical week participating in moderate and vigorous physical activity at work, for travel and for recreation.
Region of the Americas		
Aruba	Steps, 2006	Assessed days and time in a typical week participating in moderate and vigorous physical activity at work, for travel and for recreation.
Barbados	The Barbados Health of the Nation Survey, 2015	Data were collected using the recent Physical Activity Questionnaire (RPAQ), which assesses activity in the past 4 weeks across 4 domains: at home, during transport, at work, and in leisure time. The RPAQ does not explicitly ask about participation in muscle strengthening and balance and coordination activities, but it does ask about the types of activities undertaken including swimming, walking, running, cycling, aerobics, gardening, racquet sports, water sports, and team sports, to which strength and balance codes could be assigned.
Bermuda	Steps, 2014	Assessed days and time in a typical week participating in moderate and vigorous physical activity at work, for travel and for recreation.
Canada	Canadian Fitness and Lifestyle Research Institute, Physical Activity Level of Canadians, 2014	This survey assessed the type of physical activities undertaken during the 12 months prior to the survey. It does not explicitly ask about participation in muscle strengthening and balance and coordination activities, but it does generate a long list of activities, to which strength and balance codes could be assigned.
Cayman Islands	Steps, 2012	Assessed days and time in a typical week participating in moderate and vigorous physical activity at work, for travel and for recreation.
Chile	National Health Survey, 2009-2010	These data are from the GPAQ, which assesses days and time in a typical week participating in moderate and vigorous physical activity at work, for travel and for recreation.
Colombia	ENSIN National Survey, 2010	The Colombian national survey included questions from the IPAQ (long version) which collects data on days and time in the past 7 days undertaking moderate and vigorous activities across a range of domains including work, transport, at home, and in sport and leisure.
Cuba	National Survey, 2014	Assessed days and time in a typical week participating in moderate and vigorous physical activity at work, for travel and for recreation.
Dominica	Steps, 2008	Assessed days and time in a typical week participating in moderate and vigorous physical activity at work, for travel and for recreation.
Grenada	Steps, 2010-2011	Assessed days and time in a typical week participating in moderate and vigorous physical activity at work, for travel and for recreation.
Paraguay	First Survey of Risk Factors for Non-Communicable Chronic Disease in the General Population, 2012	Assessed days and time in a typical week participating in moderate and vigorous physical activity at work, for travel and for recreation.

Table 3. (Continuous from previous page).

Region / Country	Survey name	Description
Puerto Rico	Behavioural Risk Factor Surveillance Survey, 2013	This survey asks about non-work related activity in the past month. The survey captures the two most frequently undertaken activity types, the frequency of participation and the usual duration of bouts. In addition, the survey includes a question on activities that strengthen muscles.
St Kitts and Nevis	Steps, 2008	Assessed days and time in a typical week participating in moderate and vigorous physical activity at work, for travel and for recreation.
St Lucia	Steps, 2012	Assessed days and time in a typical week participating in moderate and vigorous physical activity at work, for travel and for recreation.
St Vincent and the Grenadines	Steps, 2013-2014	Assessed days and time in a typical week participating in moderate and vigorous physical activity at work, for travel and for recreation.
Uruguay	Second National Survey on Risk Factors for Non-Communicable Disease, 2013	These data are from the GPAQ, which assesses days and time in a typical week participating in moderate and vigorous physical activity at work, for travel and for recreation.
Venezuela	Physical Activity and Cardiovascular Risk Factors Survey, 2006	These data are from the IPAQ Short form, which assesses days and time undertaking vigorous and moderate activity and walking in the past 7 days.
South-East Asia Region		
Thailand	Thailand Physical Activity Surveillance System, 2014	This survey used the Thai version of the GPAQ (GPAQ2). The GPAQ2 assesses days and time in a typical week participating in moderate and vigorous physical activity at work, for travel and for recreation.
Western Pacific Region		
Australia	Australian Health Survey, 2011-2012	The Australian Health Survey collected data on walking for transport, walking for fitness, and moderate and vigorous physical activity for fitness, recreation or sport undertaken in the week prior to interview.
Brunei*	NHANES, 2009-2011	
Guam	Local Survey, 2013	These data come from the Behavioural Risk Factor Surveillance Survey 2013 survey, which was also undertaken in Puerto Rico. This survey asks about non-work related activity in the past month. The survey captures the two most frequently undertaken activity types, the frequency of participation and the usual duration of bouts. In addition, the survey includes a question on activities that strengthen muscles.
Hong Kong	Physical Activity Surveillance System, 2012	Assessed days and time undertaking vigorous and moderate activities for at least 10 minutes in the past 7 days.
New Zealand	New Zealand Health Survey, 2012-2013	Assessed days and typical time spent walking at a brisk pace, and undertaking moderate and vigorous activity in the past 7 days.
Singapore*	National Health Survey, 2010	

We were unable to locate six surveys and thus made email contact with the country contact from the GoPA initiative to request a copy. This approach yielded two more surveys. We were unable to locate the surveys for the remaining four countries (Brunei, Iceland, Lithuania, and Singapore). These countries are marked with * and shaded in Tables 3 and 4.

Results

In total, 38 surveys were included in our review. Each tool was assessed to determine whether it included:

- 1) questions that explicitly asked about participation in muscle strengthening activities;
- 2) questions about participation in activities that would typically be considered to be muscle strengthening (e.g. carrying heavy loads);
- 3) questions related to balance and coordination activities;
- 4) a list of activities which would allow the subsequent categorisation of aerobic/muscle strengthening/balance activities.

The results of this review are summarised in Table 4.

Only five surveys used to inform the GoPA prevalence estimates included a question explicitly asking about

Table 4. Summary of survey characteristics in terms of assessment of muscle strengthening and balance and coordination activities (n=44 countries).

Region / Country	Survey name	Asks explicitly about muscle strengthening activities	Asks about activities which typically contribute to muscle strengthening	Asks about balance and coordination activities (amongst older adults)	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				
Iceland*	National Database, 2004				
Israel	Israeli Ministry of Health, 2011-2012				X
Lithuania*	Health Behaviour among Lithuanian Adult Population Survey				
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				

Table 4. (Continuous from previous page).

Region / Country	Survey name	Asks explicitly about muscle strengthening activities	Asks about activities which typically contribute to muscle strengthening	Asks about balance and coordination activities (amongst older adults)	Elicits detail which would allow categorisation of activity types
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				
Brunei*	NHANES, 2009-2011				
Guam	Local Survey, 2013	X			
Hong Kong	Physical Activity Surveillance System, 2012				
New Zealand	New Zealand Health Survey, 2012-2013				
Singapore*	National Health Survey, 2010				

muscle strengthening activity. These were: the Health Survey for England; the Scottish Health Survey; the Health Survey for Northern Ireland; and the Behavioural Risk Factor Surveillance Surveys conducted in Puerto Rico and Guam. In the three UK home nations' health surveys (England, Northern Ireland, 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. The three UK home nations' health 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 the Behavioural Risk Factor Surveillance Survey conducted in Puerto Rico and Guam, which is interviewer led, respondents were asked "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/or 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. The Health Survey for England, the Health Survey for Northern Ireland, and the Scottish Health Survey also capture a long list of activities which respondents have taken part in.

In Scotland, a panel of experts was convened in 2011 to determine whether each of the activities listed in the Scottish Health Survey could count towards the muscle strengthening and balance guidelines¹⁸. 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 Health Survey for England and the Health Survey for Northern Ireland, in order to report against the full physical activity recommendations including the aerobic, muscle strengthening and balance components^{19,20}. The development and application of this coding system was the only example identified for measuring balance activities. The other national surveillance systems that elicit a detailed list of the activities undertaken (Barbados, Canada, Israel, the Netherlands) would also allow an assessment against the full physical activity recommendations by adopting a similar coding system, however to date, such categorisation has not been applied to these tools.

Whilst national reports in England, Northern Ireland, and Scotland state both the prevalence of the population meeting the aerobic recommendation only, as well as the prevalence of the population meeting the aerobic and muscle strengthening recommendations, all of the prevalence estimates in the GoPA country cards were based on the aerobic physical activity recommendation only (150 minutes per week in most, but not all, cases). None of the prevalence estimates in the GoPA country cards take into account participation in muscle strengthening and/or balance activities.

Discussion

The prevalence estimates for over 60% of countries included in the GoPA 1st physical activity almanac were taken from the World Health Organization 2014 Global Status Report on Non-Communicable Diseases¹⁷. This global surveillance system provides comparable estimates on physical activity prevalence for many countries and is therefore an important resource for understanding physical activity levels globally, including regional differences, gender differences, and trends across the life course. However, the prevalence estimates from the Global Status Report are based solely on the aerobic recommendation of 150 minutes of moderate to vigorous physical activity per week.

This study reviewed 38 of the other 42 surveys that were used to inform the country prevalence estimates for the first set of GoPA country cards. A very limited

number of tools sought to assess muscle strengthening activities. Three approaches were used, either in isolation or in combination. One approach involved asking explicit questions about whether respondents had taken part in muscle strengthening activities (e.g. Puerto Rico and Guam). Another approach was to ask respondents about their participation in specific activities that are typically associated with muscle strengthening, for example heavy housework or DIY (e.g. England, Northern Ireland and Scotland). The third approach involved obtaining a detailed list of all activities that respondents had undertaken, which would allow subsequent categorisation of the activities as aerobic, muscle strengthening, or balance and coordination activities (e.g. England, Israel, the Netherlands, Northern Ireland, Scotland, Barbados, and Canada).

None of the national surveillance systems asked specific questions related to balance and coordination activities. Several surveys would allow an assessment of balance and coordination activities, as well as muscle strengthening activities, by applying a coding system to the reported activities, as done in England, Northern Ireland and Scotland. This coding system approach appears to provide the most comprehensive assessment of physical activity against the full guidelines, however some caveats remain. The categorisation of activities as aerobic, muscle strengthening or balance and coordination presents several challenges: the intensity at which the activity is carried out will influence its contribution to health; there is debate as to whether certain activities contribute to specific domains of fitness; and many activities can lead to multiple benefits, for example activities such as athletics, climbing and horse-riding are considered in the Scottish system to contribute to both muscle strength and improved balance. An additional challenge in relation to the measurement of the balance recommendation is that it is hard to identify the specific group that it applies to. The WHO recommendation applies to older adults 'with poor mobility'¹, whilst the UK recommendation applies to those 'at risk of falls'³. In the case of the UK surveys, it is not possible to determine who in the sample is 'at risk of falls', thus the coding is applied to all older adults.

Whilst some surveys, including England and Scotland, include an assessment of muscle strengthening activities (which is reported in the national surveillance reports), these data are typically not taken into account when calculating the 'headline' national prevalence estimates. For example, the prevalence estimate for England, as reported on the GoPA country card, is that 56% of women and 66% of men are achieving recommended physical activity levels¹⁹. This is based solely on achieving 150 minutes of moderate to vigorous intensity aerobic activity per week. When considering the proportion of the population that also achieve two days per week of muscle strengthening activities, the prevalence drops to 22% of women and 31% of men¹⁹. Similarly, in Scotland, the reported prevalence on the GoPA country card is 58% of women and 71% of men achieving

recommended physical activity levels. When the muscle strengthening recommendation is taken into consideration, the prevalence drops to 21% of women and 30% of men¹⁸.

Whilst it is useful that all countries report prevalence against a common metric (150 minutes per week in most cases) to aid comparability, this reinforces the dominance of the aerobic recommendation in the communication of the physical activity recommendations and its monitoring and surveillance. This undermines the importance of the muscle strengthening and balance and coordination elements of the recommendations. Furthermore, if muscle strengthening activities (for adults and older adults) and balance and coordination activities (for older adults at risk of falls) are sufficiently important to be included in the physical activity recommendations, these components should be assessed in national surveillance alongside the aerobic component of the recommendations.

Several issues arise from this review which warrant further research to inform the best way forward for national and international physical activity surveillance. Firstly, there is a need to review the strength of the evidence on the role of muscle strengthening and balance and coordination activities on health to inform whether these recommendations should be given equal prominence to the aerobic recommendation, or whether they are less critical to health than the 150 minutes of aerobic activity. One of the challenges in establishing the independent and joint effects is that those meeting the muscle strengthening recommendation tend to also be aerobically active. Typically, less than 5% of a nationally representative sample meets the muscle strengthening recommendation only^{21,22}.

Secondly, there is a need to establish the extent to which activities that improve aerobic fitness are the same as activities that strengthen muscles and improve balance and coordination. In the consensus of the expert group in Scotland which classified the contribution of over 40 activities towards the muscle strengthening and balance guidelines, activities were classified as 'always' contributing to muscle strength and improved balance, 'sometimes' contributing to these fitness elements depending on the response to a follow-up question, or 'never' contributing to muscle strength and balance. Only two activities were classified as never contributing to muscle strength (but contributing to balance always or sometimes); these were powerboating/jet skiing and table tennis. Three activities were classified as never contributing to balance (but contributing to muscle strength always or sometimes); these were rowing, running/jogging, and swimming. Four activities were classified as never contributing to muscle strength or balance; these were fishing/angling, skateboarding/inline skating, snooker/billiards/pool, and sub-aqua. The classification of some of these activities is questionable, for example the classification of skateboarding/inline skating as never contributing to muscle strength or balance. Broader consensus is needed on what activities count towards different aspects of the

guidelines, including the aerobic component.

A related issue is that most activities can contribute to more than one aspect of health, posing challenges for how we differentiate these activities in our prevalence calculations. Clarification is needed on whether individuals who achieve 150 minutes per week through the accumulation of activities across several days that are beneficial to both aerobic health and muscle strength (e.g. swimming) meet the physical activity recommendations or whether a further two days of activities to strengthen muscles are required. All of these issues present communication challenges to governments and other agencies aiming to improve public health through physical activity.

An area of health that is not explicitly addressed in the current physical activity recommendations is bone health. Research indicates that weight bearing and impact activities such as jumping, gymnastics, and dance have beneficial effects on bone health throughout the life course⁷. 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 next review of the physical activity recommendations should consider the evidence on physical activity and bone health, as well as the amount and type of activity required to maintain healthy bones.

Several limitations of this review are worth noting. The review only considered one survey from each country and this was based on the survey used to inform the GoPA prevalence estimates, given the value placed on the survey within the country. It is possible that some countries had other national or international surveillance systems which included measures of muscle strengthening and balance activities that were not included in this review. For example the prevalence estimates on the GoPA country card for the United States of America (USA) were taken from the World Health Organization 2014 Global Status Report on Non-Communicable Diseases. Thus that was the survey included in this review for the USA. It is possible that other USA based surveys such as the National Health and Nutrition Examination Survey (NHANES), the National Health Interview Survey (NHIS) or the Behavioural Risk Factor Surveillance System (BRFSS) calculate prevalence differently. In addition, we reviewed each survey as it was in the year of the reported prevalence data on the GoPA country card. It is possible that more recent iterations of the surveys differ slightly to the ones included in this review. Finally, this review focused on measures of self-reported behaviour, not fitness. Given that muscle strength and balance are relatively easy to assess through direct (e.g. handgrip dynamometer) or indirect (e.g. walking speed, chair rising and the timed get up and go) assessments, there may be merit in supplementing existing surveillance systems with objective measurements.

Conclusion

Despite national and international recommendations including specific statements on the importance of physical activity for muscle strength (for adults and older adults) and balance and coordination (for older adults at risk of falls), these components of the physical activity recommendations are rarely measured in national surveillance systems and are not considered when calculating national prevalence estimates. This paper found that all countries in the GoPA almanac reported population prevalence of physical activity based on meeting the aerobic recommendation of 150 minutes per week (or similar). No countries considered the prevalence of the (adult and older adult) population meeting the muscle strengthening guideline nor the prevalence of the (older adult at risk of falls) population achieving the balance and coordination guideline. This paper identifies several issues that warrant further research to inform the best way forward for national and international physical activity surveillance.

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References

- World Health Organization. Global recommendations on physical activity for health. Geneva; 2010.
- Physical Activity Guidelines Advisory Committee. Physical activity guidelines advisory committee report 2008. Washington, DC; 2008.
- Department of Health. Start active, stay active. London; 2011.
- Lim S, Vos T, Flaxman A. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet* 2012;380(9859):2224-60.
- Ding D, Lawson K, Kolbe-Alexander T, Finkelstein E, Katzmarzyk P, van Mechelen W, et al. The economic burden of physical inactivity: a global analysis of major Non-Communicable Diseases. *Lancet* 2016; 388:1311-1324.
- Winett R, Carpinelli R. Potential health-related benefits of resistance training. *Prev Med (Baltim)* 2001;33(5):503-13.
- Kohrt W, Bloomfield S, Little K, Nelson M, Yingling V. American College of Sports Medicine. Position Stand. Physical activity and bone health. *Med Sci Sports Exerc* 2004;36(11):1985-96.
- Warburton D, Gledhill N, Quinney A. Musculoskeletal fitness and health. *Can J Appl Physiol* 2001;26(2):217-37.
- Katzmarzyk P, Craig C. Musculoskeletal fitness and risk of mortality. *Med Sci Sports Exerc* 2002;34(5):740-4.
- Metter E, Talbot L, Schrager M, Conwit R. Skeletal muscle strength as a predictor of all-cause mortality in healthy men. *J Gerontol Ser A, Biol Sci Med Sci* 2002;57(10):B359-365.
- Goodpaster B, Park S, Harris T, Kritchevsky S, Nevitt M, Schwartz A, et al. The loss of skeletal muscle strength, mass, and quality in older adults: The health, aging and body composition study. *J Gerontol Med Sci* 2006;61A(10):1059-64.
- Lang T, Streeper T, Cawthon P, Baldwin K, Taaffe D, Harris T. Sarcopenia: Etiology, clinical consequences, intervention, and assessment. *Osteoporos Int.* 2010;21(4):543-59.
- Gardner M, Buchner D, Robertson M, Campbell A. Practical implementation of an exercise-based falls prevention programme. *Age Ageing* 2001;30(1):77-83.
- Judge J. Balance training to maintain mobility and prevent disability. *Am J Prev Med* 2003;25(3):150-6.
- Strain T, Fitzsimons C, Kelly P, Mutrie N. The forgotten guidelines: cross-sectional analysis of participation in muscle strengthening and balance & co-ordination activities by adults and older adults in Scotland. *BMC Public Health* 2016;16:1108.
- Ramirez Varela A, Pratt M, Powell K, Lee I, Bauman A, Heath G, et al. Worldwide surveillance, policy and research on physical activity and health: The Global Observatory for Physical Activity - GoPA! *J Phys Act Health* 2016;14(9):701-9.
- World Health Organization. Global status report on noncommunicable diseases 2014. Geneva, Switzerland; 2014.
- The Scottish Government. The Scottish Health Survey 2013: Volume 1: Main Report. Edinburgh, Scotland; 2014.
- Health and Social Care Information Centre. Health Survey for England, 2012 [Internet]. Leeds, UK; 2013. Available from: <http://www.hscic.gov.uk/catalogue/PUB13218>
- Department of Health Social Services and Public Safety. Health Survey Northern Ireland 2013-14 Questionnaire. Belfast, Northern Ireland; 2014.
- Zhao G, Li C, Ford E, Fulton J, Carlson S, Okoro C, et al. Leisure-time aerobic physical activity, muscle strengthening activity and mortality risks amongst US adults: the NHANES linked mortality study. *Br J Sports Med* 2014;48(3):244-9.
- Stamatakis M, Lee I, Bennie J, Freedston J, Hamer M, O'Donovan G, et al. Does strength promoting exercise confer unique health benefits? A pooled analysis of eleven population cohorts with all-cause, cancer, and cardiovascular mortality endpoints. *Am J Epidemiol* 2017; October.