Clinical Review

The Role of Physical Activity in Older Adults and Practical Intervention

Se Won Lee, MD,1 Rebecca Patel, MD,1 Bryan Werner, MD,1 Ji Won Yoo, MD,2 Timothy Tiu, MD3

Abstract

Description
Physical inactivity (PI), defined as not meeting guidelines for physical activity beyond baseline daily living activities, is common among older adults (age 65 and older) and contributes to increased morbidity, increased mortality and increased health care spending. Understanding the clinical impact of PI on common medical conditions among older adults will help primary care physicians (PCPs) to educate these patients successfully. Physical activity and exercise are effective in the primary and secondary prevention of chronic diseases that can lead to physical impairments, disability and/or premature death. Physical activity and exercise have been shown to improve cognitive dysfunction and painful musculoskeletal disorders as well as diminish frailty and reduce falls, which are highly prevalent among older adults with a significant impact on their ability to function and perform daily activities. Improving PCPs’ ability to identify PI, educate patients about the health impact of physical activity and advocate and prescribe appropriate exercise will prevent adverse health outcomes related to PI.

Keywords
physical activity; physical inactivity; sedentary behavior; exercise; older adults; evaluation; intervention; prevention

Introduction
Physical activity (PA) is decreased among older adults aged 65 years and older, the most rapidly growing age group in the United States (US). Between 20 to 50% of older adults are physically inactive, with a greater prevalence of physical inactivity (PI) in women, in urban populations and wealthier countries worldwide.1 Decreased PA is a large contributor to a number of health problems and is associated with an increase in mortality comparable to that of smoking, diabetes, hypertension, obesity or excessive alcohol consumption.2 The World Health Organization ranks PI as the fourth leading risk factor for overall morbidity and mortality worldwide.3 PI contributes to 1–2.6% of total health care costs worldwide, with a large portion of health care spending utilized by older adults with physical limitations.4 Despite these figures, in one national study, only 34% of older women were counseled about physical exercise by their primary care providers (PCPs).5

PI, often used interchangeably with insufficient PA, has been defined as not meeting the general guidelines for PA: vigorous-intensity PA for 20 minutes or more per day on at least three days per week, moderate-vigorous intensity PA 30 minutes or more per day on at least five days per week, or at least 600 metabolic equivalent (MET)-minutes/week.1 PA levels should always be modified to suit the individual patient, taking into account his or her age, comorbidities, [dis]ability or baseline level of function. The practical evaluation of PI in a clinical setting is a rich topic for review to improve provider recognition and enhance our ability to prescribe proper interventions.

It is important to recognize common risk factors for PI. Sedentary behavior, particularly increased sitting time, is a well-known risk fac-
tor for PI and is associated with many chronic medical disorders and overall mortality. Other individual risk factors include the presence of musculoskeletal (MSK) disease, mobility limitation, poor health, perceived barriers to exercise, lack of knowledge and/or depressive symptoms. These risk factors can be mitigated in physically active people.

This review briefly covers the impact of PI on selective medical problems affecting the activities of daily living (ADL) of older adults, the practical evaluation of PI and pragmatic approaches to intervention from a clinician perspective.

**Impact of Physical Inactivity and Activity on Specific Medical Conditions**

PI is a contributing factor to at least 35 chronic medical conditions, including cognitive dysfunction, cardiorespiratory disorders and a range of MSK disorders. PA and exercise can be effective in primary and secondary prevention of chronic diseases that can lead to physical impairments, disability and premature death. In addition, PA and exercise are associated with improved quality of life, successful aging and reduced health care burden.

**Cognitive Dysfunction**

Studies on older women have shown that PI is associated with cognitive impairment, Alzheimer’s disease and dementia of any type in greater than 15% of cases, while regular PA and exercise were associated with decreased risk of cognitive impairment and dysfunction. Although the exact underlying mechanisms of PA on cognitive function in patients with mild cognitive impairment and dementia are unknown, the theory that reciprocal stimulation of neuroplasticity with an enriched environment from PA is commonly posited. Other proposed mechanisms include increased blood flow to the brain, improved cardiovascular and metabolic health, prevention and treatment of depression and improved sleep quality. In addition, PA and exercise increase the volume of the hippocampus and improve white matter integrity.

A recent systemic review demonstrated that home-based PA programs, such as walking, are safe and effective in delaying cognitive decline and improving ADL and physical fitness in patients with dementia; further, such programs have high adherence. PA and exercise can be combined with cognitive exercise, with potentially synergistic effects on cognitive function in older adults who have either mild cognitive impairment or dementia, as measured by global cognitive function, ADL and mood.

**Falls**

Aging can lead to an increase in accidental falls, due to the deterioration of muscle strength, dynamic balance and speed of movement execution. We might thus expect that low levels of PA among older adults would be associated with increased risk of falls, but the relationship between PA and increased fall risks is complex. Increased fall risk is most often attributed to physical limitations, rather than being directly attributable to the low PA level. At the same time, increased PA lowers fall-related injuries by 32 to 40%. The association between PA and fracture is also controversial. PA may be associated with fracture due to activity-related injury, such as from bicycling, but protective against osteoporotic fractures.

**Musculoskeletal System**

MSK pain is strongly associated with decreased physical function among older adults, and chronic MSK pain is known to increase with advancing age. PI is either a cause or contributor to many MSK disorders, and reduced PA has been associated with an increased number of chronic MSK pain sites. For example, 37% of the arthritis population is physically inactive. This may be due to the fact that muscle strength around a joint, an important factor in preventing the progression of osteoarthritis (OA), decreases with PI. MSK pain is often cited as a barrier to engaging in PA and exercise and can lead to a vicious cycle of deteriorating function. PA, when appropriately prescribed, can improve muscle mass and strength, protecting the joint complex and thus preventing and reducing the pain and dysfunction associated with MSK disorders.

**Frailty**

Frailty is a state of increased vulnerability, which has been operationally defined as a
condition meeting three out of the following five phenotypic criteria: low grip strength, low energy, slow walking speed, low PA, and unintentional weight loss. It is one of the major geriatric syndromes, with a prevalence of 7–16% in older adults aged 65 years and older. Frailty is closely associated with adverse health outcomes, such as disability, falls, hospitalization and death. While PI is a cardinal feature of frailty, it worsens frailty by affecting multiple physiologic systems, such as with the classically-observed consequences of prolonged bed rest during hospitalization, including reductions in muscle mass, strength, gait speed and physical function. PA, particularly aerobic and strengthening exercises, are key therapies in the management of frailty.

Evaluation of Physical Activity
The first step in addressing PI in older adults is measuring their current level of PA. Evaluation methods can be divided into self-report questionnaires, diaries/logs, direct observation and wearable devices. Regardless of the method, several aspects of PA should be measured, including PA type, intensity, frequency, duration, participant’s burden, cost and individual-specific limitations. This information can be used not only to diagnose PI but also as a baseline to objectively monitor progress during follow-up.

There are several survey instruments available to evaluate physical activity levels in community-dwelling older adults. The Physical Activity Scale for the Elderly (PASE), Community Healthy Activities Model Program for Seniors (CHAMPS) Questionnaire and the Yale Physical Activity Survey (YPAS) were extensively studied in different older adult populations and reported to correlate with performance-based (6-minute walk test) and other self-reported quality measures (such as the Short-From-36 survey).

Assessment questionnaires used in health care settings include the Rapid Assessment of Physical Activity (RAPA) and the two-question “Exercise Vital Sign” by the American College of Sports Medicine (ACSM). The RAPA is a 9-item questionnaire covering the range of PA from sedentary to regular vigorous PA, as well as strength training and flexibility. Assessing the “Exercise Vital Sign” involves asking about the weekly frequency of at least moderate activity, as well as the duration of engagement for those activities on a given day.

Wearable monitoring devices can be useful for obtaining objective measurements of PA. In addition, these activity tracking devices can be useful to enhance behavioral changes to maintain a physically active lifestyle by self-monitoring and goal setting. Commonly used devices include pedometers, accelerometers, heart rate monitors and armbands with mobile phone apps. Pedometers are traditionally used to measure step counts, allowing varying levels of PA to be divided into classifications such as highly active (>10,000 steps/day), moderately active (5000–10,000 steps/day) and below active (<5000 steps/day). Accelerometers can provide more detailed information regarding the intensity and level of PA. With the advancement of mobile health technology, the accelerometers in smartphones, smartwatches and other wearable devices can provide increased data related to PA, including heart rate (HR) monitoring, profiles of PA throughout the day and intensity of activity (such as moderate to vigorous PA).

The correlation of the above-mentioned self-reported survey measures (PASE, YAPS, CHAMPS) with sensor-based activity monitors around the ankle and waist ranged from 0.36 to 0.61 with acceptable validity. When compared to the total energy expenditure, the “gold standard” metric of PA, only CHAMPS was significantly correlated (r=0.28) among self-reported survey measures, while pedometers, accelerometers and armbands were significantly correlated with the total energy expenditure (r=0.48 to 0.60).

Interventions to Promote Physical Activity: Education and Prescription
PA guidelines are widely available to the public from different federal agencies and from Despite the widespread availability of this information, there are still barriers to optimal adherence to PA guidelines among the general public. PCPs have an important role in optimizing patient adherence by educating patients about the clinical impact of PI and PA on morbidity and mortality. Older adults, espe-
Table 1. Exercise Prescription Based on Physical Activity (PA) Guideline for Older Adults (Modified from Physical Activity Guidelines for Americans, 2nd edition, US Department of Health and Human Services and Exercise is Medicine, American College of Sports Medicine).66

| Goal | Other exercises |
|------|----------------|
| Moderate-intensity: brisk walking, 5-6 in 0-10 relative intensity scale, Vigorous-intensity: jogging or running, 7-9 in 0-10 relative intensity scale | - Daily activities: some yard work, such as raking and pushing a lawnmower - Sports: tennis or basketball, walking as part of golf, hiking - Some forms of yoga

| Intensity Type of PA | Goal | Other exercises |
|---------------------|------|----------------|
| Light               | Light | Daily activities: some yard work, such as raking and pushing a lawnmower |
| Moderate            | Moderate | - Sports: tennis or basketball, walking as part of golf, hiking - Some forms of yoga |
| Vigorous            | Vigorous | Daily activities: some yard work, such as raking and pushing a lawnmower |

| Balance of PA | Time duration each session | Frequency goal: 2-3 times a day |
|---------------|---------------------------|-----------------------------|
| Moderate-intensity: brisk walking, 5-6 in 0-10 relative intensity scale | Moderate-intensity: brisk walking, 5-6 in 0-10 relative intensity scale | Daily activities: some yard work, such as raking and pushing a lawnmower |
| Vigorous-intensity: jogging or running, 7-9 in 0-10 relative intensity scale | Vigorous-intensity: jogging or running, 7-9 in 0-10 relative intensity scale | Daily activities: some yard work, such as raking and pushing a lawnmower |

Other exercises:
- Total of 150-300 mins (30-60 mins/day for 5 days/week) for moderate-intensity PA
- Additional benefits with 300 mins per week exercise
- Or 75-150 mins weekly for vigorous-intensity PA
- Balance exercise frequency: 3 sessions per week

Abbreviation: mins=minutes

Appendix

A simple PA assessment questionnaire such as the two-question "Exercise Vital Sign" can be included on the initial intake form. The American College of Sports Medicine has proposed the concept of "Exercise is Medicine," positioning "exercise prescription" as a standard medical intervention. Exercise prescription has been shown to be effective at increasing PA levels,66 and should be specific with regard to the following domains: frequency, duration, intensity and mode of exercises. Frequency and duration are familiar concepts to PCPs and patients alike, but intensity (e.g., moderate to vigorous activity during ADLs or exercise) may be less familiar and more difficult to grasp. A metabolic equivalent (MET), the ratio of work metabolic rate to standard (quiet) resting metabolic rate of 1 (4.184 kJ/kg·h·1), is a commonly used measure of the intensity of PA. Walking briskly (2.5 to 4.0 mph) and raking leaves are both considered moderate-intensity activities (about 3 to 5.9 METs). Vigorous-intensity activities (over 6 METs) include jogging or running, carrying heavy groceries or participating in a strenuous fitness class. (Table 2) Alternatively, with the increasing use of wearable devices and fitness trackers, HR monitoring can be used in guiding the intensity of exercise through a target HR. The target HR range can be easily calculated from maximum HR (220-age), multiplied by 0.64–0.76 for moderate-intensity activity and by 0.77–0.93 for vigorous-intensity activity.39 Thirty to 40 minutes of moderate-to-vigorous intensity PA was shown to mitigate the risk of death associated with increased sitting time (>8 hours/day).40

Typical PA/exercise programs for older adults include balance exercises for patients at risk of falls, flexibility training to improve mobility, aerobic endurance exercise designed to improve cardiovascular health and muscle-strengthening exercise, which can be effective at improving frailty and pain from degenerative joint disease.41 An individualized approach is key for the successful design of any PA/exercise plan.

There is evidence that a combination of aerobic exercise and resistance training is better than either form alone. Multimodal physical exercise therapy (strength, flexibility and aerobic exercise in each session) appears to be more effective at improving quality of life than generalized activity such as walking in patients with knee OA;42 however, generalization of...
this approach is limited due to the scarcity of available studies. High-intensity interval training (HIIT) involves alternating high-intensity aerobic exercise with light-recovery exercise or rest between intervals. It can be more effective at improving cardiorespiratory fitness, vascular function, skeletal muscle metabolism and cognitive function.

PCPs can be instrumental in educating community-dwelling older adults using community resources such as exercise classes at local senior centers, or local fitness centers with a personal trainer who is experienced in training this population. If there are significant functional deficits and neuromuscular challenges, a referral to a Physical Medicine and Rehabilitation specialist (physiatrist) should be considered.

**Challenges**

Despite common worries among patients and health care providers, there is scant evidence to suggest that older adults are at high risk of injury secondary to PA. Nonetheless, fear of injury has been cited as a barrier to PA, as has lack of motivation, lack of time and perceptions related to age, health status or level of fitness. Other external barriers include lack of transportation, poor weather conditions and lack of social and/or financial support. Addressing these barriers to PA can help to improve patient compliance.

The interpretation of PA measurement by different modalities can be challenging, as these provide different metrics without a universal scale widely accepted by both patients and PCPs. Although PA monitoring-based interventions were reported to be effective at improving PA among older adults, the effectiveness varies with different instruments and among different subgroups of older adults; for example, there is limited efficacy of wearable activity trackers among adults aged 80 years or greater. Furthermore, there was limited evidence of PA monitoring devices directly promoting

### Table 2. Metabolic Equivalents for Different Daily Activities and Physical Exercises

| Intensity of activity, relative intensity | Metabolic equivalent (MET) | Daily activities (MET) | Physical exercises |
|----------------------------------------|---------------------------|-----------------------|--------------------|
| Resting/Sedentary                      | 1 MET                     | Lying in bed, sitting quietly, watching a movie | |
| Light-intensity physical activity      | 1.5-3 MET                 | Computer work (1.8 MET) Laundry (2.2 MET) Preparing and serving food (2.3 MET) Washing dishes (2.3 MET) Ironing (2.3 MET) | Standing (2 MET), Walking on slow (2.0 mph), level, firm surface (2.5 MET) |
| • Very light to fairly light*          |                           |                       | Yoga (3.2MET) Walking briskly at 2.5 to 4 mph (3-5.9 MET) Golf (4.3-4.5 MET) Badminton (4.3MET) Swimming gently in a pool (1.2 mph; 4.3 MET) Tennis double play (4-5 MET) |
| • Can talk and sing                    |                           |                       |                    |
| Moderate-intensity physical activity   | 3-6 MET                   | Sweeping floors or vacuuming (3-3.5 MET) Gardening (4 MET) Raking leaves (4.2 MET) Carrying and stacking wood (5.5 MET) Stair climbing (5.5 MET) | Yoga (3.2MET) Walking briskly at 2.5 to 4 mph (3-5.9 MET) Golf (4.3-4.5 MET) Badminton (4.3MET) Swimming gently in a pool (1.2 mph; 4.3 MET) Tennis double play (4-5 MET) |
| • Fairly light to somewhat hard*       |                           |                       |                    |
| • Can talk but not sing                |                           |                       |                    |
| Vigorous-intensity physical activity   | Over 6 MET                | Shoveling sand, coals (7 MET) Carrying heavy loads such as bricks (7.5 MET) Heavy farming such as bailing hay (8 MET) Shoveling, digging ditches (8.5 MET) | Aerobic dancing (6.5 MET) Stair machine Swimming at 1.6 mph (6.8 MET) Strenuous fitness class Jogging at 5 mph (8 MET) Tennis single play (8 MET) Running (13 MET with running at 8 mph) |
| • Somewhat hard to very hard*          |                           |                       |                    |
| • Talking is interrupted by large breaths |                       |                       |                    |

Abbreviation: mph=miles per hour

*Borg perceived rate of exertion scale

388
If patient access to PA monitoring devices is limited, PCPs may utilize survey-based monitoring.

Newer and more recently popularized modes of exercise are less well known to patients and PCPs, leading to more concerns among older adults. For example, HIIT was less utilized due to low familiarity and concern for injury, despite the absence of any reports of serious adverse events associated with HIIT.

Although there is an overall reduction in the risk of cardiac death with exercise, it is true that exercise can precipitate malignant ventricular arrhythmias and increase the risk of cardiac arrest in sedentary adults with preexisting coronary artery disease or with risk factors. Pre-exercise testing, with graded exercise testing, may be indicated before vigorous exercise in this population.

MSK pain can make PA challenging for older adults, leading to reduced quality of life and disability. Common MSK injuries related to PA have been characterized as acute, overuse/repetitive strain or sprain (more frequently reported in the lower body), with falls and overexertion cited as common causes of injuries. However, MSK injuries associated with PA can be prevented by choosing safer forms of PA, tailoring individualized exercise approaches and educating patients about strategies for preventing MSK injuries, such as pre-exercise warmups.

**Conclusion**

PI is prevalent among older adults and can negatively affect chronic medical conditions, cognitive function and physical abilities, leading to decreased quality of life and increased mortality. To improve patient outcomes and reduce healthcare expenditure, physicians should strive to evaluate PA, educate patients about the health impact of PA, and prescribe detailed and appropriate exercise. Exercise prescriptions can be reviewed in detail, including frequency, duration, intensity and mode, while barriers can be discussed and managed for successful outcomes.

**Conflicts of Interest**

The authors declare they have no conflicts of interest.

Drs. Lee, Patel and Werner are employees of Sunrise Health GME Consortium, an organization affiliated with the journal’s publisher.

This research was supported (in whole or in part) by HCA Healthcare and/or an HCA Healthcare affiliated entity. The views expressed in this publication represent those of the author(s) and do not necessarily represent the official views of HCA Healthcare or any of its affiliated entities.

**Author Affiliations**

1. Department of Physical Medicine and Rehabilitation, Sunrise Health GME Consortium, Las Vegas, NV
2. Department of Internal Medicine, UNLV School of Medicine, Las Vegas, NV
3. Department of Physical Medicine and Rehabilitation, University of Miami, Miami, Florida

**References**

1. Dumith SC, Hallal PC, Reis RS, Kohl HW 3rd. Worldwide prevalence of physical inactivity and its association with human development index in 76 countries. *Prev Med*. 2011;53(1-2):24-28. https://doi.org/10.1016/j.ypmed.2011.02.017
2. Stringhini S, Carmeli C, Jokela M, et al. Socio-economic status and the 25 × 25 risk factors as determinants of premature mortality: a multicohort study and meta-analysis of 1·7 million men and women. *Lancet*. 2017;389(10075):1229-1237. https://doi.org/10.1016/S0140-6736(16)32380-7
3. Thornton JS, Fremont P, Khan K, et al. Physical activity prescription: a critical opportunity to address a modifiable risk factor for the prevention and management of chronic disease: a position statement by the Canadian Academy of Sport and Exercise Medicine. *Br J Sports Med*. 2016;50(18):1109-1114. http://dx.doi.org/10.1136/bjsports-2016-096291
4. Cheng Y, Goodin AJ, Pahor M, Manini T, Brown JD. Healthcare utilization and physical functioning in older adults in the United States. *J Am Geriatr Soc*. 2020;68(2):266-271. https://doi.org/10.1111/jgs.16260
5. Schonberg MA, Leveille SG, Marcantonio ER. Preventive health care among older women: missed opportunities and poor targeting. *Am J Med*. 2008;121(11):974-981. https://doi.org/10.1016/j.amjmed.2008.05.042
6. Ekelund U, Steene-Johannessen J, Brown WJ, et al. Does physical activity attenuate, or even eliminate, the detrimental association of sitting time with mortality? A harmonised meta-analysis of data from more than 1 million men and women. *Lancet*. 2016;388(10051):1302-1310. [https://doi.org/10.1016/S0140-6736(16)30370-1](https://doi.org/10.1016/S0140-6736(16)30370-1)

7. Lee IM, Shiroma EJ, Lobelo F, Puska P, Blair SN, Katzmarzyk PT. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *Lancet*. 2012;380(9838):219-229. [https://doi.org/10.1016/S0140-6736(12)61031-9](https://doi.org/10.1016/S0140-6736(12)61031-9)

8. Rosqvist E, Heikkinen E, Lyra TM, et al. Factors affecting the increased risk of physical inactivity among older people with depressive symptoms. *Scand J Med Sci Sports*. 2009;19(3):398-405. [https://doi.org/10.1111/j.1600-0838.2008.00798.x](https://doi.org/10.1111/j.1600-0838.2008.00798.x)

9. Booth FW, Roberts CK, Thyfault JP, Ruegsegger GN, Toedebusch RG. Role of inactivity in chronic diseases: evolutionary insight and pathophysiological mechanisms. *Physiol Rev*. 2017;97(4):1351-1402. [https://doi.org/10.1152/physrev.00019.2016](https://doi.org/10.1152/physrev.00019.2016)

10. Pahor M, Guralnik JM, Ambrosius WT, et al. Effect of structured physical activity on prevention of major mobility disability in older adults: the LIFE study randomized clinical trial. *JAMA*. 2014;311(23):2387-2396. [https://doi.org/10.1001/jama.2014.5616](https://doi.org/10.1001/jama.2014.5616)

11. Kane RL, Butler M, Fink HA, et al. *Interventions to Prevent Age-Related Cognitive Decline, Mild Cognitive Impairment, and Clinical Alzheimer’s-Type Dementia*. Rockville (MD): Agency for Healthcare Research and Quality (US); March 2017.

12. Kraft E. Cognitive function, physical activity, and aging: possible biological links and implications for multimodal interventions. *Neuropsychol Dev Cogn B Aging Neuropsychol Cogn*. 2012;19(1-2):248-263. [https://doi.org/10.1080/13825585.2011.645010](https://doi.org/10.1080/13825585.2011.645010)

13. Gallaway PJ, Miyake H, Buchowski MS, et al. Physical activity: a viable way to reduce the risks of mild cognitive impairment, Alzheimer’s disease, and vascular dementia in older adults. *Brain Sci*. Feb 20 2017;7(2):22. [https://doi.org/10.3390/brainsci7020022](https://doi.org/10.3390/brainsci7020022)

14. Joubert C, Chainay H. Aging brain: the effect of combined cognitive and physical training on cognition as compared to cognitive and physical training alone – a systematic review. *Clin Interv Aging*. 2018;13:1267-1301. [https://doi.org/10.2147/CIA.S165399](https://doi.org/10.2147/CIA.S165399)

15. Almeida SIL, Gomes da Silva M, Marques A. Home-based physical activity programs for people with dementia: systematic review and meta-analysis. *Gerontologist*. 2020;60(8):600-608. [https://doi.org/10.1093/geront/gnz176](https://doi.org/10.1093/geront/gnz176)

16. Cawthon PM, Marshall L. Physical activity, physical function and fall and fracture risk in older men. In: Orwoll E, Bilezikian J, Vanderschueren D, eds. *Osteoporosis in Men: The Effects of Gender on Skeletal Health*. 2nd ed. Academic Press; 2009:375-384.

17. Dipietro L, Campbell WW, Buchner DM, et al. Physical activity, injuries fall, and physical function in aging: an umbrella review. *Med Sci Sports Exerc*. 2019;51(6):1303-1313. [https://doi.org/10.1249/MSS.0000000000001942](https://doi.org/10.1249/MSS.0000000000001942)

18. Appleby PN, Allen NE, Roddam AW, Key TJ. Physical activity and fracture risk: a prospective study of 1898 incident fractures among 34,696 British men and women. *J Bone Miner Metab*. 2008;26(2):191-198. [https://doi.org/10.1007/s00774-007-0806-4](https://doi.org/10.1007/s00774-007-0806-4)

19. McMillan LB, Zengin A, Ebeling PR, Scott D. Prescribing physical activity for the prevention and treatment of osteoporosis in older adults. *Healthcare (Basel)*. 2017;5(4):85. [https://doi.org/10.3390/healthcare5040085](https://doi.org/10.3390/healthcare5040085)

20. Shih M, Hootman JM, Kruger J, Helmick CG. Physical activity in men and women with arthritis National Health Interview Survey, 2002. *Am J Prev Med*. 2006;30(5):385-393. [https://doi.org/10.1016/j.amepre.2005.12.005](https://doi.org/10.1016/j.amepre.2005.12.005)

21. Gay C, Chabaud A, Guille X, Coudeyre E. Educating patients about the benefits of physical activity and exercise for their hip and knee osteoarthritis. Systematic literature review. *Ann Phys Rehabil Med*. 2016;59(3):174-183. [https://doi.org/10.1016/j.rehab.2016.02.005](https://doi.org/10.1016/j.rehab.2016.02.005)

22. Murata S, Doi T, Sawa R, et al. Association between objectively measured physical activity and the number of chronic musculoskeletal pain sites in community-dwelling older adults. *Pain Med*. 2019;20(4):717-723. [https://doi.org/10.1093/pm/pny112](https://doi.org/10.1093/pm/pny112)

23. Rodríguez-Mañas L, Fried LP. Frailty in the clinical scenario. *Lancet*. 2015;385(9968):e7-e9. [https://doi.org/10.1016/S0140-6736(14)61595-6](https://doi.org/10.1016/S0140-6736(14)61595-6)

24. Cesari M, Calvani R, Marzetti E. Frailty in older persons. *Clin Geriatr Med*. Aug 2017;33(3):293-303. [https://doi.org/10.1016/j.cger.2017.02.002](https://doi.org/10.1016/j.cger.2017.02.002)

25. Kehler DS, Theo O, Rockwood K. Bed rest and accelerated aging in relation to the musculoskeletal and cardiovascular systems and frailty biomarkers: a review. *Exp Gerontol*. 2019;124:110643. [https://doi.org/10.1016/j.exger.2019.110643](https://doi.org/10.1016/j.exger.2019.110643)

26. Sylvia LG, Bernstein EE, Hubbard JL, Keating L, Anderson EJ. Practical guide to measuring physical activity. *J Acad Nutr Diet*. 2014;114(2):199-208. [https://doi.org/10.1016/j.jand.2013.09.018](https://doi.org/10.1016/j.jand.2013.09.018)

27. Harada ND, Chiu V, King AC, Stewart AL. An evaluation of three self-report physical activity instruments for older adults. *Med Sci Sports Exerc*. 2001;33(6):962-970. [https://doi.org/10.1097/00000576-200106000-00016](https://doi.org/10.1097/00000576-200106000-00016)

28. Moore DS, Ellis R, Allen PD, et al. Construct validation of physical activity surveys in culturally diverse older adults: a comparison of four com-
monly used questionnaires. *Res Q Exerc Sport*. 2008;79(1):42-50. https://doi.org/10.1080/02701362.2008.10599459

29. Colbert LH, Matthews CE, Havighurst TC, Kim K, Schoeller DA. Comparative validity of physical activity measures in older adults. *Med Sci Sports Exerc*. 2011;43(5):867-876. https://doi.org/10.1249/MSS.0b013e3181fc7162

30. Sallis R. Developing healthcare systems to support exercise: exercise as the fifth vital sign. *Br J Sports Med*. 2011;45(6):473-474. http://dx.doi.org/10.1136/bjsm.2010.083469

31. Milton K, Bull FC, Bauman A. Reliability and validity testing of a single-item physical activity measure. *Br J Sports Med*. 2011;45(3):203-208. http://dx.doi.org/10.1136/bjsm.2009.068395

32. French DP, Olander EK, Chisholm A, Mc Sharry J. Which behaviour change techniques are most effective at increasing older adults’ self-efficacy and physical activity behaviour? A systematic review. *Ann Behav Med*. 2014;48(2):225-234. https://doi.org/10.1007/s12160-014-9533-z

33. Liu JY, Kor PP, Chan CP, Kwan RY, Sze-Ki D. The effectiveness of a wearable activity tracker (WAT)-based intervention to improve physical activity levels in sedentary older adults: a systematic review and meta-analysis. *Arch Gerontol Geriatr*. 2020;91:104211. https://doi.org/10.1016/j.archger.2020.104211

34. Lobelo F, Rohm Young D, Sallis R, et al. Routine assessment and promotion of physical activity in healthcare settings: a scientific statement from the American Heart Association. *Circulation*. 2018;137(18):e495-e522. https://doi.org/10.1161/CIR.0000000000000559

35. Westerterp KR. Assessment of physical activity: a critical appraisal. *Eur J Appl Physiol*. 2009;105(6):823-828. https://doi.org/10.1007/s00421-009-1000-2

36. Piercy KL, Troiano RP, Ballard RM, et al. The physical activity guidelines for Americans. *JAMA*. 2018;320(19):2020-2028. https://doi.org/10.1001/jama.2018.14854

37. Knaggs JD, Larkin KA, Manini TM. Metabolic cost of daily activities and effect of mobility impairment in older adults. *J Am Geriatr Soc*. 2011;59(11):218-2123. https://doi.org/10.1111/j.1532-5415.2011.03655.x

38. Taylor D. Physical activity is medicine for older adults. *Postgrad Med J*. 2014;90(1059):26-32. http://dx.doi.org/10.1136/postgrad- medi-2012-131366

39. American College of Sports Medicine. *ACSM’s Resource Manual for Guidelines for Exercise Testing and Prescription*. Lippincott Williams & Wilkins; 2012.

40. Ekelund U, Steene-Johannessen J, Brown WJ, et al. Does physical activity attenuate, or even eliminate, the detrimental association of sitting time with mortality? A harmonised meta-analysis of data from more than 1 million men and women. *Lancet*. 2016;388(10051):1302-1310. https://doi.org/10.1016/S0140-6736(16)30370-1

41. Villafane JH, Bishop MD, Pedersini P, Berjano P. Physical activity and osteoarthritis: update and perspectives. *Pain Med*. 2019;20(8):1461-1463. https://doi.org/10.1093/pmn/pny283

42. Buchheit M, Laursen PB. High-intensity interval training, solutions to the programming puzzle: part I: cardiopulmonary emphasis. *Sports Med*. 2013;43(5):313-338. https://doi.org/10.1007/s12297-013-0029-x

43. Choi J, Lee M, Lee JK, Kang D, Choi JY. Correlates associated with participation in physical activity among adults: a systematic review of reviews and update. *BMC Public Health*. 2017;17(1):356. https://doi.org/10.1186/s12889-017-4255-2

44. Kang M, Marshall SJ, Barreira TV, Lee JO. Effect of pedometer-based physical activity interventions: a meta-analysis. *Res Q Exerc Sport*. 2009;80(3):648-655. https://doi.org/10.1080/02701367.2009.10599604

45. Baker G, Gray SR, Wright A, et al. The effect of a pedometer-based community walking intervention “Walking for Wellbeing in the West” on physical activity levels and health outcomes: a 12-week randomized controlled trial. *Int J Behav Nutr Phys Act*. 2008;5:44. https://doi.org/10.1186/1479-5868-5-44

46. Gabriel KP, McClain JJ, Schmid KK, et al. Issues in accelerometer methodology: the role of epoch length on estimates of physical activity and relationships with health outcomes in overweight, post-menopausal women. *Int J Behav Nutr Phys Act*. 2010;7:53. https://doi.org/10.1186/1479-5868-7-53

47. Brickwood K-J, Ahuja KDK, Watson G, O’Brien JA, Williams AD. Effects of activity tracker use with health professional support or telephone counseling on maintenance of physical activity and health outcomes in older adults: randomized controlled trial. *JMIR Mhealth Uhealth*. 2021;9(1):e18686. https://doi.org/10.2196/18686

48. McDermott MM, Spring B, Tian L, et al. Effect of low-intensity vs high-intensity home-based walking exercise on walk distance in patients with peripheral artery disease: the LITE randomized clinical trial. *JAMA*. 2021;325(13):1266-1276. https://doi.org/10.1001/jama.2021.2536

49. Dun Y, Smith JR, Liu S, Olson TP. High-intensity interval training in cardiac rehabilitation. *Clin Geriatr Med*. 2019;35(4):469-487. https://doi.org/10.1016/j.cger.2019.07.011

50. Keating CJ, Párraga Montilla JÁ, Latorre Román PÁ, Moreno Del Castillo R. Comparison of high-intensity interval training to moderate-intensity continuous training in older adults: a systematic review. *J Aging Phys Act*. 2020;1-10. https://doi.org/10.1123/japa.2019-0111

51. Gordon NF, Gulanick M, Costa F, et al. Physi-
Physical activity and exercise recommendations for stroke survivors: an American Heart Association scientific statement from the Council on Clinical Cardiology, Subcommittee on Exercise, Cardiac Rehabilitation, and Prevention; the Council on Cardiovascular Nursing; the Council on Nutrition, Physical Activity, and Metabolism; and the Stroke Council. *Circulation*. 2004;109(16):2031-2041. [https://doi.org/10.1161/01.CIR.0000126280.65777.A4](https://doi.org/10.1161/01.CIR.0000126280.65777.A4)