

## PART F. CHAPTER 9. OLDER ADULTS

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### INTRODUCTION

Advances in public health and in health care are keeping people alive longer, and consequently, the proportion of older people in the global population is increasing rapidly. As of 2016, individuals ages 65 years and older comprise about 13 percent of the United States population, and their numbers are projected to reach 72.1 million (19% of the total population) by the year 2030. This represents a two-fold increase compared with the older adult population in 2000. Moreover, the number of people 85 years and older is projected to rise to 14.6 million by 2040.<sup>1</sup> Due to these growing demographic trends, the prevention of chronic disease, the maintenance of functional status, and the preservation of physical independence in aging present major challenges that have substantial personal and public health implications.

Ample evidence now exists that regular physical activity is key to preventing and managing major chronic diseases common to older people. Physical activity is also important for preserving physical

function and mobility, which can then delay the onset of major disability.<sup>2</sup> Despite the known benefits of physical activity to health and physical function in aging, the proportion of older adults meeting recommended physical activity guidelines remains low (27%), based on data from the 2011-2012 National Health and Nutrition Examination Survey (NHANES) data.<sup>3</sup>

The *Physical Activity Guidelines Advisory Committee Report, 2008*<sup>4</sup> addressed the importance and impact of physical activity in preventing or delaying the onset of substantial functional and/or role limitations in middle-aged and older adults without such limitations. The report further addressed the relationship between physical activity and improvements in functional ability in older adults with mild, moderate, or severe functional or role limitations, as well as the role of physical activity in reducing the incidence of falls and fall-related injuries. Since the 2008 Scientific Report,<sup>4</sup> considerable evidence has emerged regarding the relative benefits of various modes or combinations of physical activity (e.g., progressive resistance training, multicomponent exercise, dual-task training, tai chi, yoga, dance) for specific physical function outcomes (e.g., strength, gait speed, balance, activities of daily living (ADL) function). The term “multicomponent” refers to physical activity interventions that include more than one type (or mode) of physical activity, with common types being aerobic, muscle-strengthening, and balance training. Dual-task interventions combine a physical activity intervention with a cognitive intervention (such as counting backward). Also, there is now convincing evidence of the magnitude of risk reduction in fall-related injuries due to various physical activity interventions. In addition, the current research has begun to address the issues of the dose-response relationship between physical activity and physical function in aging, as well as of the minimal effective dose and the maximal threshold for safety.

The *2018 Physical Activity Guidelines Advisory Committee Report* expands upon the 2008 Scientific Report by examining the relationship between physical activity and the risk of fall-related injuries, as well as the relationship between physical activity and physical function, in both the general aging population and in people living with specific chronic diseases. The 2018 Scientific Report further leverages current research in examining: 1) the dose-response relationship between exposure and outcome; 2) the mode of activity most beneficial to a specific functional outcome; and 3) whether the relationship between physical activity and physical function varies by age, race, sex, socioeconomic characteristics, or by body weight.

## REVIEW OF THE SCIENCE

### Overview of Questions Addressed

This chapter addresses three major questions and related subquestions:

1. What is the relationship between physical activity and risk of injury due to a fall?
  - a) Is there a dose-response relationship? If yes, what is the shape of the relationship?
  - b) Does the relationship vary by age, sex, race/ethnicity, socioeconomic status, or weight status?
  - c) What type(s) of physical activity are effective for preventing injuries due to a fall?
  - d) What factors (e.g., level of physical function, existing gait disability) modify the relationship between physical activity and risk of injury due to a fall?
  
2. What is the relationship between physical activity and physical function among the general aging population?
  - a) Is there a dose-response relationship? If yes, what is the shape of the relationship?
  - b) Does the relationship vary by age, sex, race/ethnicity, socioeconomic status, or weight status?
  - c) What type(s) of physical activity (single component, dual task, multicomponent) are effective for improving or maintaining physical function among the general aging population?
  - d) What impairment(s) (e.g., visual impairment, cognitive impairment, physical impairment) modify the relationship between physical activity and physical function among the general aging population?
  
3. What is the relationship between physical activity and physical function in older adults with selected chronic conditions?

### Data Sources and Process Used to Answer Questions

The Aging Subcommittee determined that systematic reviews, meta-analyses, pooled analyses, and reports provided sufficient literature to answer two of its three research questions. For Question 1 (*What is the relationship between physical activity and risk of injury due to a fall?*) the Subcommittee identified that existing reviews (systematic reviews, meta-analyses, pooled analyses, and reports) covered only a portion of the science. Specifically, the existing reviews provided evidence from randomized controlled trials (RCTs), but not evidence from cohort or case-control studies. A supplementary search for cohort and case-control studies was conducted to capture the most complete literature.

### **Question 1. What is the relationship between physical activity and risk of injury due to a fall?**

- a) Is there a dose-response relationship? If yes, what is the shape of the relationship?
- b) Does the relationship vary by age, sex, race/ethnicity, socioeconomic status, or weight status?
- c) What type(s) of physical activity are effective for preventing injuries due to a fall?
- d) What factors (e.g., level of physical function, existing gait disability) modify the relationship between physical activity and risk of injury due to a fall?

**Sources of evidence:** Systematic reviews and/or meta-analyses, a high-quality existing report, prospective cohort studies, a case-control study.

#### **Conclusion Statements**

Strong evidence demonstrates that participation by community-dwelling older adults in multicomponent group or home-based fall prevention physical activity and exercise programs can significantly reduce the risk of injury from falls, including severe falls that result in bone fracture, head trauma, open wound soft tissue injury, or any other injury requiring medical care or admission to hospital. **PAGAC Grade: Strong.**

Limited evidence suggests that a dose-response relationship exists between the amount of moderate-to-vigorous physical activity or home and group exercise and risk of fall-related injury and bone fracture. However, the small number of studies available and the diverse array of physical activities studied make it difficult to describe the shape of the relationship. **PAGAC Grade: Limited.**

Insufficient evidence is available to determine whether the relationship between physical activity and risk of injury and bone fracture due to a fall varies by age, sex, race/ethnicity, socioeconomic status, or weight status. **PAGAC Grade: Not assignable.**

Moderate evidence indicates that the risk of fall-related injury and bone fracture may be reduced using a variety of community-based group and home physical activities. Effective multicomponent physical activity regimens generally include combinations of balance, strength, endurance, gait, and physical function training, along with recreational activities. **PAGAC Grade: Moderate.**

Insufficient evidence is available to determine whether other factors (e.g., level of physical function ability and pre-existing gait disability) modify the relationship between physical activity and risk of injury due to a fall. **PAGAC Grade: Not assignable.**

## Review of the Evidence

The 2008 Scientific Report stated that, “clear evidence demonstrates that participation in physical activity programs is safe and can effectively reduce falls in older adults at elevated risk of falls.”<sup>4</sup> The 2008 Scientific Report also noted, however, that insufficient information was available from RCTs to assess the effects of regular physical activity on injuries resulting from falls. Since 2008, a number of RCTs have examined this question, and the evidence from these trials is summarized below.

The Subcommittee based its conclusions on evidence published between January 2006 and December 2016. This evidence came from three existing systematic reviews and meta-analyses of RCTs,<sup>5-7</sup> one high-quality report on RCT research in this area,<sup>8</sup> three prospective cohort studies,<sup>9-11</sup> and one case-control study.<sup>12</sup> Participants included in these studies were non-hospitalized, ambulatory adults, ages 50 years and older. The exposure of interest was all types and intensities of physical activity, and the outcomes of interest were all or any injuries from falls; fractures from falls; head injuries from falls; intra-abdominal injury from falls; medically attended injury from falls; neck, back, and spine injuries from falls; “pooled” injuries from falls; and sprains from falls.

### *Evidence on the Overall Relationship*

Results from these systematic reviews and/or meta-analyses of RCTs consistently support that fall prevention physical activity programs effectively reduce the risk of fall-related injuries by 32 to 40 percent and bone fractures by 40 to 66 percent among older adults in community and home settings.<sup>5-8</sup> These RCT findings are supported by data from three prospective cohort studies<sup>9-11</sup> and one case-control study.<sup>12</sup>

[El-Khoury et al<sup>5</sup>](#) reviewed 17 individual RCTs and performed a meta-analysis on 10 of them (N=4,305 participants ages 60 years and older). Although the definitions and classifications of injurious falls varied widely among the RCTs, their findings strongly suggest that structured physical activity interventions reduced the risk of all fall-related injuries by approximately 37 percent (pooled relative risk (RR)=0.63; 95% confidence interval (CI): 0.51-0.77). The risk of fall-related injuries requiring medical care was reduced by 30 percent (pooled RR=0.70; 95% CI: 0.54-0.92, based on 8 trials) and the risk of a severe fall-related injury (such as a fracture, head trauma, soft tissue injury requiring suturing, or any other injury requiring admission to hospital) was reduced by 43 percent (pooled RR=0.57; 95% CI: 0.36-0.90, based on 7 trials). Finally, the risk of a fall resulting in a fracture was reduced by 61 percent (pooled RR=0.39; 95% CI: 0.22-0.66, based on 6 trials). Moreover, the benefits of physical activity programs to

reduce the risk of these four categories of fall-related injuries were similar between older adults identified as being at high risk of falling versus those who were at an unspecified risk.

More recently, [Zhao et al<sup>7</sup>](#) reported that among 15 RCTs including 3,136 participants ages 53 to 83 years, physical activity reduced the risk of fall-related fractures by 40 percent (pooled RR=0.60; 95% CI: 0.45-0.84). A comparable finding of 43 percent reduced risk of fall-related fractures was reported when a sensitivity analysis was performed to retain only the 11 studies deemed “low” overall risk of bias (RR=0.57; 95% CI: 0.41-0.81). [Gillespie et al<sup>6</sup>](#) reported that among 6 RCTs including 810 participants, structured physical activity interventions reduced the risk of a fall-related fracture by 66 percent (pooled RR=0.34; 95% CI: 0.18 to 0.63).

Results from a meta-analysis of studies involving community-dwelling adults ages 65 years and older<sup>8</sup> suggest that participation in physical activity programs tailored to the risk factors and needs of each participant (i.e., “targeted” exercise) reduced the risk of fall-related injury by 33 percent (pooled RR=0.67; 95% CI: 0.51–0.89, based on 3 studies and 546 participants). Those programs designed to be the same for all participants (“untargeted” exercise) reduced the risk of fall-related injury by 56 percent (RR=0.44; 95% CI: 0.27–0.72, based on 2 studies and 426 participants). Long-term (6 months or longer) targeted and untargeted physical activity programs reduced the risk of fall-related injury by 32 percent (RR=0.68; 95% CI: 0.51-0.90, based on 2 studies and 453 participants) and by 39 percent (RR=0.61; 95% CI: 0.33-1.12, based on 2 studies and 358 participants), respectively.

**Dose-response:** Results of the meta-analyses of RCTs suggest an inverse dose-response relationship between the amount of moderate-to-vigorous physical activity performed and the magnitude of the reduction in risk of fall-related injuries and bone fractures, regardless of whether the intervention is home- or group-based. Multicomponent physical activity regimens that combine aerobic, strength, and balance training appear to be especially effective. The small number of studies and the diverse ways in which the amount of physical activity was operationalized limit confidence in making a strong statement about the shape of the dose-response of physical activity on risk of injuries from falls, however.

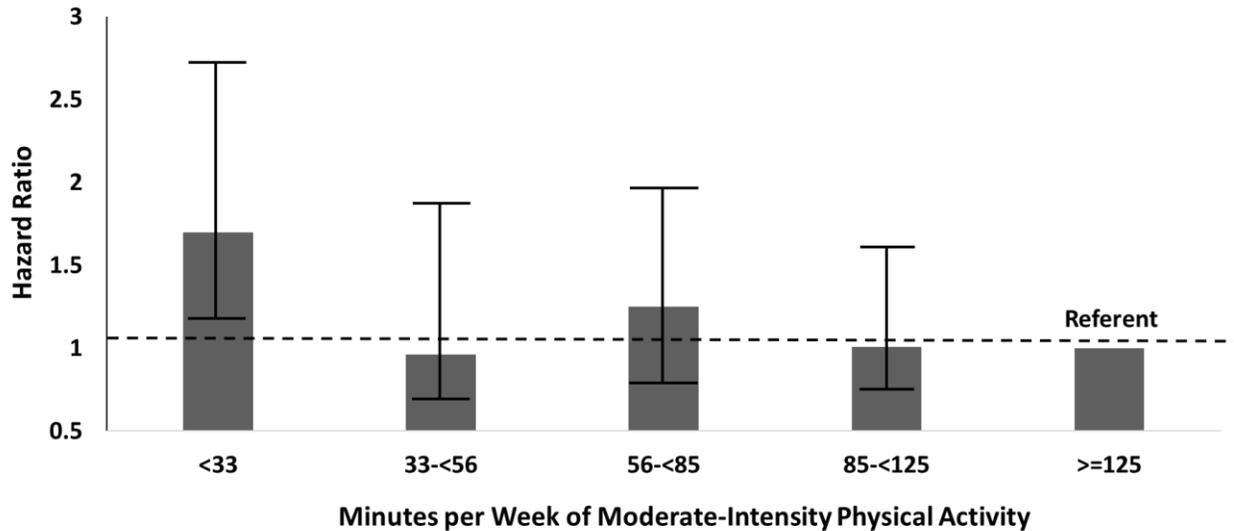
Consistent results from four high-quality epidemiologic studies (three cohort and one case-control) suggest that adults ages 65 years and older who participate in physical activity of at least moderate-intensity for 30 or more minutes per day<sup>9</sup> or for 25 or more metabolic equivalents per week,<sup>10</sup> reduce the risk of fall-related injury and bone fracture. Evidence also exists that even adults ages 85 years and older obtain similar benefits from 60 minutes or more per week of home- or group-based physical

activity.<sup>11</sup> However, it is important to note that lower amounts of moderate-intensity physical activity<sup>9, 10</sup> and walking<sup>11</sup> may not be sufficient to reduce the risk of fall-related injury and bone fracture in older age.

For example, [Heesch et al<sup>10</sup>](#) reported that among 8,188 healthy, Australian community-dwelling women (ages 70 to 75 years), self-reported high or very high levels of physical activity were associated with a 47 percent lower 6-year risk of self-reported bone fracture, compared with women who reported none or very low levels (referent group) (OR=0.53; 95% CI: 0.34-0.83). Those women reporting low (OR=0.84; 95% CI: 0.62-1.13) or moderate (OR=0.88; 95% CI: 0.66-1.19) levels of activity, however, did not significantly lower their risk of fracture. [Linattiniemi et al<sup>11</sup>](#) reported findings from 512 community-dwelling Finnish adults ages 85 years and older (the majority of whom were female). Respondents who reported participating in physical activities such as home exercise, gardening, cross-country skiing, dancing, swimming, bicycling, or group exercise for more than 60 minutes per week reduced their risk of sustaining a fall-related injury by 63 percent, compared with not performing any of these activities (OR=0.37; 95% CI: 0.19-0.72). Among this same sample, however, walking did not appear to affect the risk of injury from a fall. Indeed, those who reported walking fewer than 60 minutes per week (OR=0.87; 95% CI: 0.50-1.50), 60 to 140 minutes per week (OR=0.94; 95% CI: 0.56-1.58), and more than 140 minutes per week (OR=0.83; 0.46-1.48) experienced no significant reduction in risk of fall-related injury. In a case-control study of hip fracture among 387 Australian adults ages 65 years and older (126 cases: 261 controls), [Peel et al<sup>12</sup>](#) reported that playing sport in older age independently reduced the risk of hip fracture by 51 percent (adjusted OR=0.49; 95% CI: 0.29-0.83). Simply achieving “sufficient” versus “insufficient” levels of physical activity (based on minutes per week of walking and moderate and/or vigorous activity) did not reduce risk. Finally, [Cauley et al<sup>9</sup>](#) studied a cohort of men (N=2,731; mean age 79 years) over an average follow-up period of 3.5±0.9 years. They reported that men in the lowest quintile of daily active energy expenditure (less than 190 kilocalories per day) had a significantly higher risk of non-spine fracture compared with men in the highest quintile (greater than or equal to 775 kilocalories per day; referent group) (hazard ratio (HR)=1.82; 95% CI: 1.10-3.00). Those men in the lowest quintile of daily moderate-intensity activity (less than 33 minutes per day) experienced a 70 percent higher risk of fracture compared with those in the highest quintile (greater than or equal to 125 minutes per day; referent group) (HR=1.70; 95% CI: 1.03-2.80). Of note, is that quintiles 2 (33 to less than 56 minutes per day), 3 (56 to less than 85 minutes per day), and 4 (85 to less than 125 minutes per day) of moderate-intensity activity were not associated with an increased rate of fracture, compared

with quintile 5. A similar finding was observed for energy expenditure from moderate-intensity activity, suggesting that a minimal threshold of 33 minutes per day of moderate-intensity activity (or of 190 calories per day of active energy expenditure) was sufficient to negate the excess risk of fall-related fractures in these men (Figure F9-1).

**Figure F9-1. 3.5 Year Risk of Fracture in Older Men by Quintile of Moderate-Intensity Physical Activity: The Osteoporotic Fractures in Men Study (N=2,731)**



Source: Adapted from data found in Cauley et al., 2013.<sup>9</sup>

### *Evidence on Specific Factors*

**Demographic factors and weight status:** [Cauley et al<sup>9</sup>](#) reported that age (younger than 80 years versus 80 years and older) did not influence the relationship between higher levels of active energy expenditure or moderate-intensity physical activity and lower risk of fracture in a cohort of men ages 65 years and older. Consistent with this observation, the benefit of physical activity to reduce the risk of fall-related injury was similar among women ages 70 to 75 years<sup>10</sup> and adults ages 85 years and older.<sup>11</sup>

Although the majority of participants in the reviewed studies were female, the benefit of physical activity to reduce the risk of fall-related injuries appears consistent in cohorts of men<sup>9</sup> as well as women.<sup>10</sup> Of note, is the fact that none of the studies reviewed deliberately tested effect modification by sex. Moreover, among 512 Finnish home-dwelling adults, ages 85 years and older, female sex was one predictor of injurious falls, but its impact on the relationship between physical activity and fall-related injuries was not specifically assessed.<sup>11</sup>

Information on the race/ethnicity and socioeconomic status of participants was limited, inconsistently presented, and not statistically assessed. As a result, no conclusions about these relationships were possible.

Weight status did not significantly influence the relationship between physical activity and bone fracture risk among cohorts of women ages 70 to 75 years<sup>10</sup> or among men ages 65 years and older.<sup>9</sup>

**Type of physical activity:** The physical activity programs that effectively reduced the risk of fall-related injuries and bone fractures contained a variety of group- and home-based activities.<sup>5, 7, 8, 11, 12</sup> Most programs were multicomponent and included various combinations of moderate-intensity balance, strength, endurance, gait, and physical function training, as well as recreational activities (e.g., dancing, cycling, gardening, sports). Although the research is limited, it does not support the use of low-intensity walking as a primary mode of physical activity to reduce the risk of fall-related injuries and fractures among older adults,<sup>11, 12</sup> although walking may be included in multicomponent physical activity regimens. Unfortunately, insufficient information was available from the systematic reviews to determine the effects of individual elements (e.g., strength training, balance training) of the multicomponent training programs on the risk of fall-related injuries.

**Factors modifying the relationship:** The impact of physical activity on risk of fall-related injury in older age may be influenced by factors such as level of physical function or pre-existing gait disability. Unfortunately, the eight articles used as sources of evidence do not contain sufficient information to address this subquestion.

***For additional details on this body of evidence, visit: <https://health.gov/paguidelines/second-edition/report/supplementary-material.aspx> for the Evidence Portfolio.***

### **Comparing 2018 Findings with the 2008 Scientific Report**

The 2008 Scientific Report<sup>4</sup> presented compelling evidence that older adults may safely participate in physical activity programs to reduce their risk of falling. The evidence evaluated by the Subcommittee further emphasizes that multicomponent physical activity programs can reduce the risk of injuries and fractures due to a fall among older people. These 2018 findings expand upon those from 2008 in providing strong evidence of the magnitude of risk reduction in fall-related injuries (30 to 40 percent) and fractures (40 to 66 percent) resulting from these highly-feasible multicomponent programs.

## **Public Health Impact**

One in four individuals ages 65 years and older falls in the United States every year. Moreover, falls are the leading cause of fatal injury and the most common cause of nonfatal trauma-related hospital admissions among older adults. Physical activity programs that emphasize combinations of moderate-intensity balance, strength, endurance, gait, and physical function training appear most effective in reducing the risk of fall-related injuries and fractures in older adults. Thus, the effectiveness of these programs (performed in community settings or at home) for risk reduction has significant public health relevance in older age, due to the high prevalence of falls and fall-related injuries and fractures among older adults, as well as the consequent morbidity, disability and reduced quality of life.

### **Question 2. What is the relationship between physical activity and physical function among the general (i.e., non-institutionalized) aging population?**

- a) Is there a dose-response relationship? If yes, what is the shape of the relationship?
- b) Does the relationship vary by age, sex, race/ethnicity, socioeconomic status, or weight status?
- c) What type(s) of physical activity are effective for improving or maintaining physical function?
- d) What impairment(s) modify the relationship between physical activity and physical function among the general aging population?

**Sources of evidence:** Systematic reviews, meta-analyses, pooled analyses

#### **Conclusion Statements**

Strong evidence demonstrates that physical activity improves physical function and reduces risk of age-related loss of physical function in the general aging population. **PAGAC Grade: Strong.**

Strong evidence demonstrates an inverse dose-response relationship between volume of aerobic physical activity and risk of physical functional limitations in the general aging population. **PAGAC Grade: Strong.**

Limited evidence suggests an inverse dose-response relationship of volume of muscle-strengthening and frequency of balance training with risk of physical functional limitations in the general aging population. **PAGAC Grade: Limited.**

Limited evidence suggests that the relationship between physical activity and physical function does not vary by age, sex, or weight status in the general population of older adults. **PAGAC Grade: Limited.**

Insufficient evidence is available to determine whether the relationship between physical activity and physical function varies by race/ethnicity and socioeconomic status in the general population of older adults. **PAGAC Grade: Not assignable.**

Strong evidence demonstrates that aerobic, muscle-strengthening, and multicomponent physical activity improves physical function in the general aging population. **PAGAC Grade: Strong.**

Moderate evidence indicates that balance training improves physical function in the general aging population. **PAGAC Grade: Moderate.**

Limited evidence suggests that tai chi exercise, dance training, active video gaming, and dual-task training improve physical function in the general aging population. **PAGAC Grade: Limited.**

Insufficient evidence is available to determine the effects of flexibility activity, yoga, and qigong exercise on physical function in the general aging population. **PAGAC Grade: Not assignable.**

Limited evidence suggests that the effect of physical activity on physical function is relatively stronger in older adults with limitations in physical function compared to relatively healthy older adults. **PAGAC Grade: Limited.**

Insufficient evidence is available to determine whether visual impairments or cognitive impairments modify the relationship between physical activity and physical function among the general aging population. **PAGAC Grade: Not assignable.**

## **Review of the Evidence**

### **Introduction**

Age-related limitations in physical function are prevalent in older adults. The National Health Interview Survey ascertained the prevalence of physical limitations in 2001-2007, with limitations defined as great difficulty doing (or inability to do) basic tasks of life (e.g., walk a quarter of a mile, lift a 10-pound bag of groceries).<sup>13</sup> At that time, 22.9 percent of older adults ages 60 to 69 years reported limitations and 42.9 percent of adults ages 80 years and older reported limitations. The 2008 Scientific Report<sup>4</sup> addressed the extent that physical activity reduces risk of limitations in physical function, reasoning that “If physical activity prevents or delays disability, the majority of older Americans stand to benefit.” However, the 2008 strength of evidence rating of “moderate to strong” reflected the fact that evidence was incomplete in some respects, such as a lack of well-designed intervention trials and insufficient evidence for quantifying effects of physical activity.<sup>4</sup> Also, the conclusion did not explicitly address the effect of physical activity on physical function, but rather stated physical activity reduced risk of “function and/or role limitations.”<sup>4</sup> Thus, the Subcommittee deemed this report should determine the extent that additional research is now available on physical activity and physical function in older adults.

### Literature Reviewed

To address the relationship between physical activity and physical function among the general aging population, the Aging Subcommittee reviewed 17 systematic reviews,<sup>14-30</sup> 20 meta-analyses,<sup>31-50</sup> and 1 pooled analysis.<sup>51</sup> As described below, the reviews were sorted by the types of physical activity reviewed, and by whether they included or excluded studies of the effects of physical activity on physical function in study samples with a single, diagnosed chronic condition.

#### Reviews of RCTs of Aerobic, Muscle-Strengthening, Balance, and/or Multicomponent Physical Activity Programs, **Excluding** Studies Limited to Specific Chronic Conditions.

Three meta-analyses and one systematic review focused on healthy or community-dwelling older adults. Of the three meta-analyses, one included 23 RCTs,<sup>39</sup> one included 37 randomized and 5 non-randomized trials,<sup>36</sup> and one included 24 studies of which 13 were RCTs.<sup>43</sup> Total participants in these reviews ranged from 1,220 to 2,495. One systematic review included eight relevant trials.<sup>22</sup>

Three meta-analyses and two systematic reviews included studies in all older adults. Three meta-analyses included between 19 and 94 RCTs, though numbers of comparisons in individual analyses were commonly in the range of 5 to 15.<sup>33, 37, 49</sup> In the Cochrane meta-analyses of 133 separate analyses—many with a very small number of studies—the relevant analyses were deemed to be those reported in the abstract by the authors.<sup>37</sup> Some studies in two systematic reviews address effects of exercise on physical function.<sup>14, 15</sup>

#### Reviews of RCTs of Aerobic, Muscle-Strengthening, Balance, and/or Multicomponent Physical Activity Programs, **Including** Studies Limited to Specific Chronic Conditions

Three meta-analyses focused on community-dwelling older adults.<sup>31, 35, 38</sup> The total number of included studies ranged from 11 to 28, and total participants ranged from 617 to more than 2,500.

Three meta-analyses and four systematic reviews included studies in all older adults. Two meta-analyses reported the findings of the same review involving 33 RCTs in 2,172 older adults.<sup>41, 42</sup> One meta-analysis included studies in both older and younger adults, so it was regarded as a systematic review of 15 studies in older adults.<sup>34</sup> Some studies in four systematic reviews addressed effects of exercise on physical function.<sup>16, 17, 23, 28</sup>

### Other Reviews of Aerobic, Muscle-Strengthening, Balance, and/or Multicomponent Physical Activity Programs

One meta-analysis compared effects of progressive resistance training to power training.<sup>48</sup> Power training involves exercising against moderate resistance at maximum speed (“as fast as possible”), in the range of 33 to 60 percent of the maximum speed without resistance.<sup>48</sup> In contrast, conventional resistance training typically involves exercising against high resistance at relatively slow speeds. This meta-analysis included 11 trials involving 377 participants. Four reviews of cohort studies addressed the effect of physical activity on physical function: one meta-analysis of 9 studies involving 17,000 participants,<sup>46</sup> two broad systematic reviews that included some relevant studies,<sup>24, 29</sup> and one pooled analysis involving 357 participants.<sup>51</sup>

### Reviews of Controlled Trials of Tai Chi, Yoga, Qigong, and Flexibility Training

The Subcommittee identified three reviews of RCTs of tai chi, yoga, and/or qigong—one meta-analysis of tai chi,<sup>40</sup> one systematic review of tai chi or qigong,<sup>26</sup> and one meta-analysis of yoga.<sup>50</sup> The total number of included studies ranged from 13 to 36 RCTs. One systematic review of flexibility training included 22 studies in 1,127 participants.<sup>27</sup>

### Reviews of Dance, Video Games, and Dual-task Physical Activity Programs

The Subcommittee identified one systematic review of seven RCTs of dance interventions,<sup>18</sup> and one systematic review of 15 training studies and 3 cross-sectional studies of dancing.<sup>21</sup> Three meta-analyses of active video gaming<sup>32, 45, 47</sup> included between 16 and 18 studies.

Five reviews examined effects of dual-task training on physical function. One meta-analysis included 14 RCTs,<sup>44</sup> and four systematic reviews included some relevant studies.<sup>19, 20, 25, 30</sup>

### Lifestyle Interventions and Independence for Elders (LIFE) Study

The Aging Subcommittee was aware of a trial called “LIFE”, a large RCT of multicomponent exercise on a primary outcome of mobility disability.<sup>2</sup> The trial enrolled older adults with limitations in physical function, had a sample size of 1,635, with an exercise intervention lasting an average of 2.6 years. The trial found exercise significantly reduced risk of mobility disability, defined as inability to walk 400 meters (HR=0.82; 95% CI: 0.69-0.98). The Subcommittee was unable to locate this particular study in the above-cited reviews, so it was not included in the sources of evidence. However, the Subcommittee notes that, had this study been included as source of evidence, it would not change the conclusions of the chapter. In particular, the LIFE results were consistent with the Subcommittee’s rating of strong

evidence that physical activity has beneficial effects on physical function in older adults. LIFE reported a non-significant trend for stronger effects of exercise in adults with more limited function (HR=0.75; 95% CI: 0.60-0.94) compared to less limited (HR=0.95; 95% CI: 0.73-1.23), which does not contradict (and is consistent with) the Subcommittee's conclusion of limited evidence that effects are stronger in older adults with limitations in physical function than in healthy older adults. LIFE reported that effects of exercise did not differ by sex or age, which is consistent with the Subcommittee's finding of limited evidence that effects of physical activity do not differ by sex or age.

### *Evidence on the Overall Relationship*

The reviews of RCTs and cohort studies of aerobic, muscle-strengthening, balance, and/or multicomponent physical activity programs provided strong evidence that physical activity improves physical function and reduces risk of age-related loss of physical function in the general aging population. Significant effects of physical activity on physical function were reported by all meta-analyses whose results are summarized in Table F9-1, whether or not the meta-analyses (1) excluded studies limited to a specific chronic condition, (2) limited analyses to community dwelling or healthy adults, and (3) included only RCTs. The conclusions of systematic reviews also generally supported this conclusion.<sup>14-17, 22, 28</sup> In most cases, the measure of physical function was an "objective" or performance-based measure. Performance tests are classified by the task involved. For example, a common "gait" measure is speed of walking in meters per second measured over a short 3- or 4-meter course. A common "balance" measure is the ability to stand on one leg, with stance time measured in seconds. In the evidence description below, terminology is simplified. A statement that "physical activity improved balance" means "physical activity improved performance measures of physical function using balance tasks." However, some reviews included self-report measures of physical function, such as the 36-item Short Form Survey (SF-36) physical functioning scale, and ADL scales.

The Subcommittee regarded one meta-analysis<sup>31</sup> as a particularly relevant source of evidence. This review was recent (2017) and included only RCTs that reported objective, composite outcome measures of physical function, such as the Short Physical Performance Battery (SPPB). The review had a good quality score and included a large number (N=28) of RCTs focused on community-dwelling older adults. This meta-analysis reported an effect size (ES) of 0.45 (95% CI: 0.27-0.64).

The findings of the more relevant meta-analyses (which excluded studies limited to a specific chronic condition) supported the conclusion of strong evidence.<sup>33, 36, 37, 39, 43, 49</sup> These six meta-analyses analyzed

effects of physical activity according to type (muscle-strengthening, balance, multicomponent, any) and outcome measure (any objective measure, measures of gait speed, measures of balance, chair rise, Timed Up and Go, and ADL). Effect sizes (see Table F9-1) ranged from small (improvement of 1.6 seconds in eyes-closed one-leg stand time<sup>37</sup>) to large (ES=0.84 for resistance training on usual gait speed<sup>36</sup>).

Almost all analyses demonstrated a significant effect of a mode of physical activity on the above measures of physical function, though two analyses found a borderline significant effect and one analysis of ADL measures found a non-significant effect. A meta-analysis of balance training classified measures of balance into five categories (static and dynamic steady state; proactive and reactive balance; and performance on standard test batteries [e.g., Berg Balance Scale]), with significant effects of balance training found for all five categories.<sup>39</sup> However, the most public health relevant balance measure reported was the effect of balance training on composite performance measure of balance—the Berg Balance scale—and only the effect of training on the Berg Balance Scale are included in the table. Other categories of measures of balance generally included some physiologic measures of balance, such as force plate measures of postural sway.

**Table F9-1. Effects of Physical Activity from Meta-Analyses of RCTs of Aerobic, Muscle-Strengthening, Balance, and/or Multicomponent Physical Activity Programs**

Measure of Physical Function	Muscle-strengthening	Balance
	Effect; (confidence interval), test	Effect; (confidence interval), test
Combined Analyses		
Gait speed	ES=0.84; (95% CI: 0.52-1.16) <sup>36</sup> R=0.15; (95% CI: 0.03-0.26) <sup>43</sup> MD=0.13 m/s; (95% CI: 0.09–0.16) <sup>49</sup> SMD=0.25 m/s; (95% CI: 0.05-0.46) <sup>37</sup>	MD=0.07 m/s; (95% CI: 0.03-0.10) <sup>49</sup> #
Balance	MD=1.64 s; (95% CI: 0.97-2.13) OLSC <sup>37</sup>	SMD=1.52; (95% CI: 0.65-2.39), BBS <sup>39</sup>
Chair rise		
Timed Up and Go	MD=-4.30 s; (95% CI: -7.60 to -1.00) <sup>37</sup>	
Activities of Daily Living Scale		

Measure of Physical Function	Multicomponent	Any
	Effect; (confidence interval), test	Effect; (confidence interval), test
Combined Analyses		ES=0.37; (95% CI: 0.22- 0.52) <sup>33</sup>
Gait speed	ES=0.86; (95% CI: 0.50-1.23) <sup>36</sup> R=0.18; (95% CI: 0.12-0.24) <sup>43</sup> MD=0.05 m/s; (95% CI: 0.00-0.09) <sup>49</sup> *	ES=0.84; (95% CI: 0.61-1.06) <sup>36</sup> R=0.17; (95% CI: 0.11-0.22) <sup>43</sup> ES=0.26; (95% CI: 0.11-0.41) <sup>33</sup>
Balance	MD=5.03 s; (95% CI: 1.19-8.87), OLSO <sup>37</sup> MD=1.60 s; (95% CI: -0.01-3.20), OLSC <sup>37</sup> * MD=1.84; (95% CI: 0.71-2.97), BBS <sup>37</sup>	ES=0.27; (95% CI: 0.11-0.42) <sup>33</sup>
Chair rise		ES=0.30; (95% CI: 0.04-0.57) <sup>33</sup>
Timed Up and Go	MD=-1.63 s; (95% CI: 95% CI: -2.28 to -0.98) <sup>37</sup>	
Activities of Daily Living Scale		ES=0.05; (95% CI: -1.25-0.22) <sup>33</sup> ns

Legend: CI=confidence interval, ES=effect size, MD=mean difference, m/s=meters per second, s=seconds, SMD=standardized mean difference, R=Pearson correlation coefficient, BBS=Berg Balance Scale, OLSO=one leg stand eyes open, and OLSC=one leg stand eyes closed.

Note: Meta-analyses in this table excluded studies limited to specific chronic conditions. Reported measures of effect and confidence intervals may be rounded to two significant digits. Four meta-analyses included only RCTs.<sup>33, 37, 39, 49</sup> One meta-analysis included both randomized and non-randomized controlled trials<sup>36</sup> and one meta-analysis included randomized trials, non-randomized trials, and single arm trials.<sup>43</sup> Positive effects indicate improvement due to physical activity, except for the Timed Up and Go (where lower scores indicate better function).

\*=borderline significant effect, where one side of the 95% CI was either 0<sup>43</sup> or -0.01.<sup>37</sup> All other effects are statistically significant unless marked “ns”=non-significant. #=an analysis of dance-like movements was classified as balance training. Muscle strengthening was generally resistance training, but could include studies of power training (e.g., in [Howe et al<sup>37</sup>](#)). No meta-analysis analyzed effects of aerobic training only. Combined analyses included resistance, balance, and endurance training<sup>49</sup>; “multiple exercise types”<sup>37</sup>; and “multi-modal training.”<sup>36</sup> Analyses of “Any” training generally included trials of single activity types and multicomponent training.

The Subcommittee also reviewed findings of the other meta-analyses (which included studies limited to a specific chronic condition) to assess whether their findings were similar. The findings in these reviews also supported the conclusion of strong evidence and included the review by [Chase et al<sup>31</sup>](#) discussed above.<sup>31, 35, 38, 41, 42</sup> The reported effects of physical activity on performance measures were comparable to those in Table F9-1 in analyses including more than two or three comparisons. For example, an analysis of four trials of home-based fall prevention programs reported a significant effect of multicomponent physical activity on the balance measure of functional reach (MD=1.6 cm; 95% CI: 0.37-

2.76).<sup>35</sup> A meta-analysis of 33 RCTs of progressive resistance training reported significant effects on: (1) self-reported physical function or disability measured by a variety of instruments (standardized mean difference (SMD)=0.14; 95% CI: 0.05-0.22), (2) walking ability as measured by gait speed (SMD=0.08 meters per second; 95% CI: 0.04-0.12) (though not when measured by timed walks), (3) Timed Up and Go (SMD= -0.69 seconds; 95% CI: -1.11 to -0.27), and (4) timed chair rise (SMD=0.94; 95% CI: -1.49 to -0.38).<sup>41, 42</sup> Although one meta-analysis of any physical intervention reported a significant effect of physical activity on the SF-36 physical functioning scale (Hedges's  $g$ =0.41; 95% CI: 0.19-0.64),<sup>38</sup> a meta-analysis of only muscle-strengthening training found no effect.<sup>42</sup>

The Subcommittee noted that no meta-analysis provided an estimate of the effect of aerobic activity on physical function. However, in one systematic review of 53 RCTs of aerobic training,<sup>16</sup> 7 trials assessed effects of training on physical function. Of these, six reported at least one significant effect. Notably, all 53 studies prescribed aerobic training using relative intensity.

The Subcommittee also noted that one meta-analysis reported a non-significant effect of any activity on ADL score.<sup>33</sup> However, a systematic review prepared for Canada's physical activity guidelines reviewed cohort studies of aerobic activity in older adults.<sup>24</sup> This review concluded that aerobic activity can reduce risk of functional limitations, including ADL dependency, by as much as 50 percent. This finding was supported by a meta-analysis of cohort studies with physical activity measures that focused on aerobic activity.<sup>46</sup> This review reported low versus moderate-to-high amounts of physical activity have a large and significant reduction in risk of ADL dependency (odds ratio (OR)=0.51; 95% CI: 0.38-0.68).

**Dose-response:** A review of 24 comparisons from prospective cohort studies with covariate adjustment provided strong evidence of an inverse dose-response relationship between aerobic activity and risk of functional limitations.<sup>24</sup> This review classified dose of aerobic activity reported in cohort studies into four ordinal categories, ranging from 1=low level of activity to 4=vigorous activities and/or high activity volume. With this analysis framework, virtually every study showed an inverse dose-response relationship of aerobic activity with risk of limitations in physical function.

A meta-analysis of 23 studies of balance training provided limited evidence of a dose-response relationship between dose of balance training and physical function.<sup>39</sup> This review classified measures of balance into five categories (static and dynamic steady state; proactive and reactive balance; and performance on standard test batteries [e.g., Berg Balance Scale]), but dose-response data were provided for only one category (static steady state balance). When the dose of balance training was

measured as number of sessions per week (1 versus 2 versus 3), the number of sessions was associated with amount of improvement in balance in a dose-response manner.

Limited evidence also suggested a dose-response relationship with muscle-strengthening training. One meta-analysis reported the number of repetitions of resistance training was significantly ( $P < 0.01$ ) and positively related to the effect of the training on composite objective measures of physical function, with a trend of more improvement in function with more sets of resistance training ( $P = 0.09$ ).<sup>31</sup> However, the review did not further describe or quantify the dose-response relationship.

### *Evidence on Specific Factors*

**Age, sex, weight status:** Limited evidence suggests that the relationship between physical activity and physical function does not vary by age, sex, or weight status in the general population of older adults. One meta-analysis reported sex and body mass index (BMI) were not significant effect modifiers of the relationship of physical activity on composite physical function scores.<sup>31</sup> A meta-analysis of cohort studies reported the relationship between aerobic activity and ADL dependency did not differ significantly by age (75 years and younger versus older than 75 years).<sup>46</sup>

**Race/ethnicity, socioeconomic status:** The available evidence was insufficient to determine whether the relationship between physical activity and physical function varies by race/ethnicity and socioeconomic status in the general population of older adults. No relevant analyses were located in the sources of evidence.

### Types of Activity

**Aerobic, muscle-strengthening, and multicomponent physical activity:** Strong evidence demonstrates that aerobic, muscle-strengthening, and multicomponent physical activity improves physical function in the general aging population. The evidence for this finding was discussed above. In addition, the Subcommittee reviewed one meta-analysis of seven RCTs comparing two types of muscle-strengthening physical activity—power training and resistance training.<sup>48</sup> The meta-analysis reported a small advantage of power training over resistance training in improving physical function in older adults. These results illustrate that conventional resistance training is not the only type of muscle-strengthening activity that improves physical function in older adults.

**Tai chi:** Limited evidence suggests that tai chi improves physical function. A systematic review reported that 11 of 12 relevant RCTs found tai chi improved at least one measure of physical function (relevant

trials included a general sample of older adults and a no-exercise control group).<sup>26</sup> However, this review did not report quality scores. One meta-analysis assessed the effects of tai chi on a single physical function outcome—one leg stand time—and reported a non-significant effect.<sup>40</sup> No analyses were located that addressed how types, forms, and dose of tai chi influence its effects on physical function.

**Yoga:** Insufficient evidence was available to determine the effects of yoga on physical function. The one review of yoga included only three relevant studies (general sample of older adults and a no-exercise control group).<sup>50</sup> Data in the review showed that only 1 of the 3 studies reported a significant effect on balance-related physical function, and one of two studies reported a significant effect on mobility.

**Qigong:** Insufficient evidence was available to determine the effects of qigong on physical function. In the review that included studies of qigong, only one of the qigong studies was relevant (general sample of older adults, no-exercise control group, and physical function outcome).<sup>26</sup>

**Flexibility:** Insufficient evidence was available to determine the effect of flexibility training on physical function. A systematic review of 22 studies concluded the information regarding the relationship between functional outcomes with flexibility interventions was conflicting.<sup>27</sup> A meta-analysis of three studies of flexibility training found a non-significant effect of flexibility training on gait speed.<sup>49</sup>

**Dancing:** Limited evidence suggests dance interventions improve physical function. One review reported that dancing had positive effects on gait in five of five trials and positive effects on balance in six of six trials.<sup>18</sup> Another reviewed reported that dancing improved either balance and/or gait in 8 of 13 trials.<sup>21</sup> However, both reviews expressed concerns about how to interpret the evidence, given the diversity of dance forms studied, the diversity of outcome measures, and the small sample size of many studies. No analyses were located that addressed how the types of dance and dose influence the effects of dancing on physical function.

**Active Video Gaming:** Limited evidence suggests active video gaming interventions improve physical function. The meta-analysis with the largest number of trials reported significant effects of active video gaming on balance (SMD=0.77; 95% CI: 0.45-1.09; 16 comparisons) and functional mobility (SMD=0.56; 95% CI: 0.25-0.78; 17 comparisons).<sup>32</sup> However, the sample sizes of the trials were small, with only one trial enrolling more than 20 older adults in the intervention group. These findings were not consistently confirmed by two smaller meta-analyses: one reported a small significant effect on Berg Balance scores (MD=0.73; 95% CI: 0.17-1.29; three comparisons) and no significant effect on Timed Up and Go (six

comparisons).<sup>47</sup> The other reported a non-significant effect on Timed Up and Go (three comparisons).<sup>45</sup> One review reported that video game activity was supervised in 17 of 18 trials,<sup>47</sup> indicating the evidence is incomplete that older adults can improve physical function by self-supervised active video gaming.

**Dual-task Training:** Limited evidence suggests dual-task training improves physical function. As mentioned previously, dual-task interventions combine a physical activity intervention with a cognitive intervention. For example, a dual-task verbal fluency intervention could involve naming words beginning with a particular letter during a walking activity. One meta-analysis of 14 RCTs reported a significant improvement in gait speed under dual-task conditions, with overall mean difference (MD)=0.11 meters per second (95% CI: 0.07-0.15).<sup>44</sup> Significant effects were reported for the subgroup of trials with verbal fluency dual-task condition (MD=0.09 meters per second; 95% CI: 0.05-0.14) and arithmetic dual-task condition (MD=0.11 meters per second; 95% CI: 0.06-0.16). However, most trials were small and trials varied in definition and types of dual-task training, types of physical activity, and quality. Information provided by systematic reviews was consistent with the finding of limited evidence.<sup>19, 20, 25, 30</sup>

### Modification of Effects by Impairments

**Physical impairments:** Limited evidence suggests that physical activity has a stronger effect on physical function in older adults with limitations in physical function, compared with relatively healthy older adults. One meta-analysis compared the effect size in non-frail adults (ES=0.35; 95% CI: 0.17-0.54) to that in frail adults (ES=1.09; 95% CI: 0.55-1.64) and found the effect size was significantly larger in frail adults ( $P<0.05$ ).<sup>31</sup> The strong effects of physical activity on physical function in frail adults (Question 3 below) are consistent with this finding.

**Visual or cognitive impairments:** The available evidence was insufficient to determine whether visual impairments or cognitive impairments modify the relationship between physical activity and physical function among the general aging population. No relevant analyses were located in the sources of evidence.

***For additional details on this body of evidence, visit: <https://health.gov/paguidelines/second-edition/report/supplementary-material.aspx> for the Evidence Portfolio.***

### **Comparing 2018 Findings with the 2008 Scientific Report**

As noted above, the 2008 Scientific Report<sup>4</sup> found consistent observational evidence that physical activity reduces risk of limitations in physical function, but only limited evidence from RCTs and meta-analyses. The evidence grade was “moderate to strong.” The 2008 Committee found “moderate”

evidence that aerobic and muscle-strengthening activities were effective, particularly walking.<sup>4</sup> They also found “moderate” evidence of an inverse dose-response relationship between physical activity and risk of physical functional limitations, and limited evidence on the optimal pattern of tai chi that reduces risk of falls but no evidence rating for effects of tai chi on physical function.<sup>4</sup>

The 2018 Scientific Report provides more complete information about the relationship of physical activity and physical function. Evidence from RCTs now provides strong evidence that muscle-strengthening activities and multicomponent physical activity programs improve physical function, and provides moderate evidence that balance activities improve physical function. Hence, even though evidence is limited regarding the minimal dose of balance training (by itself) required to improve physical function, the findings indicate it is appropriate for *all* older adults to engage in multicomponent activity programs that include aerobic activity, muscle-strengthening activity, and activities that improve or maintain balance. In the 2008 Scientific Report,<sup>4</sup> this finding applied only to older adults at increased risk of falls.

Cohort studies provide strong evidence that regular aerobic activity reduces risk of functional limitations, with high levels of aerobic activity associated with approximately a 50 percent reduction in risk of major limitations. In addition, limited information now suggests a dose-response relationship for balance activities and muscle-strengthening activities, with improvement in physical function. Limited evidence now suggests as well that tai chi, dual-task training, active video gaming, and dancing have beneficial effects on physical function. Consistent with the findings of the 2008 Scientific Report,<sup>4</sup> the 2018 evidence review found insufficient evidence that flexibility activity by itself provides beneficial effects on physical function.

The 2008 Scientific Report stated, “Relative intensity is important to consider, as fitness levels are very low in many older adults.”<sup>4</sup> A finding in this evidence review is consistent with this statement, as a review of 53 clinical trials of aerobic training reported that all trials used relative intensity to prescribe aerobic training.

### **Public Health Impact**

The finding that physical activity improves physical function and reduces risk of age-related loss of physical function in the general aging population is of major public health importance. It is well known that the percent of older adults in the U.S. population is growing steadily, and by 2050 more than 20 percent of the population will be age 65 years or older. Older adults with lower levels of physical

function generally have higher health care expenditures. Older adults strongly prefer to have levels of physical function sufficient to live in community settings, rather than reside in long-term care facilities.

In particular, the finding of moderate evidence that balance activities improve physical function has public health importance. As noted above, this finding indicates it is appropriate for all older adults to engage in multicomponent training that includes balance training as a component.

The absolute size of effects may belie their public health importance. For example, it may appear that a 0.12 meters per second improvement in gait speed with muscle-strengthening training is a small effect,<sup>49</sup> but in older adults, gait speed is strongly related to mortality risk. Predicted 10-year survival at age 75 years varies across the observed range of gait speeds, from 19 percent to 87 percent in men and from 35 percent to 91 percent in women, with significant increments per 0.1 meters per second.<sup>52</sup>

Notably, several findings with “limited” evidence also have high public health importance. It would be concerning if physical activity had smaller beneficial effects in those older adults who have the most need of improvements in physical function. Adults age 75 years and older have more age-related loss of physical function, are more likely to be women, and the majority have a BMI in the range of overweight-to-obese. Limited evidence suggests that these characteristics do not influence the effect of physical activity on function. Further, the effect of physical activity on physical function is of high importance to frail adults. It is reassuring that existing evidence suggests effects of physical activity are *greater* in frail older adults compared to non-frail adults.

### **Question 3. What is the relationship between physical activity and physical function in older adults with selected chronic conditions?**

Question 3 builds upon the previous question by addressing the relationship between physical activity and physical function in discreet populations of older people having selected chronic conditions. The chronic conditions were selected based on their prevalence in older age, as well as on the availability of published research linking physical activity to physical function within each condition. The selected chronic conditions are: 1) cardiovascular disease; 2) chronic obstructive pulmonary disease (COPD); 3) cognitive impairment (e.g., Alzheimer’s disease); 4) frailty; 5) hip fracture; 6) osteoporosis and osteopenia; 7) Parkinson’s disease; 8) stroke; and 9) visual impairment.

## Conclusion Statements

Limited evidence suggests that physical activities such as muscle-strengthening, tai chi, and qigong improve physical function among older people with **cardiovascular disease**. **PAGAC Grade: Limited.**

Limited evidence suggests that tai chi and qigong exercise improves one aspect of physical function (walking ability) in individuals with **chronic obstructive pulmonary disease**. **PAGAC Grade: Limited.**

Limited evidence suggests that for individuals with **cognitive impairment**, physical activity programs improve physical function, including measures of activities of daily living. **PAGAC Grade: Limited.**

Strong evidence demonstrates that physical activity improves measures of physical function in older people with **frailty**. **PAGAC Grade: Strong.**

Moderate evidence indicates that for community-dwelling older adults who sustain a **hip fracture**, extended exercise programs (which begin after formal hip fracture rehabilitation ends) are effective for improving physical function. **PAGAC Grade: Moderate.**

Limited evidence suggests that muscle-strengthening and agility (balance) activities performed on two or more days per week improves physical function in older people who are at risk of fragility fractures due to **osteoporosis or osteopenia**. **PAGAC Grade: Limited.**

Strong evidence demonstrates that physical activity improves a number of physical function outcomes, including walking, balance, strength, and disease-specific motor scores in individuals with **Parkinson's disease**. **PAGAC Grade: Strong.**

Moderate evidence indicates that that mobility-oriented physical activity improves walking function for individuals after a **stroke**. **PAGAC Grade: Moderate.**

Insufficient evidence is available to determine the effects of physical activity on older adults with **visual impairments**. **PAGAC Grade: Not assignable.**

## Review of the Evidence

### Cardiovascular Disease

**Sources of evidence:** Systematic review, meta-analyses

The Subcommittee based its conclusion on evidence published in 2016. This evidence came from one existing systematic review<sup>53</sup> and three existing meta-analyses.<sup>54-56</sup> Participants included men and women

ages 65 years and older with existing cardiovascular disease (CVD) (ischemic heart disease, coronary artery disease, cerebrovascular disease, or heart failure) from both community and hospital settings. The exposure of interest was all types and intensities of physical activity and the outcomes of interest were performance-based indices of physical function (e.g., 6-minute walk test), Timed Up and Go, and household and physical activity mobility).

### *Evidence on the Overall Relationship*

Based on a meta-analysis of 6 RCTs involving 374 CVD patients, [Wang et al<sup>55</sup>](#) reported improvements in the 6-minute walk test among those patients performing alternative and complementary exercises compared with those performing aerobic activity or no activity over 12 weeks (SMD=59.6 meters; 95% CI: 5.0-114.2 meters). Results from a meta-analysis of 3 RCTs among 106 heart failure patients indicated that those performing one hour of tai chi 2 to 3 times per week over 12 weeks also increased their 6-minute walking distance compared with those in usual care or performing aerobic or endurance activity (SMD=1.58; 95% CI: 0.70-2.45).<sup>54</sup> [Yamamoto et al<sup>56</sup>](#) performed a meta-analysis of 7 RCTs comparing the effects of muscle-strengthening to usual care or combined muscle-strengthening or aerobic training to aerobic training alone on mobility score in 118 people with CVD who were ages 65 years and older. Those people performing muscle-strengthening activities improved their mobility score compared with those in usual care (SMD=0.61; 95% CI: 0.21-1.01). Because of the small number of systematic reviews and meta-analyses for tai chi or qigong activities, aerobic activities, and muscle-strengthening activities, as well as the limited number of physical function outcomes addressed in these reviews, the Subcommittee rated the evidence as limited.

### Chronic Obstructive Pulmonary Disease

#### **Sources of evidence:** Meta-analyses

The 2018 systematic search process located five potentially eligible reviews of the effects of physical activity on physical function in older adults with COPD.<sup>57-61</sup> Only 3 of these reviews,<sup>58, 59, 61</sup> however, met the eligibility criteria of: 1) enrolling older adults ages 50 years or older, 2) having intervention studies with a no-exercise control group, and 3) using physical activity interventions that were not part of a formal COPD medical rehabilitation program. The search located two meta-analyses of the effects of tai chi in people with COPD. Upon reviewing the studies in both of these reviews, it was determined that the more recent review<sup>59</sup> was a well-done review in the Cochrane Library and also contained all the tai chi studies in the less recent review by [Wu et al,<sup>61</sup>](#) as well as four additional studies. Therefore, the

review by [Wu et al<sup>61</sup>](#) was not used as source of evidence, leaving only the systematic reviews and meta-analyses by [Ding et al<sup>58</sup>](#) and by [Ngai et al.<sup>59</sup>](#) One review<sup>59</sup> included 12 RCTs of tai chi and the other<sup>58</sup> included 7 RCTs of qigong (which were not included in [Ngai et al<sup>59</sup>](#)) and 3 RCTs of tai chi or of tai chi or qigong (which were included in the [Ngai et al<sup>59</sup>](#) review). Thus, there was little overlap in these reviews. The search found no studies of the effects of aerobic, resistance, or a combination of aerobic and resistance activity on physical function in older adults with COPD.

To answer this question, the Subcommittee examined the relationship between physical activity and physical function in older people with COPD.<sup>58, 59</sup> Samples sizes of individual studies ranged from 10 to 206 participants and total participants ranged from 718 to 811 (N=811 overall), and the mean age in studies ranged from 54 to 74 years. The included studies enrolled both men and women living in the community and the duration of the physical activity programs was between 6 weeks and 1 year. The exposure of interest was either tai chi (with a diversity in the tai chi styles and forms included in the interventions), qigong, or a combination of tai chi and qigong. Outcomes of interest were measures of physical performance, but the meta-analyses report findings only for the 6-minute walk test.

### *Evidence on the Overall Relationship*

One meta-analysis involving 6 RCTs (N=318 participants) that compared tai chi to usual care reported improvements in the 6-minute walk test (MD=29.64 meters; 95% CI: 10.5-48.77) in favor of the tai chi group.<sup>59</sup> The other meta-analysis<sup>58</sup> involved 5 RCTs (N=349 participants) and also reported improvements in 6-minute walk test (MD=41.77 meters; 95% CI: 10.2-73.4) in the qigong and tai chi groups compared with the controls. Importantly, heterogeneity was high in both of the meta-analyses ( $I^2=59\%$ <sup>59</sup> and  $85\%$ <sup>58</sup>), and the quality of the studies included were of low or very low methodologic quality.

In sum, consistent, but limited, evidence from two meta-analyses of a modest number of generally low-quality RCTs suggests tai chi and qigong may improve walking ability (as measured by the 6-minute walk test) in older adults with COPD.

### Cognitive Impairment

**Sources of evidence:** Systematic reviews, meta-analyses

The Subcommittee based its conclusions on evidence published between 2010 and 2017, which included seven systematic reviews<sup>19, 62-68</sup> and seven meta-analyses.<sup>69-74</sup> The number of RCTs included in these

reviews were as few as 5<sup>69</sup> and were as many as 18.<sup>70</sup> Most reviews included approximately 10 RCTs.<sup>62, 67, 73</sup> Those reviews assessing changes in ADL function tended to have fewer studies (approximately 6 RCTs) with poorer methodological quality. The studies reviewed included adults that were institutionalized or community dwelling<sup>68, 74</sup> and most included all forms of diagnosed dementia, such as Alzheimer's disease, fronto-temporal dementia, or Lewy Body dementia. The exposure of interest was all types and intensities of physical activity, and the outcomes of interest were measures of physical function, such as performance-based measures (6-minute walk test, Timed Up and Go, balance) or measures of ADL.

### *Evidence on the Overall Relationship*

Approximately 20 to 30 percent of adults older than age 65 years suffer from either mild cognitive impairment or dementia. Changes in physical function often co-occur with cognitive losses, which can then accelerate the risk of disability and need for caregiving. The scientific literature indicates that physical activity training is capable of improving some measures of physical function in individuals with cognitive impairment. (For more details, see *Part F. Chapter 3. Brain Health.*) The physical function measures that showed the most consistent improvements with physical activity training include Timed Up and Go, walking speed, and Berg balance measures.<sup>73</sup> Improvements in ADL scales are also reported across several reviews.<sup>66, 70-72</sup> In fact, a meta-analysis of six high-quality RCTs,<sup>74</sup> indicates that physical activity training improves ADL function (effect size [ES]=0.80), as well as measures of physical function (ES=0.53). More recent analyses by [Forbes and Blake<sup>70</sup>](#) and [Lewis et al<sup>72</sup>](#) also report moderate to strong improvements in ADL function (ES=0.68 and 0.77, respectively). Moreover, one high-quality study reported that physical activity training can delay the deterioration of ADL performance.<sup>69</sup>

The reviews uniformly included interventions that were multicomponent and incorporated aerobic and muscle-strengthening training as well as balance, stretching, and endurance training.<sup>62, 63, 66, 68, 70, 71, 74</sup> The physical activity interventions generally ranged from 3 weeks to 12 months in duration with frequencies of 2 to 7 times per week,<sup>62, 67, 74</sup> with the length of sessions ranging from 20 minutes to 75 minutes. The intensity levels were reported as light-to-moderate but were generally not quantified or measured in many studies. Most interventions were conducted either as “community-based” or took place in senior home or nursing home facilities.

Importantly, attrition was higher in studies that included individuals with more severe cognitive impairment, thereby limiting confidence in the effects of physical activity on measures of physical function in this more severely impaired population.<sup>69, 71</sup> Few studies performed intent-to-treat analyses,

and most had inadequate blinding procedures, and a poor description of the physical activity training procedures. Given the small number of well-conducted studies and the low level of precision within them, the Subcommittee graded the evidence as limited.

### Frailty

**Sources of evidence:** Systematic reviews, meta-analyses

The Subcommittee based its conclusions on evidence published between 2008 and 2016. This evidence came from 15 existing systematic reviews of RCTs.<sup>75-89</sup> Only 3 of the 15 papers also included meta-analyses.<sup>78, 83, 84</sup> Most participants included in these studies were individuals ages 65 years and older and all met at least one established criterion for frailty. The majority of the participants were community-dwelling. The exposure of interest was all types and intensities of physical activity, and the outcomes of interest were measures of physical function, such as performance-based measures (6-minute walk test, Timed Up and Go, 30-second chair stands, gait, balance, strength) or self-reported measures of ADL or quality of life (QoL).

### *Evidence on the Overall Relationship*

All of the 15 systematic reviews or meta-analyses reported that physical activity improved some or all measures of physical function in older people with frailty.<sup>75-89</sup>

A recent meta-analysis<sup>84</sup> of 19 RCTs among community-dwelling older adults with frailty reported improvements in normal gait speed (MD=0.07 meters per second; 95% CI: 0.04-0.09) and in fast gait speed (MD=0.08 meters per second; 95% CI: 0.02-0.14) among physical activity groups, compared with control groups. Overall, physical activity decreased the time needed to walk 10 meters by 1.73 seconds, which has important clinical relevance for older people with frailty. In addition, scores on the Short Physical Performance Battery also improved with physical activity (MD=2.18; 95% CI: 1.56-2.80).

A meta-analysis of 8 RCTs involving 1,068 frail older people between the ages of 75 and 87 years (mostly women) reported that compared with a non-physical activity control group, the physical activity groups increased their gait speed by 0.07 meters per second (95% CI: 0.02-0.11).<sup>78</sup> The groups also differed in their Borg Balance Scale score (weighted mean difference (WMD)=1.69; 95% CI: 0.56-2.82)) and in the ADL performance score (WMD=5.33; 95% CI: 1.01-9.64) in favor of the physical activity groups. The physical activity programs associated with these improvements generally were between 60 and 90 min per session and repeated daily for about 3 to 12 months.

Seven of 10 studies in a systematic review by [Cadore et al](#)<sup>76</sup> reported a lower incidence of falls among frail older people (ages 70 to 90 years) in physical activity (multicomponent, muscle-strengthening training, combined endurance and yoga, or tai chi) groups, compared with those in control groups, with a reduction ranging from 22 percent to 58 percent. Moreover, 6 of 11 studies in this review reported improvements in gait speed (4 percent to 50 percent); 8 of 10 studies reported improvements in balance (5 percent to 80 percent); and 9 of 13 studies reported improvements in strength (6 percent to 60 percent).

Multicomponent physical activity training comprising aerobic, progressive muscle-strengthening, balance, and functional training appears more effective than single-component training to improve physical function among older people with frailty.<sup>76, 81, 85, 86, 89</sup> After reviewing 47 RCTs, [Theou et al](#)<sup>86</sup> concluded that multicomponent training of at least moderate intensity that is performed 3 or more times per week for a duration of 30 to 45 min per session, over at least 3 to 5 months appeared most effective to increase functional ability in older people with frailty. In general, greater improvements were observed with greater intensity of activity (particularly with progressive muscle-strengthening training),<sup>83, 87</sup> greater frequency per week, longer training durations, and greater adherence. Insufficient evidence is available to determine whether a dose-response relationship exists between physical activity and physical function in people with frailty, as only one of the systematic reviews assessed dose-response. It is important to note that only 2 of the 18 systematic reviews or meta-analyses considered adverse events from the exercise training protocols,<sup>84, 87</sup> and neither of these reviews reported any.

Given the robust and consistent literature linking physical activity to improvements in physical function in older people with frailty, the Subcommittee graded the evidence as strong. The majority of subjects in the reviewed studies were women, however, and no information was provided on race, socioeconomic status, or weight status. One observational study in the review by [Vermeulen et al](#)<sup>88</sup> reported a 2-fold higher risk of ADL disability in women (OR=8.5; 95% CI: 2.0-36.2), compared with men (OR=4.3; 95% CI: 1.1-17.1) due to low physical activity. Therefore, insufficient evidence is available to determine whether the relationship between physical activity and physical function among people with frailty varies by age, sex, race/ethnicity, socioeconomic status, or weight status.

### After Hip Fracture

**Sources of evidence:** Meta-analyses

The Subcommittee identified two meta-analyses of RCTs. Studies were eligible if the exposure or intervention in the study was physical activity or exercise. Studies of formal rehabilitation programs were not eligible to be included. One of the meta-analyses<sup>90</sup> included only “extended exercise programs,” defined as programs that are “offered after or extended for more than a regular rehabilitation period.” This meta-analysis included 11 RCTs (N=1,012 people) of physical activity judged to be of “good” or “excellent” quality and excluded RCTs of formal rehabilitation programs and with Physiotherapy Evidence Database (PEDro) quality scores of 4 or less. The other meta-analysis<sup>91, 92</sup> included a total of 13 RCTs regarded by the authors as “structured exercise programs” whose purpose was to improve mobility. To be conservative, only 8 of 13 RCTs in this [Diong et al<sup>91, 92</sup>](#) paper (N=232 people) were eligible for the meta-analysis. The majority of hip fracture patients in these studies lived in the community at the time of fracture as well as after discharge from usual care rehabilitation programs. The main types of physical activity in the trials were aerobic activity (only) typically involving weight-bearing activities such as walking, muscle-strengthening activity (only), and multicomponent programs involving some combination of aerobic activity, muscle-strengthening activity, balance training, functional training, and gait training. The outcomes of interest were measures of physical function, such as performance-based measures of gait, balance, strength, and ADL function or self-reported mobility.

### *Evidence on the Overall Relationship*

The analyses contributing to this evidence summary are listed in Table F9-2 below. For the 13 analyses in the table, significant effects of physical activity on physical function were reported for 9 analyses (in bold). Effect sizes (ES) ranged considerably, with one ES (for Timed Up and Go) typically regarded as “large” as it exceeded 0.8. The other four analyses showed non-significant trends, but nonetheless favored the physical activity group over the control group.

**Table F9-2. Effect Sizes for the Relationship Between Physical Activity and Physical Function in Older Adults After Hip Fracture**

	Auais et al., 2012 <sup>90</sup>		Diong et al., 2016 <sup>91, 92</sup>	
Physical Function Measure	Test & N of comparisons in MA	MA results	Test & N of comparisons in MA	MA results
Balance	4 different tests N=7	ES=0.32 (0.15, 0.49)	Berg Balance Scale N=4	+3.09 scale points (1.97, 4.21)
Physical Performance	4 different tests N=4	ES=0.53 (0.27, 0.78)		
	Timed Up and Go N=3	ES=0.83 (.28, 0.14)	Timed Up and Go N=3	-7.14 seconds (3.9, 10.36)
Walking	6-minute walk test N=4	ES=0.22 (-0.12, 0.57)	Gait speed N=9	+ 0.07 m/s (.01, 0.14)
	Usual gait speed N=4	ES=0.16 (-0.17, 0.48)		
	Fast gait speed N=4	ES=0.42 (0.11, 0.73)		
ADL	4 different measures N=4	ES=0.16, (-0.07, 0.35)	An ADL measure N=6	ES=0.24 (0.07, 0.41)
Self-report of physical function	SF-36 PF scale N=4	ES=0.20 (-0.30, 0.44)	Report of mobility as “good” N=2	ES=0.31 (0.10, 0.52)

Legend: MA=meta-analysis, ES=effect size, and ADL=activities of daily living.

Two additional analyses in the [Diong et al<sup>91, 92</sup>](#) supported the finding that community physical activity programs after a hip fracture have beneficial effects in older adults. First, in a meta-analysis of all 13 studies, exercise in “other settings” has a stronger effect size (ES=0.55; 95% CI: 0.24-0.85) on mobility measures than does hospital only exercise (ES=0.07; 95% CI: -0.12-0.27). The authors noted the interventions in hospital-based programs usually had fewer exercise sessions than programs in other settings, implying community-based programs are capable of providing an overall “dose” of physical activity sufficient to achieve an effect on physical function. An additional analysis of six RCTs demonstrated that exercise increases leg strength on the side of the body affected by the hip fracture (Hedge’s  $g=0.47$ ,  $P<0.001$ ).

In most RCTs, the physical activity intervention began a few weeks to a few months after discharge from formal rehabilitation. The intervention duration varied from 1 month to 1 year, with most studies lasting about 3 to 6 months. As stated previously, the most common physical activity component was muscle-strengthening exercise, sometimes in combination with other modes of activity and sometimes as the only mode.

Neither of the meta-analyses conducted subgroup analyses to determine whether the relationship between physical activity and physical function in older adults after hip fracture varied by age, sex, race, socioeconomic status, BMI, baseline physical function or baseline disease status. Also, no evidence was identified with respect to adverse events or injury during exercise.

### Osteoporosis or Osteopenia

**Sources of evidence:** Systematic reviews, meta-analyses

The Subcommittee based its most recent conclusions on evidence published between 2009 and 2016. This evidence came from four existing systematic reviews of RCTs,<sup>30, 93-95</sup> two of which included a meta-analysis.<sup>93, 94</sup> Participants included in these studies were all community-dwelling individuals ages 55 years and older with osteoporosis (with or without fractures). These studies involved only RCTs and the exposure of interest was all types and intensities of exercise, and the outcomes of interest were measures of physical function, such as performance-based measures (gait, balance, strength) or self-reported measures of ADL or QOL.

#### *Evidence on the Overall Relationship*

[Li et al<sup>94</sup>](#) provided a systematic review and meta-analysis of 4 exercise RCTs among 256 post-menopausal women with a clinical diagnosis of osteoporosis or osteopenia (with and without fractures) and measurements of health-related quality of life (measured by SF-36 and the Quality of Life Questionnaire of the European Foundation for Osteoporosis (QUALEFFO)). The authors reported that in every RCT, the physical activity groups (who participated in programs of strengthening, stretching, agility, and/or balance training) showed significant improvements in self-reported physical function (SMD=2.77; 95% CI: 2.17-3.37), compared with the control groups (no activity or stretching). Group-based programs typically produced better results, compared with the one study of a home-based program. Short-duration physical activity programs (fewer than or equal to 12 weeks) resulted in significant improvements in physical function score (SMD=6.54; 95% CI: 0.15-12.94), as did programs that were more than 12 weeks (SMD=2.74; 95% CI: 2.13-3.34). Importantly, physical activity programs that

combine strengthening with agility and balance training resulted in significant ( $P<0.05$ ) improvements in physical function score, whereas programs involving only strengthening did not. In general, the physical activity programs were performed twice per week for approximately 40 to 60 minutes per session. Compliance with the prescribed physical activities in the included studies was high (more than 80 percent) and none of the trials reported any adverse events.

Findings from another systematic review of five RCTs<sup>95</sup> support the benefits of strength training to improved physical function in older people with osteoporosis. Indeed, four of the five trials included in this review demonstrated statistically significant improvements in physical function and ADL (self-reported from the SF-36), with effect sizes ranging from trivial ( $ES=0.08$ ) to large ( $ES=1.74$ ). Those studies reporting greater compliance with the physical activity program also reported more positive outcomes. Three of the trials were supervised and involved resistance training that focused on the back, core, and upper and lower extremities 2 to 3 times per week for about 50 to 60 minutes per bout. The two trials of home-based resistance training focused on the abdomen, lower back, and hips and the activity was performed with greater frequency than the supervised programs: 3 times per day on 7 days per week in one study and 10 times per day on 5 days per week in the other.

A more recent review,<sup>93</sup> reports inconsistent findings from 7 trials comparing physical activity or active physical therapy interventions with placebo or non-exercise or non-active physical therapy interventions among 488 people (ages 40 years or older with a history of osteoporotic vertebral fractures). Due to substantial variability among the seven trials, a pooled analysis was performed using data from only two studies, which nonetheless showed significant between-group differences in favor of the physical activity group for the Timed Up and Go performance test (MD -1.13 sec, 95% CI: -1.85 to -0.42). The authors concluded that although individual trials reported benefits for pain, physical function, and quality-of-life outcomes for those people performing physical activity, the findings should be interpreted cautiously. Due to the limited number of studies and outcome measures of physical function, the Subcommittee graded the evidence as limited.

### Parkinson's Disease

**Sources of evidence:** Systematic reviews, meta-analyses

The Subcommittee based its conclusions on evidence published between 2004 and 2016. This evidence came from 20 systematic reviews.<sup>19, 96-115</sup> Only three of the reviews did not include a meta-analysis.<sup>19, 97, 99</sup> Participants included in these studies were community-dwelling older people between the ages of 57

and 88 years diagnosed with mild to moderate Parkinson’s disease (based on Hoehn and Yahr scores of 1 to 3). The physical activity training modalities were varied, ranging from conventional forms of training (aerobic or resistance training) to activities such as tango dancing, virtual reality training, yoga, and tai chi (Table F9-3). Outcomes of physical function were performance-based measures, such as Timed Up and Go, 6-minute walk test, gait velocity, balance, strength, and motor skills. As indicated in the table below, the evidence base includes a large number of studies, with large numbers of participants.

**Table F9-3. Number of Studies and Sample Sizes According to Training Mode in Individuals with Parkinson’s Disease**

Training Mode	Number of Studies	Sample Sizes
Mixed mode aerobic	35 total studies (20 RCTs) 18 RCTs 14 RCTs	N=1,210 N=901 N=495
Resistance training	12 RCTs	N=approximately 1000
Treadmill walking	18 RCTs	N=633
Tango/dance	13 total studies (9 RCTs)	N=357
Virtual reality training	8 trials	N=263
Yoga, tai chi	29 studies of various designs	N= approximately 910

Legend: RCT=randomized controlled trial.

Source: Alves Da Rocha et al., 2015,<sup>96</sup> Chung et al., 2016,<sup>98</sup> Cruickshank et al., 2015,<sup>100</sup> de Dreu et al., 2012,<sup>101</sup> Dockx et al., 2016,<sup>102</sup> Goodwin et al., 2008,<sup>103</sup> Kwok et al., 2016,<sup>104</sup> Lamotte et al., 2015,<sup>105, 106</sup> Lima et al., 2013,<sup>107</sup> Lotzke et al., 2015,<sup>108</sup> Mehrholz et al., 2015,<sup>109</sup> Ni et al., 2014,<sup>110</sup> Saltychev et al., 2016,<sup>111</sup> Sharp and Hewitt, 2014,<sup>112</sup> Shu et al., 2014,<sup>113</sup> Tillman et al., 2015,<sup>114</sup> and Yang et al., 2014.<sup>115</sup>

### *Evidence on the Overall Relationship*

Effect sizes for the relationship between any of the physical activity training modes and the physical function outcomes ranged from small to moderate. Table F9-4 shows representative pooled effect sizes across the 6 physical function measures.

**Table F9-4. Representative (Pooled) Effect Sizes for Physical Activity and Physical Function for Individuals with Parkinson’s Disease**

Physical Function Measure	Standardized Mean Differences (SMD) and 95% Confidence Intervals
Gait velocity (meters per second)	SMD=0.33; (95% CI: 0.17-0.49)
6 min walk (meters)	SMD=0.72; (95% CI: 0.08-1.36)
Timed Up and Go (seconds)	SMD=0.46; (95% CI: 0.08-0.76)
Balance score	SMD=0.36; (95% CI: 0.08-0.64)
UPDRS motor score	SMD=0.48; (95% CI: 0.21-0.75)
Strength	SMD=0.61; (95% CI: 0.35-0.87)

Legend: UPDRS=Unified Parkinson’s Disease Rating Scale.

Note: Positive values signify improvement versus control conditions.

Source: Shu et al., 2014<sup>113</sup> and Chung et al., 2016.<sup>98</sup>

One recent meta-analysis<sup>98</sup> involving seven RCTs of resistance training (N=401 participants) reported significant improvements in muscle strength (SMD=0.61; 95% CI: 0.35-0.87), balance score (SMD=0.36; 95% CI: 0.08-0.64) and Parkinsonian motor symptoms (SMD=0.48; 95% CI: 0.21-0.75) in the physical activity, compared with control groups. [Cruickshank et al<sup>100</sup>](#) also reported significant improvements in strength (SMD=0.88; 95% CI: 0.66-1.09), as well as an 11.4 percent improvement in the Unified Parkinson’s Disease Rating Scale (UPDRS) motor score. Another meta-analysis<sup>107</sup> of progressive muscle-strengthening training (four RCTs or quasi-RCTs; N=92 participants) also reported increased muscle strength (SMD=0.50; 95% CI: 0.05-0.95), as well as clinically relevant improvements in walking capacity (SMD=96 meters; 95% CI: 40-152) among people with mild to moderate Parkinson’s disease. In contrast, [Saltychev et al<sup>111</sup>](#) found no evidence to support the superiority of progressive muscle-strengthening training over other types of physical training for improving physical function in people with Parkinson's disease. This conclusion presumably is due to the fact that 5 of the 12 studies in the review used some other active exercise or balance training comparison group, thereby diminishing the magnitude of effect for progressive muscle-strengthening training.

[Kwok et al<sup>104</sup>](#) performed a meta-analysis of nine RCTs involving yoga and tai chi. Beneficial effects in UPDRS III score were reported overall (SMD=-0.91; 95% CI: -1.37 to -0.45). In the subgroup analysis, yoga demonstrated the largest effect in improving UPDRS III score (SMD= -2.35; 95% CI: -3.21 -1.50), balance score (SMD=1.48; 95% CI: 0.91-2.06) and the Timed Up and Go test (SMD= -0.97; 95% CI: -1.46 to -0.47)

and 6-Minute Walk Test (SMD=0.78; 95% CI: 0.35-1.21). Interventions with tai chi alone appear more effective than combined therapies for only a few balance and mobility outcomes, however.<sup>110, 115</sup>

Programs involving Argentine tango (N=7 studies) have demonstrated improvements in UPDRS motor severity score (ES= -0.62; 95 % CI:-1.04 to -0.21), balance score on the Mini-BESTest (ES=0.96; 95% CI: 0.60-1.31) and Berg Balance Scale (ES=0.45; 95% CI: 0.01-0.90), and gait with the Timed Up and Go test (ES= -0.46; 95% CI: -0.72 to -0.20).<sup>108</sup> Other forms of dance, such as the foxtrot or Irish dancing, have also demonstrated benefits to UPDRS motor scores (ES= -10.73; 95% CI: -15.05 to -6.16), balance score (ES=0.72; 95% CI: 0.31-1.44) and gait speed (ES=0.14 meters per second; 95% CI: 0.02-0.26) when compared with no intervention.<sup>112</sup> Physical activity programs involving a variety of activities, such as dance, hydrotherapy, aerobic exercise, boxing, Nordic walking, and tai chi<sup>96</sup> also appear effective in improving walking ability on the 6-Minute Walk Test (SMD=35 meters; 95% CI: 21-45), balance score (SMD=3.67; 95% CI: 3.05-4.30), UPDRS score (SMD= -4.22; 95% CI: -4.8 to -3.6), Timed Up and Go score (SMD=2.2 seconds; 95% CI: 1.2-4.1), and stride length (SMD= 0.112 meters; 95% CI: 0.034-2.8) in people living with Parkinson's disease. Due to the robust and consistent literature linking physical activity to improvements in physical function in older people living with Parkinson's disease, the Subcommittee graded the evidence as strong.

## Stroke

**Sources of evidence:** Systematic reviews and meta-analyses

The Subcommittee based its conclusions on evidence published between 2007 and 2015. This evidence came from two systematic review and meta-analyses.<sup>116, 117</sup> Participants included in these studies were individuals who had survived a stroke and were still able to walk, who had a walking speed of at least 0.2 meters per second.<sup>117</sup> The physical activity modalities were primarily strength or mobility training, and outcomes of physical function were performance-based measures of walking (walking velocity and endurance).

### *Evidence on the Overall Relationship*

A pooled analysis of five RCTs of strength training (N=240 participants) reported that strength training did not improve walking velocity following a stroke (Cohen's d (d)= -0.11; 95% CI: -0.46 to 0.24).<sup>116</sup> On the other hand, a pooled analysis of 10 studies of intensive mobility training (N=436 participants) by these same authors indicated a moderate beneficial effect on walking velocity (d=0.45; 95% CI: 0.14-0.77), which translated into an increase in walking speed of 0.23 meters per second (95% CI: 0.18-0.27)

in the intervention group.<sup>116</sup> A third and larger pooled analysis of 17 controlled studies also performed by [Eng and Tang<sup>116</sup>](#) (N=752 participants) reported that treadmill training improved walking velocity in people following sub-acute and chronic stroke (d=0.23; 95% CI: 0.14-0.59) and following chronic stroke alone (d=0.31 95% CI: 0.06-0.69). Walking endurance also improved (d=0.70; 95% CI: 0.29-1.10). Of note, however, is that the effect sizes for treadmill walking were not different from those involving other over-ground physical therapy mobility training modes. Finally, a meta-analysis of 6 trials (N=171 participants) involving walking with “cuing of cadence” versus walking training alone indicated an increase in walking speed of 0.23 meters per second favoring the cuing with cadence group.<sup>117</sup> The Subcommittee felt that the body of evidence linking mobility-oriented physical activity to improvements in walking function in older people following a stroke (although not large) was adequate and consistent and thus the evidence was graded as moderate.

### Visual Impairments

**Sources of evidence:** Meta-analysis

Older adults with visual impairment may have greater age-related problems with balance and may be in greater need of fall prevention programs compared older adults without this impairment. The only systematic review and meta-analysis by [Gleeson et al<sup>118</sup>](#) contained no relevant findings to address the outcomes specified.

***For additional details on this body of evidence for all these chronic conditions, visit:  
<https://health.gov/paguidelines/second-edition/report/supplementary-material.aspx> for the Evidence Portfolio.***

### **Comparing 2018 Findings with the 2008 Scientific Report**

The 2008 Scientific Report did not address the role of physical activity for maintaining or improving physical function in older people with specific chronic conditions. Thus, these current 2018 findings extend the previous report in stressing that it is never too late in life to achieve benefits from regular physical activity. This report further expands on the previous report by identifying specific modes of activity (e.g., progressive muscle-strengthening training, tai chi, tango dancing, multicomponent training) that can best benefit specific chronic conditions.

### **Public Health Impact**

About 80 percent of older adults have at least one chronic condition, and 77 percent have at least two.<sup>119</sup> Chronic diseases account for 75 percent of health care spending in the United States.<sup>119</sup> Low

levels of daily physical activity often co-exist with chronic disease, thereby accelerating the risk of functional decline, disability, and mortality. In fact, ample evidence now indicates that physical inactivity is among the strongest predictors of physical disability in older people.<sup>2</sup> Given the rapidly increasing trends in aging demographics in the United States, preventing or delaying loss of physical function and mobility is an important public health concern, and this may be especially so for older people with already established chronic conditions.

## **OVERALL SUMMARY AND CONCLUSIONS**

Strong evidence demonstrates that participation in multicomponent group or home-based fall prevention physical activity and exercise programs can reduce the risk of injury from falls, including severe falls that result in bone fracture, head trauma, open wound soft tissue injury, or any other injury requiring medical care or admission to hospital among community dwelling older adults. The evidence reviewed by the Subcommittee consistently indicated a 30 percent to 40 percent reduction in risk across studies. Limited evidence from RCTs suggest an inverse dose-response relationship between the amount of moderate-to-vigorous physical activity and the magnitude of risk reduction in fall-related injuries and bone fractures. Multicomponent physical activity regimens that combine aerobic, strength, and balance training appear to be especially effective in lowering risk of fall-related injuries, regardless of whether the exercise is home- or group-based.

Among the general aging population, strong evidence demonstrates that physical activity improves physical function and reduces the risk of age-related loss of physical function in an inverse graded manner. Moreover, evidence (albeit limited) now suggest that the benefits of physical activity to physical function may be greater in older adults with limitations in physical function compared with their healthier counterparts. Aerobic, muscle-strengthening, and multicomponent physical activity appear to have the strongest relationship to improvements in physical function in the general aging population, although balance training is also effective. Physical activities such as tai chi, dance training, active video gaming, and dual-task training also improve physical function in the general aging population, although the data are limited at this time.

Strong evidence also demonstrates that physical activity improves physical function in frail older adults. Multicomponent exercise training of at least moderate intensity that is performed 3 or more times per

week for a duration of 30 to 45 min per session, over at least 3 to 5 months appears most effective to increase functional ability in frail older people. Strong evidence also demonstrates that physical activity improves a number of physical function outcomes, including walking, balance, strength, and disease-specific motor scores in individuals with Parkinson's disease. The physical activity training modalities associated with these improvements ranged from conventional forms of training (aerobic or resistance training) to activities such as tango dancing, virtual reality training, yoga and tai chi. Moderate evidence suggests that extended exercise programs can improve physical function even following a hip fracture or a stroke. Muscle-strengthening exercise (alone or in combination with other modes) appears effective in individuals following hip fracture, while mobility-oriented physical activity improves walking function for individuals after a stroke. For the other chronic diseases (CVD, cognitive impairment, COPD, osteoporosis, and visual impairment), the evidence is too limited to make conclusions about the relationship between physical activity and physical function. Nonetheless, evidence suggests that it is never too late in life to benefit from physical activity.

## NEEDS FOR FUTURE RESEARCH

1. Conduct large-scale randomized controlled trials of older adults at high risk of falls designed with fall-related injuries and bone fractures as the primary outcomes of interest.

**Rationale:** The incidence of fall-related injury or bone fracture is typically a secondary outcome of interest for randomized controlled trials designed to assess the effect of physical activity on the rate of falling. This issue results in insufficient sample sizes across studies to assess injurious falls and fractures, increases the potential for selection or information bias, and results in inadequate collection of pertinent injury-related data.

2. Conduct large observational and experimental studies to investigate further the dose-response relationships between physical activity (aerobic, muscle-strengthening, balance, and multicomponent) and fall-related injuries and bone fractures.

**Rationale:** Currently, little information is available regarding the dose-response relationship between physical activity and fall-related injuries in older adults. Such information is necessary for setting minimum activity thresholds for effectiveness and maximum thresholds for safety.

3. Conduct large-scale randomized controlled trials comparing various doses of balance training and muscle-strengthening training on physical function in the general population of older people.

**Rationale:** Little information is currently available on the amount of balance and muscle-strengthening training necessary to maintain or to improve physical function among generally healthy older people. Such information is important for attenuating the aging-related decline in physical function, thereby delaying the onset of frailty and maintaining physical independence in aging.

4. Conduct large-scale randomized controlled trials to determine the effects of tai chi, qigong, dance, active video gaming, and yoga on physical function in healthy older adults, as well as those with different chronic conditions.

**Rationale:** These activities have only recently been considered as effective strategies for maintaining and improving physical function in older people. These forms of physical activity may be especially beneficial for those with already-existing chronic disease and/or limitations to mobility. Such research should address: 1) the types or modes of such activity that are most effective for specific chronic conditions; and 2) the minimal effective doses of these activities for improving physical function.

5. Conduct prospective cohort studies of physical activity and physical function in older adults that include objective measures (e.g., heart rate monitors) of relative intensity of activity.

**Rationale:** The relationship of relative versus absolute intensity to the health benefits of regular physical activity remains unclear. Epidemiologic (i.e., observational) studies using objective monitoring would: 1) allow for more robust analyses of how intensity affects health benefits, and 2) facilitate integration of findings from observational studies (which typically measure intensity of activity using absolute intensity) with those from randomized controlled trials (which typically measure intensity of activity using relative intensity).

6. Conduct more meta-analyses with meta-regressions to determine the extent to which the heterogeneity of results often observed among different studies of physical activity and physical function can be explained by variation in the tests used to measure physical function.

**Rationale:** Composite measures of physical function (such as the combination of measures resulting in a single score used in [Diong et al<sup>91,92</sup>](#) tend to result in stronger effect sizes with physical activity, compared with single measures. This may be due to the fact that physical function comprises a constellation of attributes that may not be adequately captured by a single measure. Moreover, comparisons among studies is difficult due to differences in how physical function is characterized and assessed (performance measures versus self-reported activities of daily living function or quality of life). Such meta-analyses would allow investigators to derive a single best composite measure to be used consistently in future studies of physical function.

7. Conduct more experimental research on dual-task training that clearly describe the dual-task training procedures and the parameters of the secondary task. In addition, these studies should provide evidence of whether dual-task costs were reduced by training and whether dual-task training transfers to untrained tasks.

**Rationale:** Dual-task training is a relatively new area of research in aging, and the methodologic quality of the studies reviewed for this report ranged from poor to moderate. To ensure internal validity and reproducibility, future research in this area should provide as much detail as possible in describing the methods and should consider multiple outcome tasks (trained and untrained) in the analysis.

8. Conduct large-scale randomized controlled trials and/or meta-regression analyses to establish dose-response effects of aerobic and resistance training on physical function for people with chronic obstructive pulmonary disease, frailty, osteoporosis, cognitive impairment, Parkinson's disease, visual impairments, and following hip fracture or stroke.

**Rationale:** Currently, little information is available regarding the dose-response relationship between aerobic and strengthening activities and physical function in specific vulnerable subgroups of older adults. These modes of activity are proven effective in minimizing the age-related decline in physiological reserve and function among the general aging population, and thus may be especially important for older people with chronic conditions that limited their mobility. Such information is necessary for setting minimum activity thresholds for effectiveness and maximum thresholds for safety.

9. Conduct large-scale randomized controlled trials to investigate the optimal dose and mode of physical activity necessary to improve and maintain balance function and reduce injury-related falls and fractures in persons with frailty, hip fracture, osteoporosis, Parkinson's disease, visual impairments, and stroke.

**Rationale:** Balance is essential for maintaining physical function and mobility, particularly among people with existing functional and mobility limitations due to frailty, osteoporosis, Parkinson's disease, visual impairments, or following hip fracture or a stroke. Currently, little information is available regarding the types or optimal dose of exercise for improving balance function. Such information is necessary for setting minimum activity thresholds for effectiveness and maximum thresholds for safety.

10. Conduct large-scale randomized controlled trials with 6- and 12-month post-intervention follow-up assessments to determine the effects of physical activity on activities of daily living mobility, instrumental activities of daily living, free-living physical or ambulatory activity and social participation for older individuals with chronic disease. These individuals are at accelerated risk of functional decline, disability, and social isolation.

**Rationale:** Little evidence currently exists on how improvements in strength, balance, and endurance following a physical activity intervention to improve physical function translate into everyday improvements in activities of daily living function and social participation, especially after the formal intervention period is over. Such knowledge would provide important information on how improvements in physiologic function can contribute to and sustain certain behavioral aspects of healthy aging (such as self-care, independence, social engagement) and quality of life.

11. Conduct large cohort and experimental studies to determine the dose-intensity and timing of physical activity necessary to prevent functional decline or to improve physical function across the spectrum of cognitive dysfunction and dementia.

**Rationale:** Limited evidence currently exists about the impact of physical activity training on physical function limitations that often co-occur with cognitive dysfunction and dementia. Cognition and mobility are intimately linked, and improving physical function through physical activity in a cognitively impaired population might have broad effects for independence and activities of daily living.

12. Conduct large-scale observational or experimental studies with adequate statistical power to determine whether the relationship between physical activity and risk of fall-related injuries or loss of physical function in older people varies by race/ethnicity, sex, socioeconomic status, or level of existing impairments across the aging spectrum.

**Rationale:** The vast majority of available research has been conducted on older white women, thereby limiting the generalizability of the findings to this demographic subgroup alone. Moreover, the potential impact of these influential factors often is not considered in statistical analyses, thus limiting the ability to determine whether effect modification exists at all. Results from this type of research would provide stronger scientific foundations for local, state, and national government, medical, and community wellness entities committed to reducing possible health disparities among various demographic sectors. This research would also support public and private partners in developing effective physical activity programs and policies to help individuals maintain their health and function through older age.

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