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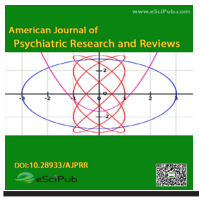

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Inactivity and Sedentary Behavior in Aging Adults: A Narrative Review

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ABSTRACT

The recent literature (last five years) on inactivity and sedentary behavior in aging (ageing) adults is predominantly focused on negative effects of inactivity/sedentary behavior along with some studies on predictors/risk variables and interventions. Aging has been typically defined as starting as early as 60 or 65. And, inactivity has been defined as reduced time being active and/or increased time being sedentary. The prevalence rates for inactivity in aging adults have been highly variable in this literature, ranging from a low of 21% to a high of 79%. Negative effects have included cognitive impairment, reduced muscle strength, frailty, depression and mortality. The Negative biological effects have included increased cytokines and triglycerides as well as increased hippocampal volume and white matter hyperintensities. Predictors/risk factors have been social isolation, loneliness, inadequate nutrition and multiple demographic variables. Interventions have been effective including stepping, Pilates and mobile health exercises. More well-designed longitudinal studies are needed as well as more robust randomized controlled trials.

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This narrative review involved entering the terms inactivity, sedentary behavior and aging (ageing) into PubMed and PsycINFO. The search yielded 209 papers for the last five years. However, following exclusion criteria including case studies and non-English language papers, this review is a summary of the research reported in 47 papers. This recent literature is predominantly focused on negative effects of inactivity/sedentary behavior on aging adults along with studies on predictors/risk factors and interventions. This narrative review is accordingly divided into sections on prevalence of inactivity/sedentary behavior in aging adults, negative effects, predictors/risk factors and interventions. These are followed by a section on methodological limitations of the research.

Definitions of Inactivity and Sedentary Behavior

In this literature, inactivity and sedentary behavior have sometimes been used interchangeably and sometimes operationally defined differently and measured in tandem. Both physical inactivity and sedentary behavior have frequently been assessed by the Physical Activity Scale for the Elderly (Klicnik et al, 2022) and occasionally by accelerometer (Rodriguez-Gomez et al, 2018). According to the Copenhagen Consensus Statement, “Physical activity entails body movement that increases energy expenditure relative to rest and is often characterized in terms of intensity from light to moderate to rigorous “(Bangsbro et al,2019).

Prevalence of Inactivity and Sedentary Behavior in Aging Adults

The prevalence of inactivity and sedentary behavior in older adults has varied widely across cultures from a low of 21% inactivity in Malaysia (Ibrahim et al, 2022) to a high of 79% sedentary behavior in European older adults (Gine-Garriga et al, 2020) (see table 1). In the latter study, an accelerometer was used to measure physical activity in 1360 adults (mean age=75 years). Based on the accelerometer data, 19% engaged in light intensity physical activity, and only 3% engaged in moderate to vigorous activity.

The prevalence of inactivity and sedentary behavior in aging adults in other countries include 30% for France (Pierre et al, 2022), 34% for Singapore (Aithal et al, 2022) and 58% for Brazil (Christofoletti et al, 2022). The prevalence has also varied by year of the study. For example, studies from Malaysia indicated a prevalence of 49% in 2019 (Chan et al, 2019), but 30% in 2020 (Chan et al, 2020) and 21% in 2022 (Ibrahim et al, 2022), suggesting that the prevalence of inactivity in aging adults had been decreasing in that country.

Inactivity has also been measured by hours per day. So, for example, in a study that used two devices for assessing activity (ActivPAL and ActiGraph), sedentary behavior was noted to occur approximately 10 hours per day, light intensity activity 5 hours per day, and moderate to vigorous activity 1 hour per day (Rosenberg et al, 2020). In this sample (mean age=77 years), different types of activity were also noted including sitting 10 hours per day, standing 4 hours per day, and stepping 1 hour per day.

Effects of Inactivity and/or Sedentary Behavior on Aging Adults

The effects of inactivity and/or sedentary behavior on aging adults are also highly variable, and typically depend on the interests of the researchers (see table 2). The negative effects include cognitive impairment, limited activities of daily living, blood pressure dysregulation, limited muscle strength, frailty, Sarcopenia, bone loss, depression, and mortality. Of these negative effects, the most frequently studied were cognitive impairment followed by depression.

Cognitive Impairment

Reports on the associations between inactivity, sedentary behavior and cognitive impairment have been highly variable. In one study (N =3780, 55 to 87-year-olds), sitting time greater than 75% of daily activity related to a 60% greater odds of cognitive impairment (Gafni et al, 2022). These authors also reported that not

meeting physical activity guidelines related to 27% greater odds of cognitive impairment.

In another study entitled “Profiles of sedentary behaviors in the oldest old” (N =852 adults greater than 80-years-old), the most passive group had lower cognitive function (Zhou et al, 2022). That group also had more difficulties with activities of daily living.

More specific cognitive functions were explored in a study on 75 old adults (mean age=75 years) (Coelho et al, 2020). In this sample, total sedentary time was associated with several measures of executive function (e.g. planning and time management) and memory problems. Less cognitive demanding sedentary behavior (TV viewing and napping) was associated with worse performance on executive function and memory tasks (e.g. building times on Lego towers). Executive function was the most compromised in older adults who were physically inactive.

Memory, language and executive function problems have been reported in still another study on aging adults (Moreira et al, 2022). In this study, the type of sedentary behavior was again a factor. Engaging in mentally active sedentary behavior as, for example, occupational screen time, did not lead to inferior cognitive function. Similarly, in a systematic review, sedentary behavior for reading and computer use was positively associated with cognitive function (Mellow et al, 2022). In this review of 23 studies (N= 23,000 old adults, mean age=71 years), greater physical activity and less sedentary behavior were related to greater cognitive function. In addition, cognitive function was related to sleep as an inverted U-shaped function with too few and too many hours of sleep being associated with inferior cognitive function.

As in all of these cross-sectional studies, direction of effects cannot be determined. Inactivity could be disturbing sleep which, in turn, impairs cognitive function or vice versa or the problems could be bi-directional or reciprocal.

Physical Health

Sedentary behavior has been explored for its association with health in later life (Russell et al, 2019). In this sample from the National Health and Aging Trends Study (N= 1587), multivariate models were used to explore the association of time and six sedentary behaviors including TV, sitting and talking, hobbies, computers, driving, and resting. TV watching was the most frequent and resting the least frequent of the sedentary behaviors, but both TV and resting were associated with worse health.

In a paper entitled “Physical activity and sedentarism among seniors in France and their impact on health”, “sedentarity” was noted in 30% of the sample (Pierre et al, 2022). The criterion for sedentarism was adults who failed to meet the WHO recommended physical activity levels (N = 1155 greater than 55–year-old adults). Older adults in this sample averaged six hours per day in sedentary activities which contributed to their ill health.

Muscle Strength

Muscle strength has been notably associated with physical activity of older adults. Low grip strength is one example of inactivity effects (Wang et sl, 2019). Low grip strength has also been associated with greater sedentary behavior (Ramsey et al, 2021). In this sample, greater sedentary behavior was also associated with lower body muscle strength and inferior performance on the chair-to-stand test. Grip strength (hand grip) has also been studied in older Brazilian adults (Christofoletti et al, 2022). In this sample, low grip strength occurred in 58% of all-day sitters, 23% of sitters and 19% of active sitters.

Frailty

Frailty has also resulted from inactivity. In a sample from the Toledo Study for Healthy Aging (N=771), greater frailty, along with less physical function, was reported for the physically inactive and high sedentary group (Manas et al,2019). As others have noted, “heterogeneity in aging can be explained by frailty” (Kehler et al, 2019).

These authors also suggested that long sedentary bouts and sedentary time are risk factors for mortality in frail individuals, but not in fit individuals.

Sarcopenia

Given that sarcopenia (loss of muscle mass) is highly associated with frailty (multi-system impairment), it is not surprising that sedentary behavior has also affected sarcopenia (deSouza et al, 2022). In that sample (N=1165), sedentary behavior, as measured by the International Physical Activity Questionnaire and a report of greater than two hours watching TV or video, was related to sarcopenia. Sarcopenia was measured by the amount of time over 5 trials that exceeded 15 seconds in the sit-to-stand test.

Bone Loss

Bone loss typically accompanies frailty and sarcopenia. In a study on bone and skeletal muscle change in "oldest–old women" (greater than 75-years-old), systematic declines in bone and muscle were associated with physical inactivity (Cavedon et al, 2030). Dual energy x-ray absorptiometry revealed that whole body bone mineral density was decreased by 15%. In another study on associations between sedentary time, physical activity and bone health (N =871), physical activity was measured by an accelerometer and bone mass by bone densitometry (Rodriguez-Gomez et al, 2018). The combined effect of all movement (physical inactivity and sedentary behavior) was associated with whole body, leg and femoral region bone mass in the entire sample. Leg and pelvic bone were more affected in males and whole body, arm, and leg bone in females. More vigorous activity led to greater bone mass, most especially in males. A physical activity increase and sedentary behavior decrease were associated with reduced bone fracture risk in women.

Negative Affect and Depression

Negative affect and depression have also been associated with sedentary behavior and inactivity in older adults. For example, in a sample from the Swedish National Study on Aging and Care (N=595 greater than 65--year-old adults), a greater amount of sitting and less physical activity led to negative affect (Chen et al, 2021). Social participation and support lessened this association.

Although COVID has been noted to exacerbate sedentary behavior and inactivity, engaging in vigorous and moderately vigorous activity has led to greater resilience, positive affect and less depression in one sample during COVID (N=483 in greater than 60-year-old adults) (Camedo et al,2020).

In a systematic review and meta-analysis of 24 studies on physically active adults greater than 60-years-old, there was a lesser risk of depression (Cunningham et al, 2020). In this meta-analysis, physical activity also decreased the risk of breast and prostate cancer, fractures, falls, activities of daily living disability, cognitive decline, dementia, Alzheimer's, other morbidities and mortality.

Physiological and Biochemical Effects

Physiological and biochemical effects of inactivity in aging adults have included blood pressure dysregulation, increased cytokines and triglycerides and decreased hippocampal volume. In a paper entitled "Sedentary behavior is associated with reduced cardiovagal baroreflex sensitivity in healthy adults", greater sedentary behavior was associated with dysregulation of arterial blood pressure (Mori et al, 2022). This was particularly noted in males.

Sedentary behavior has also been associated with alterations in cytokines and chemokines (MacNeil et al, 2021). The metabolic profiles of old adults being physically inactive and sedentary have also included higher cholesterol LDL and triglyceride levels and lower cholesterol HDL (Tian et al. 2021).

In a review of the literature on sedentary behavior and the biological hallmarks of aging, several effects have been noted (Raffin et al, 2023). These include genomic instability, telomere attrition, epigenetic, alterations, loss of

proteostasis (protein homeostasis), dysregulated nutrient sensing, mitochondrial dysfunction, cellular senescence, stem cell exhaustion, and altered intercellular communication. These measures have not been made on the same individuals, so their relative effects are not known.

In a paper entitled “Hemodynamic and structural brain measures in high and low sedentary older adults”, data were reviewed from the Irish Longitudinal Study on Aging (N=718) (Massakkers et al, 2021). High sedentary individuals had less hippocampal volumes and greater white matter hyperintensities. These findings could relate to the cognitive deficits that have been noted in sedentary old adults, e. g. poor memory.

Mortality

In a paper called “Associations between sedentary time and six–year all–cause mortality”, a large sample (N=17,048) was followed for six years (Li et al, 2022). When a group who spent less than four hours in sedentary time per day was compared to a group who were sedentary 8 to 11 hours per day, the higher sedentary folks were more likely to experience all–cause mortality. For each one hour per day of sedentary time, the risk increased 3% for all-cause mortality.

Risk Factors/Predictors

Several risk factors/predictors have been reported in this recent literature on inactivity/ sedentary behavior in aging adults (see table 3). They include age itself, social isolation, loneliness, and studies in which multiple factors were explored.

Age

Despite a significant literature on centenarians suggesting that they have reached that age because they continue to be active and have a healthy diet (Field, 2023), at least one study in this literature suggests that centenarians versus nongenarians (90 years plus) had less steps per day on the accelerometer, but also fewer breaks (Hernandez–Vicente et al, 2019). The greatest activity in both groups occurred between 10 am and noon. These data are limited for their small and unequal sample sizes (only 18 centenarians and 11 nongenarians).

Social Isolation

Social isolation has been noted to lead to inactivity in the SHARE project (Survey of Health, Aging and Retirement in Europe) (N =67,173 adults from 17 European countries) (Matos et al, 2021). in this sample, greater social isolation led to greater inactivity and a less healthy diet (too few fruits and vegetables).

In a study, entitled “Social contact impacts physical activity and sedentary behavior among older adults in Japan due to COVID–19“(N=1925, mean age = 74), sedentary time increased six hours per week during COVID (Otaki et al, 2022). Also during COVID, social contact decreased in 76% of the sample and virtual contact decreased in 39% of the sample. The physical activity decrease was associated with the decrease in social participation and interactions with friends.

Loneliness

Social isolation would be expected to lead to loneliness. Loneliness has been a predictor, variable for fatigue, inactivity and cognitive impairment. In a study entitled “Is loneliness, a predictor of the modern geriatric giants?”, four syndromes were researched including frailty (linked to fatigue and physical inactivity), Sarcopenia , anorexia of aging and cognitive impairment (the four giants) (Gine-Garriga et al, 2021). The prevalence of each of these was noted for the sample from the Survey of Health, Aging and Retirement of Europe project (N= 17,742). The prevalence of loneliness was given at 9 to 12%, fatigue at 16%, physical inactivity at 10%, Sarcopenia at 6%, anorexia at 5% and cognitive impairment at 10%.

In another study, however, loneliness and/or social isolation was reported in both physically, active and physically inactive older adults (deJoning et al, 2021). This study may have been under- powered and gender-biased with only 24 women (mean age=73) being

Table 1. Prevalence of inactivity and sedentary behavior in aging adults.

Prevalence	First author
21% Malaysia	Ibrahim
30% France	Pierre
30% Malaysia	Chan, 2020
34% Singapore	Aithal
49% Malaysia	Chan, 2019
58% Brazil	Christofoletti
79% European countries	Gine-Garriga

Table 2. Effects of inactivity and sedentary behavior in aging adults.

Effects	First author
Cognitive impairment	Gafni, Zhou, Coelho, Moreira, Melluw
Physical health	Russell, Pierre
Muscle strength	Wang, Ramsey, Christofoletti
Frailty	Manas
Sarcopenia	deSouza
Bone loss	Cavedon, Rodriguez-Gomez
Negative affect and depression	Chen, Camedo, Cunningham
Physiological and biochemical effects	
Dysregulated arterial blood pressure	Mori
Cytokines and chemokines	MacNei
>LDL and triglycerides and <HDL	Tian
Telomere attrition	Raffin
<hippocampal volume	Massakers
>mortality	Li

Table 3. Risk factors/predictors of inactivity and sedentary behavior in aging adults.

Risk factor	First author
Age	Hernandez-Vicente
Social isolation	Matos, Otaki
Loneliness	Gine-Garriga, DeJonning
Multiple factors	Chan, Ibrahim, Gine-Garriga, Aithal

Table 4. Protective factors of inactivity and sedentary behavior in aging adults.

Protective factor	First author
Retirement	Suorsa, Pasadena
Neighborhood walkability	Greenwood-Hickman
Denser greenness	Kienik

Table 5. Interventions for inactivity and sedentary behavior in aging adults.

Interventions	First author
“stand up and move”	Crombie
Home-square stepping	Lees
Mobile health	Niemicz
Pilates	Soori

interviewed and transcripts being thematically analyzed.

Multiple Risk Factor Studies

A number of researchers have reported multiple risk factors. For example, in a study, entitled "Prevalence and factors associated with physical inactivity among older adults in Malaysia" (N=3969, greater than 60-year-old adults), the Global Physical Activity Questionnaire was given during a face-to-face interview (Chan et al, 2020). Physical inactivity was noted in 30% of this sample and the risk factors were being greater than 80 years, being unemployed, having functional limitations, and having diabetes and dementia.

Surprisingly, one year earlier, the same research group reported a significantly greater prevalence in this sample from the National Health and Morbidity Survey (N=equals 3790 greater than 60-year-old-adults) (Chan et al, 2019). These authors reported 48% prevalence of physical inactivity in this 2019 study and 30% in their 2020 study, suggesting that the prevalence was decreasing in Malaysia. Multiple risks were identified in this sample as well including being female, older age, single, having no formal education, spending greater than seven hours in sedentary time, diabetes, anemia, and mobility impairment. The two different time samples shared the risk factors of being female and older age and having diabetes.

In a study by a different group in Malaysia, a sample (N=555) was followed for three years and the Physical Activity Scale for the Elderly was used to assess physical activity (Ibrahim et al, 2022). Inactivity was noted in 21% of the sample and the predictors of inactivity were older age, smoking, lower gait speed and lower cognitive status. **In** this literature, inactivity and sedentary behavior have sometimes been used interchangeably and sometimes operationally defined differently and measured in tandem.

In a study already described, in which 79% of time was spent in sedentary behavior and 90% time in light intensity physical activity, females were noted to engage in light physical activity and males in moderate physical activity (Gine-Garriga et al, 2020). Although the sample was said to watch TV and read 47% of the time, the risk factors for sedentary behavior were older age, being female, single, taking more meds, being obese or overweight, and having a slower gait.

Finally, in a sample from Singapore (N= 2240 greater than 60-year-old adults), insufficient activity was noted in 34% and sedentary behavior (defined as greater than seven hours per day) was seen in 17% of the aging adults (Aithal et al, 2022). The risk factors in this sample were being an older female, residing in smaller housing, living with a child without a spouse, functional limitations and sensory impairment.

Protective Factors

The few buffers or protective factors for physical inactivity that have been noted in this literature on aging adults include retirement, a walkable location, and a greener environment (see table 4). Retirement has, surprisingly, favored activity. In a paper entitled "Objectively measured sedentary time before and after transition to retirement, a sample from the Finnish Retirement and Aging Study was assessed (N= 478, mean age=63) (Suorsa et al, 2020). Based on monitoring by a wrist ActiGraph accelerometer, pre-retirement activity averaged eight hours and 10 minutes in females and nine hours and 49 minutes in males. Post retirement activity increased 29 minutes for females, although there was no change for males.

In another study, greater sedentary time but also greater physical activity were noted at a non-home environment on weekdays, and at home on weekends in a sample of 53 retirees and 137 workers (Pasadena et al. 2021). Greater moderately vigorous physical activity was noted on days off (34 minutes more). No difference was noted for the retirees at 33 minutes more activity on days off.

In a paper, entitled “Associations between perceived neighborhood walkability and device/based physical activity and sedentary behavior patterns in older adults” (N=1077), the participants were given the Physical Activity Neighborhood Environment Scale. (Greenwood-Hickman et al, 2022). Greater scores on neighborhood walkability were associated with more steps and sit-to-stand transitions.

In a paper entitled ”Leisure sedentary time and physical activity are higher in neighborhoods with denser greenness” (N=36,580 Canadians), both sedentary time and physical activity as assessed by the Physical Activity for Elderly Scale were greater in those aging adults living in neighborhoods with greater greenness (Klienik et al, 2022).

Interventions

Interventions have enhanced activity level in inactive aging adults (see table 5). Those interventions that were found in the current literature on aging adults include “stand-up-and-move”, stepping, mobile health and Pilates. In a paper entitled “The feasibility and effectiveness of a community-based intervention to reduce sedentary behavior”, sedentary behavior was defined as sitting more than 6 hours per day (Crombie et al, 2021). The “stand-up-and-move” intervention done at home significantly reduced sedentary behavior.

In another intervention study entitled “Potential value of home square–stepping exercise for inactive, older adults“, a sample of 10 adults older than 65 engaged in a three-week square-stepping intervention (Lees et al, 2022). Based on pedometer measures, stepping increased 12% and 8 of the 10 adults reached moderate intensity activity levels.

In a review paper entitled, “mHealth supported intervention with potential to address sedentary behavior in older adults: a scoping review“, physical activity was noted to increase following mobile health exercises. But the results are tenuous given that mobile health was combined with non-mobile health exercises in 13 studies, and only three of those addressed sedentary behavior (Schepens Niemicet al, 2022).

In the only other intervention study that could be found in this literature, aerobic exercises were compared with Pilates in a sample of 75 inactive older women (Soori et al, 2022). Following 12 weeks of Pilates and aerobics, activity levels increased for both groups, but the Pilates versus the aerobics group experienced a greater decrease in depression. This could relate to a larger portion of the body being exercised in the Pilates group. If more pressure receptors are being stimulated, greater vagal activity and serotonin release would be expected leading to less depression (Field, 2022).

Methodological Limitations

Some methodological limitations can be noted for these recent studies on inactivity and sedentary behavior in aging adults. All aspects of the studies have been highly variable including the sampling methods, the sample sizes, the measures, the prevalence, the effects and the risk factors. Aging has been variously defined as starting at 60 or 65 or at 80 or 85. And the different age adult groups have rarely been compared except for the comparison of nongenarians and centenarians (Hernandez-Vicente et al, 2019). Although the age range of the samples typically spanned 10 years, age was not considered as a potential risk factor for inactivity or sedentary behavior but was treated as a covariate in most of the data analyses.

The researchers have primarily used self-report scales like the Physical Activity Scale for the Elderly, although some have used accelerometers and actigraphs to record activity. But even those more objective measures yielded variable results. In a systematic review of 95 studies (93% from high-income countries), for example, the researchers reported on the impact of different ways of distributing and using accelerometers (Pulsford et al, 2023). This review revealed that consent and adherence were greater for devices delivered in person and accelerometers worn on the wrist versus the

waist. These results were not surprising in that older adults frequently appreciate social interaction and dislike waist measurements.

Inactivity and sedentary behavior have sometimes been used interchangeably and sometimes differently defined and measured in tandem, and in at least one study, both physical activity and sedentary time had positive effects. The variability in the age groups sampled, the various definitions of inactivity and the different measures used have made it difficult to conduct systematic reviews and meta-analyses, resulting in very few of those in this literature. Based on the variability of the measures, the prevalence rates for inactivity in aging adults have also been highly variable, ranging from a low of 21% to a high of 79%, although some of the variance may relate to cultural and location (e. g. urban/rural) differences in the samples.

The research has been primarily focused on the negative effects of inactivity/sedentary behavior. Although several negative effects have been reported, ranging from cognitive impairment to frailty to mortality, the studies have focused on these as single variables rather than exploring multiple negative effects for their relative contributions to the variance in the outcomes. And, virtually no positive effects have been reported for either inactivity or sedentary behavior. The predictor variables have also been typically treated as individual risk factors such as social isolation. And, surprisingly, diabetes was the only chronic illness that repeatedly emerged as a risk factor, although several medical conditions would be expected to limit activity.

Most of the studies are cross-sectional, making directionality impossible to determine. Some of the variables could be treated as effects or as risks. For example, depression was treated as a negative effect of inactivity, although depression could also be a risk factor for inactivity. And, social isolation was treated as a risk factor, although it could also be seen as a negative effect of inactivity.

Some conditions that have favorably affected activity in aging adults include retirement, walkable neighborhoods and greener neighborhoods. Interventions have included physical activities like “stand-up-and-move”, stepping and Pilates. But these interventions have not been compared, so their relative effectiveness for inactivity/sedentary behavior in aging adults is not known.

For future directions, beyond correcting methodological limitations of the existing literature, several topics seem to be missing from this literature. Surprisingly, bad nutrition, which has contributed significantly to frailty in aging adults, did not appear in this literature. And, the Silver Sneakers activity programs that have served many seniors was only mentioned as continuing during COVID on video programs.

Conclusions

Recent literature on inactivity and sedentary behavior in aging adults has been predominantly focused on their negative effects. Those have included cognitive impairment, reduced muscle strength, frailty, depression and mortality and biological effects have included increased cytokines, triglycerides, hippocampal volume and white matter hyperintensities. Social isolation, loneliness, inadequate nutrition and multiple demographics have been identified as significant predictor variables. Stepping, Pilates and mobile health exercises have been effective interventions. Although more longitudinal studies and robust randomized controlled trials are needed, this literature highlights the negative effects of inactivity and sedentary behavior on aging adults.

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