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Older Americans, the most rapidly growing age group, are the least physically active[1] and generate the highest healthcare expenditures.[2] For example, older persons who were functionally dependent accounted for 46% of the healthcare expenditures, but only made up 20% of the older adult population.[3] Additionally, they spent $5000 more per year than people who remained independent. Physical activity (PA) may play an important role in maintaining health and physical function while reducing the healthcare burden.[4] Recommendations for PA began in 1975 with the American College of Sports Medicine's (ACSM) guidelines for exercise testing and prescription. While little space was devoted to PA in older adults, likely due to the limited amount of research, today a wealth of literature is available touting its benefits. Throughout the past two decades many obstacles to adopting PA, a safe and effective modality for improving physical capacity in older adults, have been overcome. Many questions still remain; the one which we attempt to address in this brief review is whether PA can maintain physical function in older adults.

Physical activity has a myriad of effects that stem from physiological adaptations that may transfer to improvements in clinical outcomes such as reducing the risk of falls.[5] The purpose of this article is to briefly review the current literature regarding whether PA can help maintain physical function in older adults and offer some suggestions for clinicians wanting to improve physical function with PA. As illustrated in fig 1, individuals who begin a regular PA programme early in life and maintain this over the years will likely have high physical performance throughout the lifespan, although a decline in physical function is inevitable. Potentially more clinically relevant is whether a PA programme can set a person on a different trajectory over time (see curves in fig 1). Although this has never been formally tested in a clinical trial, scientists in the field anticipate that beginning a PA programme can reset the normal trajectory of functional decline no matter what the stage of disability. However, what will be gleaned from this review and others[6 7] is that, while there is consistent evidence that various types of short-term PA programmes improve physical capacity, very little is known as to whether PA can reduce the long-term incidence of physical disability.

AGEING AND PHYSICAL FUNCTION

Ageing is clearly associated with a decline in most physiological systems that culminates in limited physical capacity. The cardiovascular and musculoskeletal systems have received the most attention as they are involved with the most basic functions of everyday life. Regarding the cardiovascular system, ageing is associated with a dramatic decline in maximal aerobic performance that is due to a decrease in cardiac output (i.e. the delivery of oxygenated blood to muscles) and oxygen uptake at the muscle.[8] Maximal strength is also reduced with age, which results from a combination of loss of muscle mass (also termed sarcopenia) and neural control.[9] While it is commonly thought that high levels of PA can thwart the aging process, age-related changes continue to be evident despite lifelong high-intensity PA. For example, master marathon runners[10] and power lifters[11] who continue to train 2–4 h per day remain susceptible to the physiological declines seen with age. However, it is likely that an individual who begins and maintains a PA programme throughout the lifespan will have a greater reserve capacity to maintain high function into late life (fig 1). The age-related decline in physiological systems becomes clinically and socially relevant when it impacts societal roles and expectations that feed the pathway to disablement.[12]

EVIDENCE FOR PHYSICAL ACTIVITY AND IMPROVED PHYSICAL FUNCTION

Epidemiological studies have clearly demonstrated a dose–response pattern for PA that is associated with a lower risk of physical limitations.[13–15] Additionally, many small studies have reported beneficial effects of PA on physical capacity and precursors of physical disability.[16–19] For example, chronic resistance and aerobic exercise increase muscle strength, aerobic capacity and bone density.[20–23] This effect even occurs in frail elderly persons[24 25] and in persons with specific diseases highly associated with disability (i.e. osteoarthritis and cardiovascular disease).[26 27] Specifically, resistance training has a moderate to large effect on muscle strength with similar findings on endurance due to aerobic exercise. These effects do seem to transfer to functional activities such as sit-to-stand, stair climbing and walking tasks.[19 21 26 28]

It remains unclear whether improvements in physical function can lead to lower rates of disability.[6] Older disabled adults with osteoarthritis who were enrolled into the Fitness Arthritis and Seniors Trial (FAST) and underwent a 1.5 year PA programme (aerobic or resistance training) showed modest improvements in disability, physical function and pain.[29] Additional evidence suggests that PA may reduce the incidence of disability, as Penninx and coworkers found that older adults free of limitations in the FAST study and who

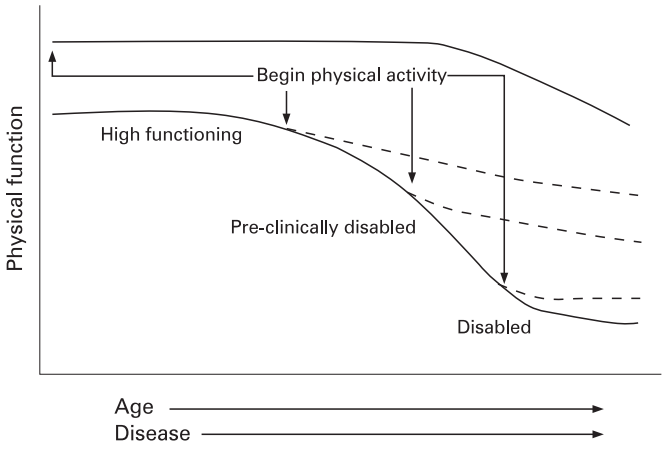

Figure 1 Physical function as viewed with increasing age and onset of disease. Physical activity (PA) is thought to impact physical function at many stages throughout life to change the trajectory of decline. Dotted lines represent new trajectory with beginning and maintaining a PA programme. Additionally, beginning a PA programme at an early age may be associated with greater reserve capacity and a decline that occurs later in life.
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participated in the intervention programme were approximately 40% less likely to develop incident disability than controls.[30]

Emerging evidence for the effects of PA on markers of disability comes from the LIFE-P study, in which 424 sedentary persons at risk of disability were randomised to a 12 month PA programme or health education control group. For example, scores on the short physical performance battery (SPPB) improved with PA while the successful ageing education control group demonstrated no change. Considering that SPPB scores are consistently associated with incident disability in older adults, the improvement in SPPB scores >1 point suggests a meaningful change that may transition into reduced disability. Additionally, time until major mobility disability, defined as the incidence of not being able to complete the 400 metre walk, showed a strong trend toward reduction in the PA group (see hazard ratios in fig 2). Further research with a longer follow-up time is needed to definitely conclude on the effects of PA on the onset of disability.

Consistent with the findings presented in the review noted above, the Surgeon General's report on PA points to "promising evidence" that exercise in older adults may preserve the ability to maintain independent living. While this statement relies on clinical trial evidence regarding the effects of exercise on impairments such as decreased strength and balance, evidence supporting the beneficial effects of exercise on maintenance of physical function with PA is primarily based on observational studies.

PHYSICAL ACTIVITY RECOMMENDATIONS FOR OLDER ADULTS

In 1995, the ACSM and Centers for Disease Control issued a preventive recommendation that "Every US adult should accumulate 30 minutes or more of moderate-intensity physical activity on most, preferably all, days of the week."[31] The recommendations are identical to those from the World Health Organization (WHO) Regional Office for Europe. ACSM and the American Heart Association (AHA) have recently amended these recommendations[32] and made separate recommendations for all adults aged ⩾65 years and adults aged 50–64 years with clinically significant disease impairments and limitations.[33] The WHO recommendations have remained the same.[34] Because of the diverse disease aetiology in older adults, a global recommendation is difficult to embrace completely. This difficulty is partly related to potential safety concerns in this diverse group, but it is becoming clear that the types and intensity of exercise being recommended are relatively safe in older adults and serious adverse events in clinical trials are rare.[35 36] The ACSM/AHA recommends that older adults take a multifactorial approach to PA by performing aerobic, strength, and flexibility exercise (a decision algorithm with an exercise prescription is outlined in fig 2). Additionally, older adults should have an activity plan that incorporates each category of activity, but also they should consider how, when and where PA will be performed. For example, sedentary individuals should begin by performing shorter bouts of activity and gradually move toward performing more continuous bouts of activity.

EMERGING AREAS OF RESEARCH

Physical activity represents an extremely promising intervention; yet evidence for prevention of mobility and outright disability remains inconclusive,[6] deriving only from secondary data analyses.[37] Many cross-sectional and a few longitudinal studies have documented a clear association between PA and onset of disability. Additionally, dozens of studies demonstrate that older adults have a high propensity to improve upon physiological properties underlying disability (i.e. muscle strength and aerobic capacity) despite the occurrence of disease conditions.[38 39] These studies typically assess continuous measures of function that are sensitive indicators of the physiological effects of interventions and have been useful for guiding the refinement of exercise interventions. However, it is imperative to adopt an objectively measured outcome that discriminates between being able or unable to perform a critical task of daily living. As an example, the findings from the Diabetes Prevention Program (DPP) offered definitive evidence

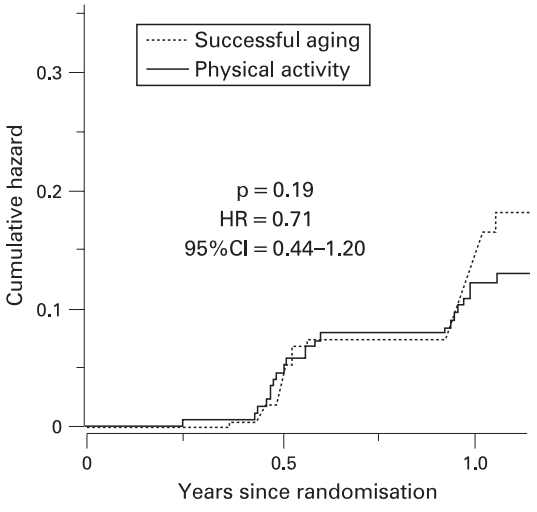

Figure 2 Cumulative hazard of time until major mobility disability and until major mobility disability according to randomised groups (PA or a Successful Ageing (SA) health education control group) in the LIFE-P study. CI, confidence interval; HR, hazard ratio.
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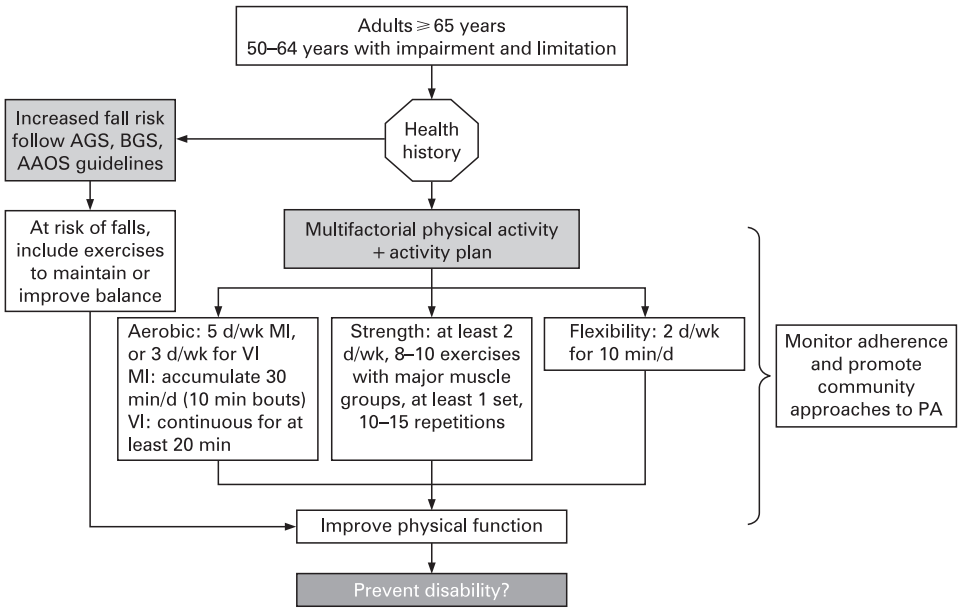

Figure 3 Algorithm summarising the ACSM/AHA current recommendations for physical activity in older adults to improve physical function and potentially to prevent physical disability. Clinicians are encouraged to assess health history in guiding the exercise prescription for improving physical function. Moderate-intensity (MI) exercise should be gauged as a 5–6 on a 10 point effort scale (0 = sitting and 10 = all-out effort). Vigorous-intensity (VI) exercise should be a 7 or 8 on this same scale.

that a lifestyle intervention could prevent the onset of diabetes, rather than just improving the continuous measure of blood sugar.[40] One such outcome for disability has been proposed in the LIFE-P study. Major mobility disability, characterised as inability to walk 400 m, fits a description that encompasses important aspects of independent living and can be objectively measured. Additionally, unlike continuous measures of physical function that often improve with short duration of PA, a long follow-up time will be needed to assess when older individuals are unable to walk 400 m. Development of outcomes, such as major mobility disability, is an emerging area of research to move the field forward and create a clear message for public health and clinical practice.

In preparation for developing PA guidelines from the Department of Health Human Services, an advisory committee reported on the evidence on PA for improving health of Americans (download report at http://www.health.gov/PAGuidelines/). The report includes a chapter dedicated to the functional health of older adults and reviews the literature related to PA for reducing the incidence of disability in older adults. The development of such guidelines is an important step in recognising the importance of PA in older adults and is thought to spearhead future investigations to identify ideal programmes to maintain functional health in older adults.

An active research programme aimed at discovering better PA methodologies to improve physical function remains ongoing. Leading the way are scientists interested in not only improving cardiovascular and musculoskeletal systems through traditionally based exercise programmes, but also incorporating task-specific exercise (TSE). TSE, which involves practising tasks of everyday life in a progressively challenging manner, has shown recent success at improving function as it incorporates task specificity and highlights the neural control of movement.[19, 41–44] As recently demonstrated in a clinical trial conducted by de Vreede and colleagues, a TSE programme in healthy older adults resulted in enhanced physical function and muscle power without adaptation in maximal strength.[44] This was contrary to results in the resistance training arm, where individuals showed little change in physical function yet substantially increased their maximal force production. More importantly, a revaluation of participants 6 months after discontinuation of training showed that the TSE group maintained their physical function while the resistance-trained group returned to baseline levels. Research into other modalities of exercise, such as TSE training, may lead to more effective interventions to maintain independence on tasks commonly encountered throughout the day.

RECOMMENDATION FOR THE CLINICIAN

While there is no clear evidence that the current recommendations maintain physical function in older adults, many studies have demonstrated a robust effect of PA on acute improvements in physical function. It is thought that these acute improvements may alter the trajectory of decline in physical capacity in hopes of maintaining physical function into late life. Using the current recommendations as a guideline, clinicians are encouraged to follow the algorithm illustrated in fig 3 as a guideline for maintaining physical function. This algorithm highlights the ACSM/AHA current recommendations that older adults should be encouraged to perform moderate-intensity aerobic PA for a minimum of 30 minutes on 5 days each week or vigorous-intensity aerobic PA for a minimum of 20 minutes 3 days per week.[33] This dose can be accumulated in sessions of 10 minutes or more. Additionally, older adults should perform at least two non-consecutive days of moderate to high-intensity resistance training each week. Additional pieces of fig 3 are to assess an individual's health history, monitor adherence and promote community approaches to PA. The assessment of health history can be performed using the Physical Activity Readiness Questionnaire (PAR-Q),[45] but clinicians are encouraged to assess fall risk, which leads to a separate exercise prescription as outlined by the guidelines to prevent falls in older adults.[5] Future research will determine whether the current recommendations will maintain physical function that prevents physical disability in older adults.

Competing interests: None.

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