Physical activity in older people: a systematic review

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Abstract

Background: Physical activity (PA) in older people is critically important in the prevention of disease, maintenance of independence and improvement of quality of life. Little is known about the physical activity of the older adults or their compliance with current physical activity guidelines.

Methods: A systematic literature search of the published literature was conducted. Included were published reports of original research that independently reported: the PA level of non-institutional older adults (aged 60 years and over); and the proportion of older adults in the different samples who met PA recommendations or guidelines. The review was restricted to studies published since 2000 to provide a current picture of older adults’ PA levels.

Results: Fifty three papers were included in the review. The percentage of older adults meeting recommended physical activity ranged from 2.4 – 83.0% across the studies. Definitions of “recommended” physical activity in older adults varied across the studies as did approaches to measurement which posed methodological challenges to data analysis. Older age groups were less likely than the reference group to be regularly active, and women were less likely than men to achieve regular physical activity, especially leisure time physical activity, when measured by both subjective and objective criteria.

Conclusion: The review highlights the need for studies which recruit representative random samples of community based older people and employ validated measurement methods consistently to enable comparison of PA levels over time and between countries.

Keywords: Physical activity, Exercise, Older people, Older adults

Background

Regular physical activity (PA) can bring significant health benefits to people of all ages and the need for PA does not end in later life with evidence increasingly indicating that PA can extend years of active independent living, reduce disability and improve the quality of life for older people [1]. Indeed a large scale longitudinal 8 year study found that every additional 15 minutes of daily PA up to 100 minutes per day resulted in a further 4% decrease in mortality from any cause [2]. Increasing PA will help minimise the burden on health and social care through enabling healthy ageing [3,4].

There is no known review of PA among older people and it is not known whether active older people comply with recommended PA levels. Understanding the extent of PA will provide a global perspective of PA among older people within the context of an increasing desire to promote PA goals across all age groups. The aim of this review was to establish global levels of PA among older people as reported in the published literature. Establishing PA prevalence in older community dwelling people provides a baseline against which changes in PA can be measured, international comparisons drawn and the success or otherwise of public health interventions to increase PA evaluated.

Methods

Search strategy

The following methods were used to locate relevant published studies from January 2000 – 11 April 2011. Electronic searches of computerized databases were carried out on English language databases (The Cochrane Library, PubMed, MEDLINE, EMBASE, CINAHL, PsycINFO, * Correspondence: alison.while@kcl.ac.uk
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British Nursing Index (BNI) and Scopus) and Chinese databases: Chinese Biomedical, VIP Chinese Science Journals and WANFANG DATA. Keyword combinations for electronic database searches are listed in Table 1. The search was limited to the English and Chinese languages.

**Selection criteria**

Papers were reviewed if they met the following criteria: (1) original research; (2) independently reported the PA level of non-institutional older people (adults aged 60 years and over); (3) reported the proportion of any of PA recommendation or guidelines achieved by the sample.

No attempt was made to access unpublished studies or other ‘grey’ literature. The study selection process is set out in Figure 1.

**Data extraction and appraisal**

All authors devised the research strategy. Initial screening was undertaken by one researcher (FS) and then checked by another (AEW). Disagreements about inclusion were discussed until agreement was reached. One researcher (FS) extracted the following data from the selected studies: country of study, study sample, measurements, recommendations and main results. Another researcher (AEW) verified the extracted data and made corrections where necessary. Disagreements were resolved by reference to the third researcher (IJN). All three researchers contributed to the synthesis of the data.

**PA recommendations or guidelines**

Definitions of “recommended” PA in older adults varied across the studies with some studies employing two or more guidelines. These guidelines are summarized in Table 2. The minimum recommended PA level in the guidelines in most studies was 150 minutes of moderate or vigorous PA per week and we adopted this standard as the desired PA level for the purpose of this review. We categorised the selected studies according to their underpinning PA guidelines, and identified studies as falling into one of two groups according to the detail provided by the study authors on the guidelines followed. Twenty six studies which stated only the total amount of PA per week were classified within the ‘detailed guideline group’. According to the Physical Activity Guideline Advisory Committee’s report [5], detailed guidelines, such as 1995 CDC/ACSM guideline is too specific. In other words, the existing scientific evidence cannot distinguish the health benefits of 30 minutes of PA on 5 days a week from those gained through 50 minutes of PA on 3 days a week.

**Results and discussion**

**An overview of selected papers**

A total of 53 papers met the inclusion criteria. The main findings of the selected studies are reported in Tables 3 and 4.

Most of the studies were conducted in the United States and Australia (USA n=19; Australia n=10; UK n=5; Brazil n=4; China n=4; Canada n=4; New Zealand n=1; Colombia n=1; South Africa n=1; Greece and Cyprus n=1; Cyprus n=1; Sweden n=1; Switzerland n=1). Forty nine papers reported cross-sectional studies and four reported longitudinal studies. The sample sizes ranged from 54 – 43,259. The number of studies conducted each year over the search period was not constant (1990–1994, n=2; 1995–1999, n=12; 2000–2004, n=32; 2005–2009, n=18; 2010–2011, n=2) with more than half being conducted between 2000 and 2004.

Forty seven studies measured PA intensity, duration, and frequency using subjective measures (interview or self-reported questionnaires) and six reported objective data gathered using an accelerometer. Two studies compared subjective and objective data measurements. While 39 studies recorded PA taken in periods of 10 minutes or more, other studies recorded all PA.

Physical activity comprises leisure-time PA, occupational PA, household PA and transportation PA. Leisure-time PA (LTPA) was most often measured and compared to the criterion for meeting PA recommendations. However, occupational, household and transportation PA were gathered in some studies. PA volume was calculated differently across the studies including: total metabolic equivalents (METs), minutes of weekly PA; minutes of participation in and frequency of PA during the week; kilocalories expended per kilogram of weight per day; and time in moderate to vigorous PA from accelerometers. To calculate minutes of weekly moderate to vigorous PA, some authors summed the duration of moderate and vigorous PA (MPA+VPA) while others doubled the time of vigorous PA because of its higher

### Table 1 Search terms

| Facets      | Search terms                                      |
|-------------|---------------------------------------------------|
| PA          | Exercise/s; physical activity/activities          |
| Old people  | Aged, old people, elderly, elders, aging adult, ageing adult, old men, old women, older people, older men, older women, older person |
| Research    | Prevalence, health survey/surveys, survey/surveys, surveillance, statistics, epidemiologic |
intensity (MPA+2VPA). The definition of moderate and vigorous PA also varied across the studies. For instance, the minimum cut off of moderate PA varied from 3 MET, 3.3 MET to 4 MET across the studies. Given the variety of methods of data collection and calculation of PA level, a meta-analysis was not attempted.

Levels of PA within recommendations or guidelines
Thirty two studies adopted the more detailed PA guidelines while 26 studies were in the less detailed group with some studies employing two or more guidelines. Although most of the PA guidelines stated the total PA amount which should be accumulated in bouts of at
least 10 minutes, 14 of the 53 studies recorded all moderate or vigorous PA (see Table 2).

**General PA prevalence in older adults**

Tables 3 and 4 present a synopsis of the findings relating to older people's PA levels from each country. Across the 53 papers, the percentage of older adults meeting the guidelines ranged from 2.4% [55] to 83% [49] with most studies reporting that 20-60% of the samples met the guideline. When LTPA was measured, 20 studies excluded household work with reported PA prevalence ranging from 6.23% [58] to 67.51% [27], while 14 included household work with reported PA prevalence of 10.86% [31] to 66.7% [16]. Seventeen studies measured all domains of PA (including occupational, household, transportation and recreational PA) with reported PA prevalence of 11.67% [31] to 77.22% [51], and two studies reported that 31.7% [13] and 62.4% [45] of older people achieved sufficient PA through walking. In six papers PA prevalence was reported by age group, gender group, or residential area group (rural versus urban), but not for the sample overall.

### Self-reported PA

In 48 subjectively measured PA studies, 29 studies adopted the more detailed PA guidelines and 21 studies adopted the less detailed PA guidelines (5 studies adopted 2 criteria). Studies that employed the more detailed guidelines reported PA prevalence ranging from 6.2% in the Health Survey for England [38] to 82.6% in an urban Chinese sample [47]. Using the less detailed guidelines (criteria), sufficient PA in the other studies increased from 21.3% [34] to 83.0% [49] in a small older female sample.

Those studies that accumulated PA data by 10 minutes bouts reported a relatively lower PA prevalence. The two studies which only included PA data of more than 30 minute sessions reported the lowest PA prevalence (10.9% [30]; 6.23% [58]) across all the subjectively measured PA studies.

### Objectively measured PA

Six studies used accelerometers and reported extractable data (i.e. proportion of the sample meeting the criterion of sufficient PA rather than measures of central tendency).
| NO. | Author, year of publication, country | Data collection period | Sample size* | Data source | N and % of sufficiently active old people | Comment |
|-----|-------------------------------------|------------------------|--------------|-------------|----------------------------------------|---------|
| 1   | Merom et al. [6] 2006, Australia    | 1989-1990              | 8160, (60+yr) | National health survey | 2285, 28%                           | High quality, National representative sample, Validated questionnaire |
|     |                                     | 1995-1996              | 7620, (60+yr) | National health survey | 2027, 26.6%                          |         |
|     |                                     | 2000                   | 4359, (60+yr) | National health survey | 1125, 25.8%                          |         |
| 2   | Jerome et al. [7] 2006, USA         | 1991(I) and 1994 (II)  | 243 F (70-79yr) without functional deficit | Women’s Health and Aging Studies I and II | 53, 22%                           | High quality, Regional representative sample, Validated questionnaire |
| 3   | Brownson et al. [8] 2000, USA       | 1996                   | 24406, 14307 (65-74yr), and 10099 (75+yr) | Behavioural Risk Factor Surveillance System (BRFSS) | CDC-ACSM 1995 5696, 23.34% |
|     |                                     |                        |              |             | 65-74: 25.7 % 75 +: 20.0%            |         |
|     |                                     |                        |              |             | SGR 1996 6480, 26.55% |
|     |                                     |                        |              |             | 65-74: 30.4 % 75 +: 21.1%            |         |
| 4   | Brach et al. [9] 2004, USA          | 1998                   | 3075 (70–79), 1584 F | Health ABC study | 750, 24.4% Men: 33.07% |
|     |                                     |                        |              |             | Women: 16.22%                        |         |
| 5   | Phongsavan et al. [10] 2004, Australia | 1998 | 4321, 1675 M | NSW State health survey | Domestic PA excluded 1634, 37.82% Men: 46.7% Women: 32.2% |
|     |                                     |                        |              |             | Domestic PA included 2184, 50.55% Men: 59.8% Women: 44.7% | High quality Regional representative sample Validated questionnaire |
| 6   | Chau et al. [11], 2008, Australia   | 1998                   | 2068, (65+yr) | NSW Population health survey | 748, 36.15%                           | High quality Regional representative sample Validated questionnaire |
|     |                                     |                        |              |             | 65-74: 1357,40.1% |
|     |                                     |                        |              |             | 75 +: 711,28.6% | |
|     |                                     |                        |              |             | 2002 3420, (65+yr) | 1295, 37.88% |
|     |                                     |                        |              |             | 65-74: 2038,41.8% |
|     |                                     |                        |              |             | 75 +:1382, 32.1% | |
|     |                                     |                        |              |             | 2003 3577, (65+yr) | 1217, 34.02% |
|     |                                     |                        |              |             | 65-74: 2022,39.8% |
|     |                                     |                        |              |             | 75-1555,26.5% | |
|     |                                     |                        |              |             | 2004 2706, (65+yr) | 1073, 39.66% |
|     |                                     |                        |              |             | 65-74: 1552,45.5% |
|     |                                     |                        |              |             | 75-1154, 31.8% | |
|     |                                     |                        |              |             | 2005 3391, (65+yr) | 1350, 39.82% |
|     |                                     |                        |              |             | 65-74: 1921,45.5% |
|     |                                     |                        |              |             | 75-1470, 32.4% | |
| No. | Study | Year | Age Group | Study Type | Sample Size | % of Participants | Prevalence | Notes |
|-----|--------|------|-----------|------------|--------------|-----------------|------------|-------|
| 7   | Hamdorf et al. [12] | 2002, Australia | 773, (60+yr) | Social Environmental Risk Context Information System (SERCIS) | Didn't report the prevalence of whole sample 60–64: 181, 50.8%, 85+:26, 15.4% Figure 2 showed the trend of declining | | | High quality Regional representative sample Validated questionnaire |
| 8   | Merom et al. [13] | 2009, Australia | 2068, (65+yr) | The NSW Population health survey | 532, 25.73% 65-74: 1357,280 75+: 711, 21.4 | | | High quality Regional representative sample Validated questionnaire |
|     |         | 2002 | 3420, (65+yr) | The NSW Population health survey | 970, 28.35% 65-74: 2038,30.9% 75+: 1382, 24.6% | | | |
|     |         | 2003 | 3577, (65+yr) | The NSW Population health survey | 899, 25.13% 65-74: 2022,29.3% 75+:1555,19.7% | | | |
|     |         | 2004 | 2706, (65+yr) | The NSW Population health survey | 781, 28.85% 65-74:1552, 32.3% 75+: 1154, 24.2% | | | |
|     |         | 2005 | 3391, (65+yr) | The NSW Population health survey | 985, 29.04% 65-74:1921, 32.9% 75+: 1470, 24.0% | | | |
|     |         | 2006 | 2388, (65+yr) | The NSW Population health survey | 744, 31.17% 65-74: 1318,35.7% 75+: 1070, 25.6% | | | |
| 9   | Heesch & Brown [14] | 2008, Australia | 3613 F, 75.28 (73–78 yr) | Australian Longitudinal Study on Women’s Health | 1572, 43.5% | | | High quality National representative sample Validated questionnaire |
| 10  | Lim & Taylor [15] | 2005, Australia | 8881, 5045 F, 73.8 (95%CI 73.6–74.0yr) | NSW Older People’s Health Survey (OPHS) | 4343, 48.9% Women, 39.7%, Men, 61.1% | | | High quality Regional representative sample Validated questionnaire |
| 11  | Lawlor et al. [16] | 2002, UK | 2341 F (60-79yr) | British Women's Heart and Health Study | Domestic PA included 1561, 66.7% Domestic PA excluded 492, 21% | | | High quality National representative sample Validated questionnaire |
| 12  | Hillsdon et al. [17] | 2008, UK | 4103 F, (60-79yr) | British Women's Heart and Health Study | 926, 22.57% | | | High quality National representative sample Validated questionnaire |
Table 3 Physical activity studies which used subjective measures (Continued)

|   | Study                | Year | Sample Size | Gender | Age Groups | Activity Levels | Sample Quality |
|---|----------------------|------|-------------|--------|------------|----------------|----------------|
| 13| Brown et al. [18]    | 2003 | 30146 (65+yr), 17081 F | BRFSS  | 30146, 37.5%, Men: 42.03% | Women: 31.90% | High quality National representative sample, Validated questionnaire |
| 14| Brown et al. [19]    | 2005 | 22174 (65+yr), 13834 F | BRFSS  | 22174, 41.50%, Men: 47.38% | Women: 37.96% | High quality National representative sample, Validated questionnaire |
| 15| Ashe et al. [20]     | 2009 | 24233 (65+yr), 60%F (76% reported having one or more chronic diseases) | Canadian Community Health Survey Cycle 1.1 | No chronic disease | One or more chronic disease | High quality National representative sample Validated questionnaire |
| 16| US CDC [21]          | 2007 | (65+yr), ( whole sample 205,140) | BRFSS  | Men 43.1% women 32.2% | High quality National representative sample Validated questionnaire |
| 17| Muntner et al. [22]  | 2005 | 1824 (65-79yr), 939 M | InterASIA study | Rural 52.7% Urban 9.8% | High quality National representative sample Validated questionnaire |
| 18| Benedetti et al. [23]| 2008 | 875, 71.6 ± 7.9 (65-101yr), 437M | A representative survey: Profile of Old Persons in the Municipality of Florianópolis | 519, 59.3% Men 63.6% | Women 55% | High quality Regional representative sample Validated questionnaire |
| 19| Ding et al. [24]     | 2009 | 799 (60+yr) | 2002 Beijing Nutrition and Health Survey | 254, 31.79% 60–74: 673, 33% 75+: 126, 25.3% | High quality Regional representative sample Validated questionnaire |
| 20| Hallal et al. [25]   | 2003 | 583 (60+yr), 360F | Cross-sectional survey Pelotas, Brazil | 270, 46.3% 60–69:307,56.2% 70+276,35.3% Men 60–69:124,55.4% 70+99,43% | Women 60–69:183, 56.8% 70+: 177,30.3% | High quality Regional representative sample Validated questionnaire |
| 21| 2007                 |      |             |        |            | 60-69: 42.7% 70+: 23.7% |            |
| Study Ref. | Year, Country | Age Range, Sample Size | Study Design, Location | Results | Quality | Notes |
|-----------|---------------|------------------------|------------------------|---------|---------|-------|
| Knuth et al. [26] | 2010 Brazil | (65+yr), (whole sample 2969) | Cross-sectional survey Pelotas, Brazil | Total: 2739, 67.51% 65-79: 3257, 80.9% 80+: 800, 58.1% Sports/exercise Total: 515, 12.7% 65-79: 25.9% 80+: 24.77% Habitual Total: 2314, 57.04% 80+: 51.7% 65-79: 45.4% | High quality Regional representative sample Validated questionnaire | |
| Meyer [27] | 2002 Switzerland | 4057 (65+yr) | Swiss Health Survey* | Total: 2314, 57.04% 80+: 51.7% 65-79: 45.4% | High quality National representative sample Validated questionnaire | |
| Frank et al. [28] | 2010, USA | 1970 (65+yr) | Strategies for Metropolitan Atlanta's Regional Transportation and Air Quality (SMARTRAQ study, Atlanta region) | Total: 791, 40.16% 65–74: 1198, 42.7% 75–84: 622, 38.0% 85+:150, 28.8% | High quality Regional representative sample Validated questionnaire | |
| Guinn et al. [29] | 2002, USA | 244 (60-81yr), 162 or 170 F | Cross-sectional survey in a retirement area, Texas | 136, 55.74% men: (82) 74, 66.57% women: (162)170, 50.59% | Weak quality Sample bias likely due to recruitment procedure Testing of instrument not reported. % of male or female was inconsistent in the paper | |
| Taylor-Piliae et al. [30] | 2006, USA | 1010, 65.8 ±2.8 (60–69yr), 631 M | Healthy control of Atherosclerotic disease vascular function and genetic epidemiology (ADVANCE) Study | All domain PA measured by Stanford Seven-Day PA Recall 646, 64% On-the-job activity and leisure-time activities measured by Stanford Brief Activity Survey 616, 61%, Men 61.5% women 60.7% | High quality Sample was selected from a medical insurance programme Validated questionnaire | |
| Allender et al, [31] | 2008, UK | 1181 (65+yr) | Health Survey for England (HSE) | | High quality National representative sample Validated questionnaire | |
| No. | Authors            | Year | Sample Size | Design | Data Collection | Methods | Sample Description | Physical Activity Measures | Notes |
|-----|--------------------|------|-------------|--------|-----------------|---------|-------------------|-----------------------------|-------|
| 27  | Florindo et al.    | 2003 | 1318        | Regional | Health Survey of the Municipality of Sao Paulo | Total PA 899, 68.2% | High quality Regional representative sample Validated questionnaire |
|     | (60-65yr), the whole sample was 1318 |      |             |         |                 | LTPA 232, 17.6% |       |                          |       |
|     |                    |      |             |         |                 | Transportation 83, 6.3% |       |                          |       |
|     |                    |      |             |         |                 | Occupational 250, 19% |       |                          |       |
|     |                    |      |             |         |                 | Household 585, 44.4% |       |                          |       |
| 28  | Joubert et al.     | 2003 | (60+yr)     | National | World Health Survey 2003 | Men 60-69: 21.2% | High quality National representative sample Method of sample recruitment not reported Validated questionnaire |
|     |                    |      |             |         |                 | Women 60-69: 18.4% |       |                          |       |
|     |                    |      |             |         |                 | 70+: 22.3% |       |                          |       |
|     |                    |      |             |         |                 | Women 70+: 10% |       |                          |       |
| 29  | Meisner et al.     | 2003 | (60+yr), 6823F | National | Part of Canadian Community Health Survey (CCHS, Cycle 2.1) | Men 2565, 21.3% | High quality National representative sample Validated questionnaire |
|     |                    |      |             |         |                 | Women  |       |                          |       |
|     |                    |      |             |         |                 | 60-69: 21.2% |       |                          |       |
|     |                    |      |             |         |                 | 70+: 22.3% |       |                          |       |
| 30  | Mummery et al.     | 2003 | (60+yr), 1009 F | National | Obstacles to Action Survey | 974, 51.4% | High quality National representative sample Validated questionnaire |
|     |                    |      |             |         |                 | Men 55.2% |       |                          |       |
|     |                    |      |             |         |                 | 60-64:603, 56.5 |       |                          |       |
|     |                    |      |             |         |                 | 70-74: 363, 51.1% |       |                          |       |
|     |                    |      |             |         |                 | 80+: 213, 32.3% |       |                          |       |
| 31  | McGuire et al.     | 2003 | 36,010 F (65+yr) | Stratified random sample of HealthPartners membership, used questions from the BRFSS | BRFSS | 6986, 19.4% | High quality National representative sample Validated questionnaire |
|     |                    |      |             |         |                 | 65-69:10071, 23.0% |       |                          |       |
|     |                    |      |             |         |                 | 70-74: 9150, 18.5% |       |                          |       |
|     |                    |      |             |         |                 | 80-84: 5580, 15.6% |       |                          |       |
|     |                    |      |             |         |                 | 85+: 3300, 13.6% |       |                          |       |
| 32  | Pronk et al.       | 2004 | 685,745± 6.7yr | Stratified random sample of HealthPartners membership, used questions from the BRFSS | 279, 40.7% | High quality Stratified random sample Validated questionnaire |
|     |                    |      |             |         |                 | 65-69: 1007, 23.0% |       |                          |       |
|     |                    |      |             |         |                 | 70-74: 9150, 18.5% |       |                          |       |
|     |                    |      |             |         |                 | 80-84: 5580, 15.6% |       |                          |       |
|     |                    |      |             |         |                 | 85+: 3300, 13.6% |       |                          |       |
| 33  | Stamatakis et al.  | 2003 | (65+yr), 1187 M | Health Survey for England (HsFE) | Domestic excluded | Total 279, 40.7% | High quality National representative sample Validated questionnaire |
|     |                    |      |             |         |                 | Men 7.6% |       |                          |       |
|     |                    |      |             |         |                 | Women 5.2% |       |                          |       |
|     |                    |      |             |         |                 | 75+: 441, 8.7% |       |                          |       |
|     |                    |      |             |         |                 | Women 9.03% |       |                          |       |
|     |                    |      |             |         |                 | 65-74: 853, 13.0% |       |                          |       |
|     |                    |      |             |         |                 | 75+: 717, 4.3% |       |                          |       |
| No. | Study Details | Year | Sample Size | Study Design | Study/Follow-up Period | Key Findings | Notes |
|-----|---------------|------|-------------|--------------|------------------------|--------------|-------|
| 34  | D’Simio et al. [39] 2006, Australia | 2004 | 1588 (60-75yr) | Queensland Cancer Risk Study (Active Australia Survey) | 891, 56.1% | High quality Regional representative sample Validated questionnaire |
| 35  | Ready et al. [40] 2009, Canada | 2005 | 889 (65+yr) | Cross-sectional survey of random sample, Winnipeg, Canada | CPAG | High quality Regional representative sample Validated questionnaire |
|     |               |      |             |              | Men: 65-79: 46.9% Women: 65-79: 54.4% |             |       |
|     |               |      |             |              | 80+: 24.4% Women: 80+: 40% |             |       |
| 36  | Panagiotakos et al. [41] 2007, Cyprus | 2004-2005 | 117 (65+yr) | Health and nutrition survey of elderly people in Cyprus (group without diabetes) | 67, 57.26% | High quality Random sample from multi-geographical area Validated questionnaire |
| 37  | Sims et al. [42] 2007, Australia | not reported | 330 (65+yr), 190F | Cross-sectional survey using AAS questions Victoria, Australia | 187, 56.7% | High quality Regional representative sample Validated questionnaire |
|     |               | 2005-2006 |             |              | Men: 65-79: 63%, Women: 65-79: 63.7% |             |       |
|     |               |      |             |              | 80+: 42.2%, Women: 80+: 48.2% |             |       |
| 38  | Tucker et al. [43] 2011, USA | 2005-2006 | 1018 (60+yr) | NHANES 2005–2006, self-reported data | PAGA 2008 (MPA+VPA) 534, 52.44% | High quality National representative sample Validated questionnaire |
|     |               |      |             |              | 60-69: 441, 59.7% 70+: 577, 46.9% |             |       |
|     |               |      |             |              | PAGA 2008 (MPA+2VPA) 538, 52.89% |             |       |
|     |               |      |             |              | 60-69: 441, 60.6% 70+: 577, 47.0% |             |       |
|     |               |      |             |              | ≥500 MET-min-wk-1 572, 56.22% |             |       |
|     |               |      |             |              | 60-69: 441, 63.6% 70+: 577, 50.8% |             |       |
| 39  | Tyrovoulos et al. [44] 2009, Mediterranean Islands from Greece and Cyprus | 2005-2007 | 930 non-diabetic 74±7.1yr | MEDIS (Mediterranean Islands) study but the Measurement and criteria changed slightly | 353, 38% | High quality Random sample from multi-geographical area Validated questionnaire |
| Study | Year 1 | Year 2 | Participants | Study Design | Measures | Sample Size | Gender Distribution | Quality | Reference |
|-------|--------|--------|--------------|--------------|-----------|-------------|---------------------|---------|-----------|
| 40 Gómez et al. [45] | 2010, Colombia | 2007 | 1966, 70.7±7.7yr | Multilevel cross-sectional study, Bogotá | | | | 1227, 62.4% | High quality Random sample from multi neighbourhood in one city Validate questionnaire |
| 41 McGuire et al. [46] | 2010, USA | 2007 | 6138 (65+yr) | BRFSS 2007 of Hawaii, Kansas & Washington | | | | 2671, 43.51% | High quality Regional representative sample Validated questionnaire |
| 42 Xu et al. [47] | 2009, China | 2007 | 407 (65-69yr) | Cross-sectional survey, Guangdong Province using GPAQ | | | | Rural 60.9% Unban 82.6% | High quality Regional representative sample Validated questionnaire |
| 43 US CDC, [48] | 2008, USA | 2007 | (65+yr), (whole sample 399,107) | BRFSS | | | | 4127, 51.2% | High quality National representative sample Validated questionnaire |
| 44 Bird et al. [49] | 2008, Australia | not reported 2006-2008 | 66F (69.3 ± 6.7yr) | Cross-sectional survey Western Region of Melbourne | | | | 55, 83%, Small sample | Moderate quality Non-random small sample Validated measurement |
| 45 Carlson et al. [50] | 2010, USA | 2008 | 2008 (65+yr), (whole sample 21,781) | National Health Interview Survey employed light-moderate to substitute moderate PAGA 2008 | | | | 30.4% | High quality National representative sample Validated questionnaire |
| 46 Hurtig-Wennlof et al. [51] | 2010, Sweden | not reported before 2009 | 54 (66-85yr), 31F | Direct validity study using accelerometer-measured PA | | | | 39, 72.22% | Moderate quality Small convenience sample Modified version of validated instrument and Testing of instrument reported. |
| 47 Shores et al. [52] | 2009, USA | not reported Before 2009 | 448 (65+yr),238 M | Cross-sectional survey Western North Carolina used 7-day recall | | | | 134, 29.9% | Moderate quality Random sample Low response rate Testing of instrument not reported. |
| 48 Xue [53] | 2010, China | 2015 (60-75yr),910M | Cross-sectional survey Nanjing, Jiangsu province | | | | 956, 47.44%, Men:44.2% Women: 50.1% | Moderate quality Non-random sample, Validated questionnaire |
| 49 Fleming et al. [54] | 2007, USA | 1997–2003 | 43,259 , 74.9± 6.9 yr, 16198M | National Health Interview Survey (NHIS) | | | | 8695, 20.1% (age adjusted 21.1%), Men: 25.6%, (25.8% adjusted), Women: 16.8%, (17.6% adjusted) | High quality National representative sample, Validated questionnaire |
| No. | Author, Year of publication, Country | Sample size/Data source | Data collection period | Accelerometer | Main variable (cut point) | Epoch/ 10 min bouts | Guidelines Number and percentage of sufficiently active old people |
|-----|-------------------------------------|-------------------------|------------------------|---------------|--------------------------|---------------------|---------------------------------------------------------------|
| 50  | Troiano et al. [55] 2003–2004, USA | 1260, 624 M/ National Health and Nutritional Examination Survey, NHANES | 2003–2004 | Actigraph model 7164 | MPA (2020–5998 counts/min) VPA (5999 counts/min) | 1min /Y | CDC 1995 30, 2.4% men 2.5% women 2.3% |
| 38  | Tucker et al [43] 2011, USA | 1018 (60+yr)/ NHANES, accelerometry recorded data | 2005–2006 | Actigraph model 7164 | MPA (2020–5998 counts/min) VPA (5999 counts/min) | 1min /Y | PAGA 2008 74, 7.25% 60–69: 441, 8.5% 70+: 577, 6.3% |
| 51  | Harris et al. [56] 2009, UK | 238 (65+yr)/ Cross-sectional survey from Oxfordshire, UK | 2006 | Actigraph model GT1M | MPA (2000–3999 count/min) VPA (≥4000 count/min) | 1min /Y | PAGA 2008 6, 2.5% |
| 46  | Hurtig-Wennlof et al. [51] 2010, Sweden | 54 (66 -85yr), 23M/ direct validity study by accelerometer | not reported, Before 2009 | Actigraph, model GT1M | MPA (mixed lifestyle activities: 760–2019 counts/min; ambulatory activities: 2020–4944 counts/min) VPA: ≥4944 counts/min | 1SS /N | CDC 1995 47, 87.04% |
| 52  | Colley et al. [57] 2011, Canada | 901 (60-79yr), 452 M/Canadian Health Measures Survey (CHMS) | 2007-2009 | Actical accelerometer (Phillips – Respironics, Oregon, USA) | MPA(1,535–3,962 counts/min) VPA (≥3,962 counts/min) | 1min /Y | CDC 1995 40, 4.5% men: 5.3% women: 3.8% |
| 53  | Davis & Fox [3] 2007 UK, France & Italy | 163 (76.1±4.0 yr), 70 M/healthy volunteers recruited to the Better Ageing Project at four European sites based in the UK, France and Italy. | not reported, 2004-2006 | Actigraph model 7164 | MVPA (≥1952 counts/min) | 1min /Y | PAGA 2008 21, 13.1% men: 13.7% women: 12.6% |

**Guidelines**

- CDC 1995
- PAGA 2008
- PAGA 2008
- CDC 1995
- CDC 1995
- CDC 1995
- PAGA 2008
- CDC 1995
- PAGA 2008
The actigraph accelerometer was used in five studies and Actical in one study. When measured against the less detailed guidelines, the lowest prevalence (1.84%) was reported by Davis and Fox [3] based on an European sample and the highest was 17.2% from a US national survey, NHANES 2005–2006 [43]. Applying the more detailed guidelines, Davis and Fox [3] found nobody achieved sufficient PA and Colley [57] reported the highest proportion of 4.5% in this group with the exception of Hurtig-Wennlof et al.’s [51] exceptional finding of 87.04%.

However, there was a difference between the studies using self-report compared to the objective measurement of PA. In our review, two studies compared the subjective and objective data. Tucker et al.’s [43] analysis of the NHANES 2005–2006 data found that the sufficiently active group proportion defined by accelerometer measurement was 7.25% and 17.24% (using different guidelines); this increased to 54.2% when measured by questionnaire. Hurtig-Wennlof et al.’s Swedish study [51] reported a 87.04% objectively measured PA prevalence which was higher than the self-reported IPAQ data of 72.2%.

Gender differences in PA
Twenty two studies reported the recommended PA prevalence in males and females separately. In general, men’s PA levels were higher than women’s. In the self-reported data, gender differences of PA ranged from 0.8% [30] to 21.4% [15], while the differences measured by accelerometer were significantly lower (0.2% and 1.5%). However, we noticed that in the self-reported total PA, increased participation in PA by women exceeded that of men in three studies [40,53].

Residential differences in PA
Two Chinese papers reported the PA prevalence by place of residence and reported different results. Muntner et al. [22] reported sufficient all domain PA prevalence among 52.7% of their rural and 9.8% of their urban older people samples using the US CDC 1995 criterion from the InterASIAN Study. However, Xu et al. [47] reported that Guangdong province urban residents were more active than rural residents, with 82.6% of the urban and 60.9% of the rural samples attaining the HP 2010 goals measured by GPAQ.

PA prevalence across age groups
Eighteen studies measured PA subjectively and two studies measured PA objectively across different age groups, however, the majority divided the samples into two age groups and reported that the older old were more sedentary than the younger old. Only five studies divided the group by relatively narrow age bands. Patterns of participation in PA decreased progressively with age for both men and women although there was variation across the studies. In McGuire et al.’s study [36] PA declined from 23.0% in the 65–69 year group to 13.6% in 85+ year group but in Mummery et al.’s study [35], the difference between the 60–64 year group and 80+ year group was 24.2%. There was an unexpected rise in the 70–74 year age group in the Sims et al.’s [42] study although the general trends decreased with age. Although Hamdorf et al. [12] did not report the detailed percentage for each age group, we can see the same gradually declining trend from 50.8% in the 60–64 year age group to 15.4% in 85+ year age group in Figure 2.

PA prevalence trends over time
A crucial aspect of investigating trends over time is the comparability of methods. Differences in instruments, cut-off points, PA definitions and domains of activity investigated posed significant challenges to our review. Although nine studies reported the results of the BRFSS, not all the studies included national representative samples making it difficult to assess trends. Therefore, we only included the results of longitudinal studies or the findings from the same surveillance evaluated by the same criterion to establish the trend from seven studies. In Australia between 1990–2000 the proportion LTPA of older people aged 60 years and over meeting the PA guideline decreased from 28% to 25.8% in Merom et al.’s report [13] while the NSW Population Health Survey [11] report. The USCDC compared the BRFSS data in 2001 and 2005 and reported that the US’ older population was more active, with a rising prevalence of 43.1% to 44.5% in men and 32.2% to 36.3% in women [21]. Another paper using the BRFSS 2001 and BRFSS 2007 reported the same overall trend from 37.5% to 39.3% [48]. Conversely, Knuth et al. [26] reported a clear drop in PA prevalence between 2002 and 2007 in Brazil. In 2002, the proportions of older people reaching the PAGA 2008 guideline were 56.2% and 35.3% in the 60–69 year and 70+ year age groups respectively and decreased to 42.7% and 23.7% in 2007.

Discussion
Demographic differences in PA prevalence
One of the challenges facing the development of disease prevention programmes is the lack of reliable data for PA levels and trends [59] and the data for PA levels in older people is no exception. Generally within the included studies, the older old age groups were less likely than those of younger age to be regularly active, and women were less likely than men to achieve regular PA, especially in LTPA across both the subjectively and
objectively measured PA studies regardless of the PA guidelines adopted. The decline in PA with age may be the most consistent finding in PA epidemiology [60,61] with the higher PA prevalence among males echoing the findings of previous studies [62] which may reflect increasing disability with age and cultural norms across the genders. However, one Australian study [42] found that the decline of LTPA across the age groups was not consistent with LTPA peaking in the 70–74 year group. Additionally three studies reported that women were more active than men in relation to total PA [25,40,53]. This pattern also appeared in other studies [63] which may reflect the inclusion of household activities and other non-leisure, non-sport activities [53] in the total PA, which, in many cases, are largely specific to women. However, this was not a consistent finding across the included studies regardless of the guidelines category, indicating the need to quantify household activities accurately to enable comparisons across genders.

**PA trends by country and over time**

In our review, there was a slightly increasing trend towards recommended PA levels in older people in Australia and the US over the last 10 years but a decrease in Brazil. Studies of time trends in PA have been conducted mostly in developed countries and their results indicate that LTPA levels appear to be increasing [31,34,64,65]. Nevertheless, the data indicate that substantial numbers of older adults do not engage in sufficient PA to promote their health and there is considerable variation in the levels of PA reported across countries. Further, we found little data on time trends in PA in developing countries which was echoed in a recent systematic review [66]. However, the decline in PA in Brazil [26] is perhaps indicative of changes in occupational PA with the emergence of increasing sedentary work in developing countries which will present a future public health challenge especially when combined with dietary changes. Similarly Hallal et al. have also highlighted the lower proportions of adults who are physically active in south east Asia [59].

**The difference between objectively and subjectively measured PA prevalence**

The only two studies comparing self-reported PA to accelerometer measured PA in our review yielded contradictory results [43,51] with Tucker et al.’s [43] findings being consistent with the majority of other similar studies [67]. It is likely that the subjective PA studies reflect social desirability, recall bias and that there is underestimation of PA using objective measurement; PA monitors are worn typically on the hip which means that they do not accurately assess upper body activities or account for movements that require extra effort, such as walking uphill or carrying loads. Hurtig-Wennlof et al.’s [51] contradictory findings were probably caused by the lower cut-off point of MPA at 760 counts per minute (contrasting with about 2000 counts/min in the other studies) and the inclusion of PA under 10 minute bouts. This highlights the need for well designed studies using objectively measured PA to generate the evidence base for public health initiatives.

**Review limitations**

Limitations of this review arise from the discrepancies and inconsistencies in instrumentation, PA type measured, guidelines or recommendations adopted by different researchers, algorithms, sample frames and other confounding factors. These made it difficult to make full use of the extracted data and impossible to compare the PA prevalence between different regions/countries or assess PA trends with certainty.

**Conclusion**

Dramatic global population ageing has brought new demands to improve older people’s health by adding “quality” to their extended lives [68]. The review was undertaken
against the background of the WHO recommendations on PA for adults aged 65 years and older [69]. Despite these recommendations physical inactivity is an increasing global health burden [70] with PA surveillance emerging as one of the priorities of global public health for the development of effective non-communicable disease prevention programmes [59]. International efforts to increase PA have been reported within the adult or youth populations [38,66,71-73]. However, PA levels of older adults have attracted less interest so there are limited data regarding the prevalence of various types of PA in older adults and the proportion of older people whose PA meets PA guidelines. This review is the first of its kind and revealed many methodological challenges to data analysis across the selected studies. Robust studies which recruit representative random samples and consistently employ validated measurement instruments are needed to enable comparisons in PA levels to be drawn over time and between countries. More evidence of PA levels amongst older people is needed to inform public health strategies which could extend the health and quality of life of people into old age.

Abbreviations
AAS: Active Australia Survey; BRFSS: Behavioural Risk Factor Surveillance System; CDC-ACS: Centers for Disease Control and Prevention and the American College of Sports Medicine; CHMS: Canadian Health Measures Survey; CCHS: Canadian Community Health Survey; GPAQ: Global Physical Activity Questionnaire; IPAQ: International Physical Activity Questionnaire; LTTP: Leisure-time physical activity; MET: Total metabolic equivalents; MPA: Moderate physical activity; NHANES: National Health and Nutritional Examination Survey; NHIS: National Health Interview Survey; PA: Physical activity; PAGA: Physical Activity Guidelines for Americans; SGR: US Surgeon General’s Report; VPA: Vigorous physical activity.

Competing interests
None declared by the authors. This review was unfunded.

Authors’ contributions
All authors devised the research strategy; initial screening was undertaken by FS and then checked by AEW. FS extracted the data which was checked by AEW. Disagreements were resolved by reference to IJN. All authors contributed to the data synthesis and production of the paper. All authors read and approved the final manuscript.

Authors’ information
FS is a doctoral student. AEW and UN are established health service researchers. This review was conducted to understand the prevalence and measurement of physical activity in older people.

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