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Housework is associated with better cognitive, physical and sensorimotor functions in community-dwelling older adults – the Yishun Study.

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Title: Housework is associated with better cognitive, physical and sensorimotor functions in community-dwelling older adults – the Yishun Study.

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Abstract

Introduction: Regular moderate-to-vigorous intensity recreational physical activity (PA) protects against ill health. The relationship between non-recreational PA with ageing health is less explored, especially in high income countries. We examined the associations between housework and functional health among younger and older Singaporean community-dwelling adults.

Methods: Younger (<65yrs,*n*=249) and older (≥65yrs,*n*=240) adults were randomly recruited cross-sectionally from a large Singapore residential town. Light (LH) and heavy housework (HH), recreational, occupational and transport-related PA were assessed using PA questionnaires. Participants were dichotomised into low- and high-volume LH and HH groups. Physical, cognitive and sensorimotor functions were measured using Short Physical Performance Battery, repeated-chair-sit-to-stand, gait speed, Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) and Physiological Profile Assessment (PPA). Results were adjusted for level of recreational and other non-recreational PA.

Results: High housework groups had 5–8% higher RBANS score than low housework groups, among older adults only. Specifically, HH was associated with 14% higher attention score, and LH with 8–12% higher immediate/delayed memory scores. In older adults, sit-to-stand-time and PPA scores were 8% and 23% lower in high HH than low HH group. SPPB and gait speed did not differ with age or HH. LH was not associated with physical or sensorimotor function.

Conclusion: Among older adults, housework is associated with better cognitive function, specifically in attention and memory. Associations between housework with physical and sensorimotor performance were intensity-dependent. In Singapore,

housework PA may improve functional health among community-dwelling older adults, independent of recreation and other non-recreational physical activities.

Key words: Housework intensity, Functional health, High-income countries, Ageing, Household chores, Non-recreational physical activity

Article Summary

Strengths and limitations of this study

- Most research in high-income countries focused on the effects and intensity of recreational physical activity on functional health, but non-recreational physical activity such as housework tasks are a large part of everyday activities in older people, and may affect multitude of health outcomes.
- This study demonstrates, for the first time, housework is associated with better cognitive, physical and sensorimotor functions in older adults, independent of recreational, occupational and transport-related physical activities, even in high-income countries like Singapore.
- Results indicating that incorporating physical activity into daily lifestyle through domestic duties (i.e., housework) has the potential to achieve higher physical activity can be used by policymakers to promote healthier ageing.
- This study is cross-sectional; therefore, associations between housework and functional health in older adults do not necessarily reflect causality.
- Housework activities were self-reported and not objectively measured.

Introduction

Regular physical activity (PA) improves physical and mental health, mitigates the risks and effects of chronic diseases, and reduces falls, immobility, dependency and mortality among older adults [1]. Yet, prevalence of insufficient PA was 27·5% globally, and was more than double in high-income countries than low-income countries (36·8% vs 16·2%) [2]. Among the high-income Asia Pacific countries, the prevalence of insufficient PA was highest in Singapore at 36·5% [2].

In wealthier countries, transition towards more sedentary occupations and motorised transportation could explain the higher levels of inactivity. The majority of PA in high-income countries are from recreational PA, which differed from low-income countries where PA is predominantly from non-recreational activities, including transportation, occupational and housework [2,3]. Furthermore, the prevalence of insufficient PA has increased by ~5% in high-income countries between 2001 and 2016 [3], suggesting that better strategies are required to increase PA, especially among older adults, due to their increased vulnerability to adverse health outcomes [4].

Earlier studies in high-income countries largely focused on the effects of recreational PA on physical and mental capacities, which are key risk factors for falls among older adults [5-7]. Few studies have examined the independent effects of non-recreational activity, such as housework tasks, on age-associated decline in functional ability. Furthermore, although the effects of exercise intensity have been widely investigated [1], there was no study on the associations between housework intensity and age-associated functional health. With the rapidly ageing population

and increasing life expectancy worldwide, approaches to promote healthy ageing, which centres upon the maintenance of functional ability, are urgently needed [8].

Housework activities are a large part of everyday activities in older people, and account for a significant proportion of self-reported PA [9]. Other than a meaningful occupation, housework is also a component of instrumental activities of daily living – both key factors of successful ageing. Additionally, acute and chronic housework are associated with improved cognition, brain volume and executive function, and negatively associated with frailty [10-12]. Regardless of country income levels, higher levels of non-recreational PA were associated with a graded reduction in mortality and cardiovascular diseases, suggesting the important role of non-recreational PA such as housework, on improving health outcomes even in high-income countries [3]. Housework may also confer benefits on physical and mental function among older adults in a high-income country such as Singapore. Therefore, we studied the associations between light and heavy housework activities, with cognitive, physical and sensorimotor function, among younger and older adults in Singapore.

Methods

Settings

Community-dwelling adults (≥21 years) were recruited from a large north-eastern residential town of Yishun in Singapore, with residential population of 220,320 (50·6% females), with 12·2% older adults (≥65 years). This is similar to the overall Singapore residential population of 4,044,200 (51·1% females), with 15·2% older adults (≥65 years) [13].

Participants

Participants were recruited cross-sectionally from the Yishun Study through random sampling, in quotas of 20 to 40 participants in each sex and age group (10-year age groups between 21–60 years old and 5-year age groups after 60 years), to obtain a representative sample of ~300 men and ~300 women [14]. Briefly, community-dwelling adults aged 21 years and above who were independent in performing activities of daily living, had <5 comorbidities, and no neuromuscular or cognitive disorders were recruited. Those between 21–64 years and 65–90 years in age were categorized as younger and older participants respectively. Participants self-reported their years of education and medical conditions and comorbidities. Ethics approval was obtained from the National Healthcare Group DSRB (2017/00212), in accordance with the relevant guidelines from the Declaration of Helsinki and the ethical principles in the Belmont Report. All participants gave written informed consent.

Patient and public involvement

Neither patients nor the public were involved in the design, planning, conduct or reporting of this study.

Anthropometric assessment

Body weight and height were measured using an electronic scale and stadiometer respectively (SECA, Hamburg, Germany). Body mass index was calculated as body weight (kg) divided by height (m) squared.

Housework and PA

Data on housework were self-reported and collected according to the Longitudinal Ageing Study Amsterdam PA questionnaire (LAPAQ) [15], which consists of frequency and time spent on light and heavy household tasks. Light housework tasks (LH) included washing the dishes, dusting, making the bed, doing the laundry, hanging out the laundry, ironing, tidying up, and cooking meals. Heavy housework tasks (HH) included window cleaning, changing beddings, beating the mat, vacuuming, washing or scrubbing the floor, and chores involving sawing, carpeting, repairing or painting. The median time spent per week on household activities was used to dichotomize participants into high and low groups for LH (315 min/week) and HH (15 min/week) groups. Light housework was assigned a metabolic equivalent of task (MET) of 2·5 and heavy housework was assigned a MET of 4·0 [16].

Recreational (sport, fitness or leisure time activities), transport (active commuting/travel) and occupational (work) PA was determined using the Global Physical Activity Questionnaire (GPAQ), which consists of questions assessing the frequency and duration of vigorous- or moderate-intensity activities during a typical week [17]. A cut-off of ≥600 MET minutes/week (≥150 min/week of moderate-intensity or ≥75 min/week of vigorous-intensity PA) was used to determine percentage of participants who met the current PA guidelines [3,18].

Cognitive function

Cognitive performance was assessed by the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS). RBANS is a standardized age-adjusted

battery that is sensitive to cognitive impairment [19]. RBANS assesses global and specific cognitive domains including immediate and delayed memory, visuospatial-construction, language, and attention.

Physical function

Habitual gait speed was assessed using a 6m GAITRite Walkway (CIR Systems Inc, Sparta, NJ) with 2m lead in and out phase. Participants performed three trials and the average timing was recorded. The Short Physical Performance Battery (SPPB) consists of 3 subtests including balance, gait and sit-to-stand [14,20]. The balance subtest composed of 3 parts with progressive difficulty, including unaided feet-together stand, semi-tandem stand and full-tandem stand. Participants were timed until they moved or 10s elapsed time. Gait speed was assessed by participants walking 8ft at their usual pace, with a moving start [20]. The average timing was recorded over two trials. To assess sit-to-stand time, participants folded their arms across their chest and performed five chair stands as quickly as possible. Each of the 3 subtests was scored from 0–4 and the total score was the sum of 3 subtests, ranging from 0–12. Higher SPPB scores indicated better physical function [20].

Sensorimotor or Physiological falls risk assessments

Physiological falls risk was determined using the physiological profile assessment (PPA) short version, which has been shown to predict fall incidents and consists of five validated sensorimotor measures: visual contrast sensitivity, hand reaction time, knee extension strength, proprioception and postural sway [21,22]. The five measures were weighted to compute a composite PPA index score using the NeuRA

FallScreen® Falls Risk Calculator (https://fbirc.neura.edu.au/fallscreen). Higher PPA scores indicates poorer sensorimotor performance and greater falls risk [21,22].

Statistical analysis

All statistical analyses were performed using R version 3·6·2 (R Foundation for statistical computing, Vienna, Austria). A sample size of 400 (100 per group) was needed for the trial to have 80% power to detect a two-sided hypothesis test at an α level of 0·05 (effect size of 0·2) (G*Power, version 3·1, Germany). All participants with completed outcome measures were included for analysis. Numerical variables are presented as mean (standard deviation, SD) in text and figures unless otherwise stated. Participant characteristics were analyzed using independent samples t-test to assess potential differences between high and low HH and LH groups. Sensorimotor, cognitive and physical function measures were analyzed using two-way analysis of variance (ANOVA) for HH and LH independently, with age group (younger vs older), housework groups (low vs high), and their interaction (age*housework) as fixed effects. A value of $p<0·05$ was considered statistically significant.

Results

Participant characteristics

A total of 249 participants (57% women) with mean age of 44 years (SD 14 years) in the younger group, and 240 participants (57·1% women) with mean age of 75 years (SD 6 years) in the older group were included in the analysis. Ethnic distribution of participants (82·0% Chinese, 8·4% Malay, 6·7% Indians, and 2·9% from other races) was similar to that of Singapore's population [13]. A total of 36% and 48% of the

participants in the younger and older group respectively, met the recommended PA level derived exclusively from recreational PA [18]. These values were lower than 61% and 66% of the younger and older participants respectively, who attained the recommended PA level exclusively through housework activities.

Participant demographics between high and low HH and LH groups, such as age, education, anthropometric, PA and housework data, are summarised in Table 1. Within the younger group, high LH group were shorter and had less years of education than low LH group (all $p<0{\cdot}001$, Table 1). Total, recreational and occupational PA did not differ between high and low HH and LH groups in younger and older adults (all $p>0{\cdot}05$, Table 1). Within the younger but not the older group, transport-related PA was 39% lower in low LH than high LH group ($p=0{\cdot}003$, Table 1). Regardless of age group, compared with low HH and LH groups, participants in the high HH and LH groups spent more time on both light and heavy housework activities per week and had higher total housework MET min/week (all $p<0{\cdot}001$, Table 1).

For subsequent light housework analyses, age, sex, height, education, transport PA and heavy housework were included in the model to adjust for confounding variables. To adjust for confounding factors, age, sex and light housework were included in model for subsequent heavy housework analyses. Adjusting for recreational and occupational PA in the analyses did not affect any of the results presented; hence, data are presented with recreational and occupational PA excluded from the model.

Association of heavy housework activities with cognitive function

Within the older group, global cognition was 8% higher in the high HH than low HH group (p=0·012), but did not differ between high and low HH groups among the younger individuals (p=0·630) (age*housework;p=0·031, Fig 1a). Attention index score was 14% higher in the high HH than low HH group within the older (p=0·014) but not the younger (p=0·304) group (age*housework;p=0·012, Fig 1d). Immediate memory index scores between high and low HH groups were not statistically significant among older (p=0·055) and younger adults (p=0·332), despite significant interaction effects (age*housework;p=0·038, Fig 1b). No significant interaction effects between age and HH groups were observed for delayed memory (p=0·108), visuospatial-construction (p=0·183) and language index scores (p=0·776) (Fig 1c,e&f).

Association of heavy housework activities with physical and sensorimotor function

The interaction effects between age and HH groups were not significant for total SPPB score (p=0·155, Fig 2a) and gait speed (p=0·482, Fig 2b). Within the older but not the younger group, sit-to-stand time was 8% lower in the high HH than low HH group (p=0·011 vs p=0·722) (age*housework;p=0·036, Fig 2c). PPA index score was 23% lower in the high HH than low HH group, among the older adults (p=0·040), but not the younger adults (p=0·477) (age*housework;p=0·046, Fig 2d).

Association of light housework activities with cognitive function

Compared with low LH group, high LH group had 5% higher global cognition score among the older but not the younger adults (p=0·016 vs p=0·335) (age*housework;p=0·015, Fig 3a). Within the older but not the younger individuals,

immediate and delayed memory index scores were also 12% (p<0·001 vs p=0·165) and 8% (p=0·004 vs p=0·729) higher in high LH than low LH group respectively (age*housework;p<0·001 and p=0·022, Fig 3b&c). No significant interaction effects between age and LH groups were observed for attention (p=0·194), visuospatial-construction (p=0·781) and language index scores (p=0·318) (Fig 3d–f).

Association of light housework activities with physical and sensorimotor function

The interaction effects between age and LH groups were not significant for total SPPB score (p=0·709), gait speed (p=0·136), sit-to-stand (p=0·445) (Fig 4a–c). PPA index scores between high and low LH groups were not statistically significant among older (p=0·067) and younger adults (p=0·178), despite significant interaction effects (age*housework;p=0·021, Fig 4d).

Discussion

The present study is the first to report that housework activity is associated with cognitive, physical and sensorimotor functions among older but not younger adults in Singapore. We show that more adults attained recommended physical activity levels through housework than recreation. Furthermore, higher levels of housework activity are associated with better cognition in older adults. Higher levels of heavy, but not light housework, were independently associated with better physical and sensorimotor functions in older adults only. These positive associations of housework with functional performance in older adults were independent of recreational, occupational and transport-related physical activities. Our results suggest that in addition to other forms of PA, housework may also confer benefits on functional health in older adults from a high-income country.

Regardless of intensity, higher levels of housework activities were associated with improved global cognition, among our population of older adults. In agreement with our findings, lower levels of housework activities were associated with mild cognitive impairment, cognitive decline and lower grey matter volume among older adults [11,23,24], suggesting that housework activities may have cognitive benefits, possibly through an increase in brain volume, as observed with exercise [25]. However, the positive associations between housework and cognition were not apparent in younger adults in our population. Differences in years of education between younger and older adults likely explain the disparity. Compared with older adults, younger adults in this study had five more years of education on average. Since education level is positively associated with baseline cognitive function and slower cognitive decline [26], it is plausible that higher education levels and cognitive function in younger adults decreases the potential for housework-related cognitive improvements. Our study findings support that among the community-dwelling older adults with fewer education years, housework might ameliorate age-associated cognitive decline, even in high-income countries.

Nonetheless, our results demonstrate that the intensity of housework affected different cognitive domains. Heavy housework was associated with improvements in the attention domain, while light housework was associated with improvements in both delayed and immediate memory domains in older adults. While none of the studies have investigated the associations between housework intensity and specific cognitive domains, earlier studies reported that aerobic exercise interventions of varying intensities improved specific cognitive function domains, including executive

and motor function, attention and memory, through an increase in hippocampal volume and brain-derived neurotrophic factor expression [27-29]. Given that housework accounted for a significant proportion (~24–36%) of self-reported moderate-to-vigorous-intensity PA among older adults, it is plausible that housework improves cognition through a similar mechanism as PA or exercise [9]. These results support that a combination of light and heavy housework tasks may improve age-associated decline in cognitive function, specifically for attention and memory domains. More studies are required to understand the underlying mechanisms driving the differing associations of housework intensity with specific cognitive domains.

Poorer cognitive performance in attention and executive functions were associated with poorer physical function, slower gait, postural instability and future falls among community-dwelling older adults [30-32]. We show that higher levels of heavy housework activities were also independently associated with better sensorimotor performance and chair-stand time in older but not younger adults. Our results suggest that apart from improving cognitive function, heavy housework likely benefits physical and sensorimotor performance, which could in turn reduce physiological falls risk. While the effects of housework on falls are less clear, exercise interventions improved both physical and cognitive functions, and reduced rate of falls in community-dwelling older adults with or without cognitive impairment, suggesting that the favourable effects of exercise on physical function and falls were independent of cognitive function [5-7]. Furthermore, longer chair-stand time and poorer cognitive performance (processing speed and executive function) independently increased the risk of injurious falls over 3–10 years by 10–23%, among older Swedish adults [33]. These results collectively suggest that similar to

exercise, the associated improvement in physical and cognitive functions with heavy housework may independently reduce risk of falls among community-dwelling older adults.

We compared the independent associations of light and heavy housework activities, and demonstrated that unlike heavy housework, light housework was not associated with better physical or sensorimotor function. The lack of associations could be due to the already high functional ability of our study participants [14]. In support, compared with lower intensity exercise, greater improvements in functional ability and decreased fear of falling were observed after high intensity exercise in older adults [34-36]. These results indicate a dose-response effect for exercise intensity on physical function and falls risk in older adults. Similarly, we propose that the associations between housework with better physical and sensorimotor function is dependent on intensity, especially in community-dwelling older adults.

Notably, regardless of age group, a higher percentage (18–25%) of study participants met the PA guidelines derived exclusively from housework, than that attained solely through recreational PA. This finding reflects the challenges inherent with recreational PA participation, which is by definition, done during discretionary hours of the day outside of occupational and domestic duties. Incorporating PA into daily lifestyle through domestic duties (i.e., housework) has the potential to achieve higher PA, which is associated with improved functional health especially among older community-dwelling adults.

Our study recruited adults aged 21–80+ randomly from a large residential town representative of Singapore's population, suggesting a good degree of generalisability. We also included a comparison between older and younger adults in the study, to elucidate the age-associated effects of housework activities on cognitive, physical and sensorimotor function. However, although associations can be drawn from the study results, the cross-sectional design does not prove causality. It is plausible that healthier older adults with higher functional ability engaged in higher levels of housework. Nonetheless, in a 13-year follow-up study, productive housework activities such as cooking and shopping were associated with lower mortality risk in older adults [37], suggesting that housework activities likely improve health in older adults. The study findings cannot be generalised to people living in institutions. In the present study, housework and PA measures were self-reported based on type, intensity, frequency and duration per week. Although the LAPAQ and GPAQ used in this study is valid and reliable [15,17], future studies using more objective measures of housework and PA should be undertaken. It is possible that socio-economic status may mediate the effects of housework on health [38], which should be further examined in the Asian cultural context.

In conclusion, our study suggests that a combination of light and heavy housework is associated with better cognition, specifically in attention and memory domains, among community-dwelling older adults. Furthermore, the associations of housework levels with better physical and sensorimotor functions in older adults were intensity-dependent. Housework may also complement recreational physical activities among current older community-dwelling adults in high-income countries towards healthier aging.

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Contributions

SYL performed the data analysis, interpretation, visualisation and wrote the manuscript. SLW, TPN, BWJP and LKL contributed to the study concept and design. BWJP, LKL, KAJ, WTS, KKC administered the project and collected the data. BWJP, LKL accessed and verified the underlying data. SLW, TPN contributed to the critical revision of the manuscript for important intellectual content. All authors read and approved the final manuscript.

Declaration of Interest

None declared.

Data sharing statement

The datasets used and/or analysed during the current study are available from the corresponding author SLW on reasonable request.

References

1. McPhee JS, French DP, Jackson D, Nazroo J, Pendleton N, Degens H. Physical activity in older age: perspectives for healthy ageing and frailty. *Biogerontology* 2016; **17**(3): 567-80.
2. Guthold R, Stevens GA, Riley LM, Bull FC. Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1·9 million participants. *The Lancet Global Health* 2018; **6**(10): e1077-e86.
3. Lear SA, Hu W, Rangarajan S, et al. The effect of physical activity on mortality and cardiovascular disease in 130 000 people from 17 high-income, middle-income, and low-income countries: the PURE study. *Lancet* 2017; **390**(10113): 2643-54.
4. Cunningham C, R OS, Caserotti P, Tully MA. Consequences of physical inactivity in older adults: A systematic review of reviews and meta-analyses. *Scand J Med Sci Sports* 2020; **30**(5): 816-27.
5. Sherrington C, Michaleff ZA, Fairhall N, et al. Exercise to prevent falls in older adults: an updated systematic review and meta-analysis. *Br J Sports Med* 2017; **51**(24): 1750-8.
6. Lam FM, Huang MZ, Liao LR, Chung RC, Kwok TC, Pang MY. Physical exercise improves strength, balance, mobility, and endurance in people with cognitive impairment and dementia: a systematic review. *J Physiother* 2018; **64**(1): 4-15.
7. García-Hermoso A, Ramirez-Vélez R, Sáez de Asteasu ML, et al. Safety and Effectiveness of Long-Term Exercise Interventions in Older Adults: A Systematic Review and Meta-analysis of Randomized Controlled Trials. *Sports Med* 2020; **50**(6): 1095-106.

8. Beard JR, Officer A, de Carvalho IA, et al. The World report on ageing and health: a policy framework for healthy ageing. *Lancet* 2016; **387**(10033): 2145-54.
9. Murphy MH, Donnelly P, Breslin G, Shibli S, Nevill AM. Does doing housework keep you healthy? The contribution of domestic physical activity to meeting current recommendations for health. *BMC Public Health* 2013; **13**: 966.
10. Stephan AJ, Strobl R, Müller M, et al. A high level of household physical activity compensates for lack of leisure time physical activity with regard to deficit accumulation: Results from the KORA-Age study. *Prev Med* 2016; **86**: 64-9.
11. Koblinsky ND, Meusel L-AC, Greenwood CE, Anderson ND. Household physical activity is positively associated with gray matter volume in older adults. *BMC Geriatrics* 2021; **21**(1): 104.
12. Tsuchiya K, Mitsui S, Fukuyama R, et al. An acute bout of housework activities has beneficial effects on executive function. *Neuropsychiatr Dis Treat* 2018; **14**: 61-72.
13. Singapore DoS. Population and Population Structure. 2020. https://www.singstat.gov.sg./find-data/search-by-theme/population/population-and-population-structure/latest-data (accessed 25 March 2021 2021).
14. Lee SY, Choo PL, Pang BWJ, et al. SPPB reference values and performance in assessing sarcopenia in community-dwelling Singaporeans – Yishun study. *BMC Geriatrics* 2021; **21**(1): 213.
15. Stel VS, Smit JH, Pluijm SM, Visser M, Deeg DJ, Lips P. Comparison of the LASA Physical Activity Questionnaire with a 7-day diary and pedometer. *J Clin Epidemiol* 2004; **57**(3): 252-8.

16. Siebeling L, Wiebers S, Beem L, Puhan MA, Ter Riet G. Validity and reproducibility of a physical activity questionnaire for older adults: questionnaire versus accelerometer for assessing physical activity in older adults. *Clin Epidemiol* 2012; **4**: 171-80.
17. Bull FC, Maslin TS, Armstrong T. Global physical activity questionnaire (GPAQ): nine country reliability and validity study. *J Phys Act Health* 2009; **6**(6): 790-804.
18. Haskell WL, Lee IM, Pate RR, et al. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Med Sci Sports Exerc* 2007; **39**(8): 1423-34.
19. Randolph C, Tierney MC, Mohr E, Chase TN. The Repeatable Battery for the Assessment of Neuropsychological Status (RBANS): preliminary clinical validity. *J Clin Exp Neuropsychol* 1998; **20**(3): 310-9.
20. Guralnik JM, Ferrucci L, Simonsick EM, Salive ME, Wallace RB. Lower-extremity function in persons over the age of 70 years as a predictor of subsequent disability. *N Engl J Med* 1995; **332**(9): 556-61.
21. Lord SR, Ward JA, Williams P, Anstey KJ. Physiological factors associated with falls in older community-dwelling women. *J Am Geriatr Soc* 1994; **42**(10): 1110-7.
22. Lord SR, Menz HB, Tiedemann A. A Physiological Profile Approach to Falls Risk Assessment and Prevention. *Physical Therapy* 2003; **83**(3): 237-52.
23. Jiang C, Xu Y. The association between mild cognitive impairment and doing housework. *Aging Ment Health* 2014; **18**(2): 212-6.
24. Peng Z, Jiang H, Wang X, et al. The Efficacy of Cognitive Training for Elderly Chinese Individuals with Mild Cognitive Impairment. *Biomed Res Int* 2019; **2019**: 4347281.

25. Erickson KI, Leckie RL, Weinstein AM. Physical activity, fitness, and gray matter volume. *Neurobiology of Aging* 2014; **35**: S20-S8.
26. Clouston SAP, Smith DM, Mukherjee S, et al. Education and Cognitive Decline: An Integrative Analysis of Global Longitudinal Studies of Cognitive Aging. *The Journals of Gerontology: Series B* 2020; **75**(7): e151-e60.
27. Angevaren M, Aufdemkampe G, Verhaar HJ, Aleman A, Vanhees L. Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment. *Cochrane Database Syst Rev* 2008; (3): Cd005381.
28. Gomez-Pinilla F, Hillman C. The influence of exercise on cognitive abilities. *Compr Physiol* 2013; **3**(1): 403-28.
29. Smith PJ, Blumenthal JA, Hoffman BM, et al. Aerobic exercise and neurocognitive performance: a meta-analytic review of randomized controlled trials. *Psychosom Med* 2010; **72**(3): 239-52.
30. Tabbarah M, Crimmins EM, Seeman TE. The Relationship Between Cognitive and Physical Performance: MacArthur Studies of Successful Aging. *The Journals of Gerontology: Series A* 2002; **57**(4): M228-M35.
31. Montero-Odasso M, Speechley M. Falls in Cognitively Impaired Older Adults: Implications for Risk Assessment And Prevention. *J Am Geriatr Soc* 2018; **66**(2): 367-75.
32. Muir SW, Gopaul K, Montero Odasso MM. The role of cognitive impairment in fall risk among older adults: a systematic review and meta-analysis. *Age and Ageing* 2012; **41**(3): 299-308.
33. Welmer A-K, Rizzuto D, Laukka EJ, Johnell K, Fratiglioni L. Cognitive and Physical Function in Relation to the Risk of Injurious Falls in Older Adults: A

Population-Based Study. *The Journals of Gerontology: Series A* 2017; **72**(5): 669-75.

34. Sanders LMJ, Hortobágyi T, Karssemeijer EGA, Van der Zee EA, Scherder EJA, van Heuvelen MJG. Effects of low- and high-intensity physical exercise on physical and cognitive function in older persons with dementia: a randomized controlled trial. *Alzheimers Res Ther* 2020; **12**(1): 28.
35. Jiménez-García JD, Hita-Contreras F, de la Torre-Cruz M, et al. Risk of Falls in Healthy Older Adults: Benefits of High-Intensity Interval Training Using Lower Body Suspension Exercises. *J Aging Phys Act* 2019; **27**(3): 325-33.
36. Edholm P, Nilsson A, Kadi F. Physical function in older adults: Impacts of past and present physical activity behaviors. *Scand J Med Sci Sports* 2019; **29**(3): 415-21.
37. Glass TA, de Leon CM, Marottoli RA, Berkman LF. Population based study of social and productive activities as predictors of survival among elderly Americans. *Bmj* 1999; **319**(7208): 478-83.
38. Rodriguez-Stanley J, Alonso-Ferres M, Zilioli S, Slatcher RB. Housework, health, and well-being in older adults: The role of socioeconomic status. *J Fam Psychol* 2020; **34**(5): 610-20.

Table and Figure Captions

Table 1. Mean (SD) Participant characteristics for high and low heavy housework and light housework groups, within younger and older groups.

	Heavy Housework (HH)			**Light Housework (LH)**		
	Low	High	*p* value	Low	High	*p* value
Younger						
n	100	149		137	112	
Sex, Female (n (%))	48 (48)	94 (63)		62 (45)	80 (71)	
Age (years)	43 (15)	44 (13)	0·516	42 (14)	46 (13)	**0·015**
Education (Years)	12 (4)	12 (4)	0·493	13 (4)	11 (4)	**<0·001**
Height (m)	1·64 (0·09)	1·62 (0·08)	0·115	1·65 (0·08)	1·60 (0·08)	**<0·001**
Weight (kg)	68·0 (15·2)	67·7 (17·3)	0·875	69·0 (17·2)	66·4 (15·5)	0·219
Body Mass Index	25·2 (4·8)	25·6 (5·6)	0·557	25·1 (5·4)	25·8 (5·2)	0·324
Physical Activity (MET min/week)						
Recreational	576 (784)	774 (1302)	0·137	637 (933)	764 (1324)	0·393
Transport	2065 (3010)	2003 (2228)	0·861	1577 (1955)	2579 (3075)	**0·003**
Occupational	1686 (3619)	2408 (5658)	0·220	2052 (4252)	2199 (5699)	0·821
Total	4327 (5151)	5185 (6903)	0·263	4266 (4971)	5543 (7511)	0·125
Housework						
Heavy (min/week)	0 (2)	192 (292)	**<0·001**	47 (81)	198 (335)	**<0·001**
Light (min/week)	198 (363)	584 (593)	**<0·001**	95 (87)	838 (592)	**<0·001**
Total (MET min/week)	496 (908)	2228 (2079)	**<0·001**	425 (458)	2887 (2120)	**<0·001**
Older						
n	132	108		103	137	
Sex, Female (n (%))	63 (48)	74 (69)		39 (38)	98 (72)	
Age (Years)	77 (6)	73 (6)	**<0·001**	77 (7)	74 (6)	**0·004**
Education (Years)	6 (4)	7 (5)	0·168	7 (5)	7 (5)	0·764
Height (m)	1·57 (0·09)	1·57 (0·08)	0·987	1·58 (0·08)	1·56 (0·08)	0·064
Weight (kg)	60·1 (10·3)	58·5 (9·6)	0·192	60·4 (9·8)	58·6 (10·1)	0·161
Body Mass Index	24·5 (3·7)	23·8 (3·3)	0·102	24·2 (3·5)	24·1 (3·5)	0·778
Physical Activity (MET min/week)						
Recreational	828 (1053)	890 (1047)	0·650	867 (1181)	847 (941)	0·884
Transport	1561 (1565)	1836 (2050)	0·253	1554 (1964)	1783 (1667)	0·340
Occupational	676 (2269)	401 (1397)	0·251	547 (2113)	557 (1783)	0·968
Total	3065 (2731)	3127 (2531)	0·856	2968 (2968)	3187 (2366)	0·537
Housework						

Heavy (min/week)	0 (0)	131 (140)	**<0·001**	31 (72)	80 (134)	**<0·001**
Light (min/week)	446 (508)	684 (568)	**<0·001**	89 (93)	902 (485)	**<0·001**
Total (MET min/week)	1116 (1270)	2236 (1584)	**<0·001**	347 (377)	2576 (1349)	**<0·001**

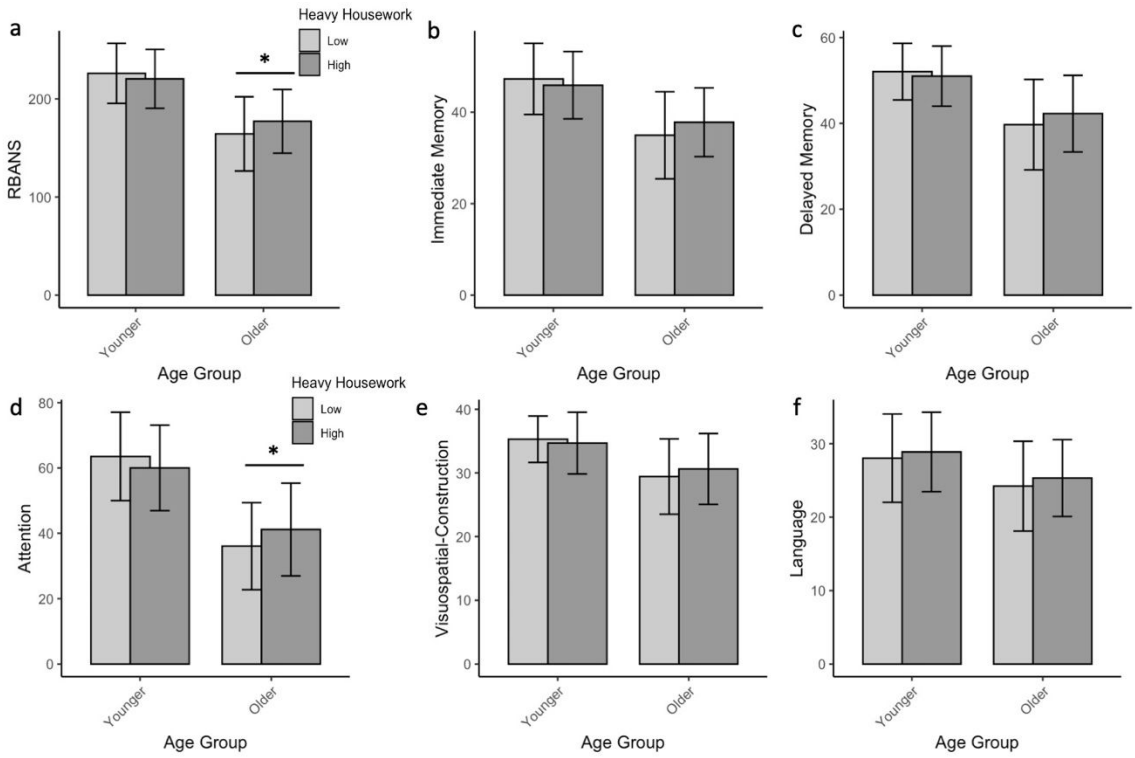

Figure 1. Mean (SD) of global cognitive function and specific domains between high and low heavy housework groups, within younger and older adults. *p<0·05, adjusted for age, sex and time spent on light housework per week.

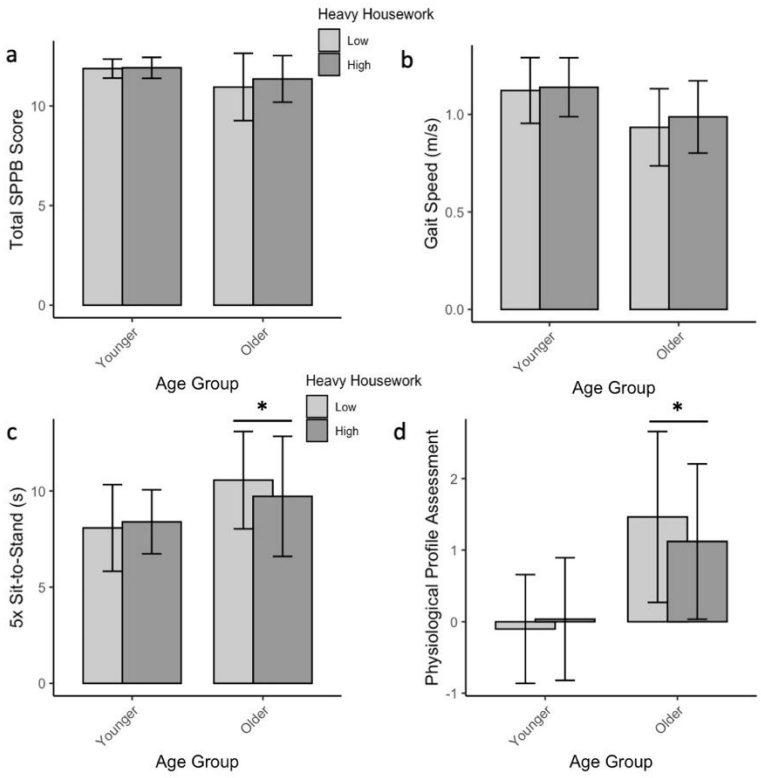

Figure 2. Mean (SD) of physical and sensorimotor function measures including total short physical performance battery score (a), 6m habitual gait speed (b), and five-times repeated chair sit-to-stand time (c), and physiological profile assessment (d), between high and low heavy housework groups, within younger and older adults. *p<0·05, adjusted for age, sex and time spent on light housework per week.

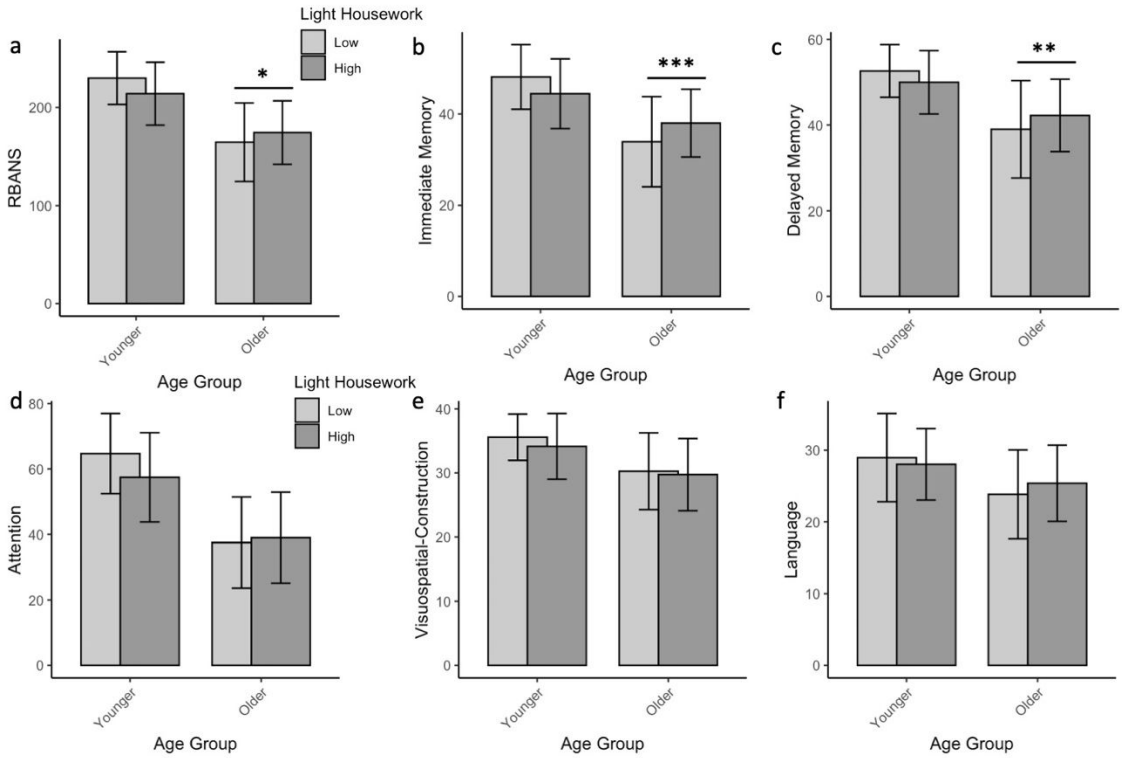

Figure 3. Mean (SD) of global cognitive function and specific domains between high and low light housework groups, within younger and older adults. *p<0·05, **p<0·01, ***p<0·001, adjusted for age, sex, height, years of education, transport-related physical activity and time spent on heavy housework per week.

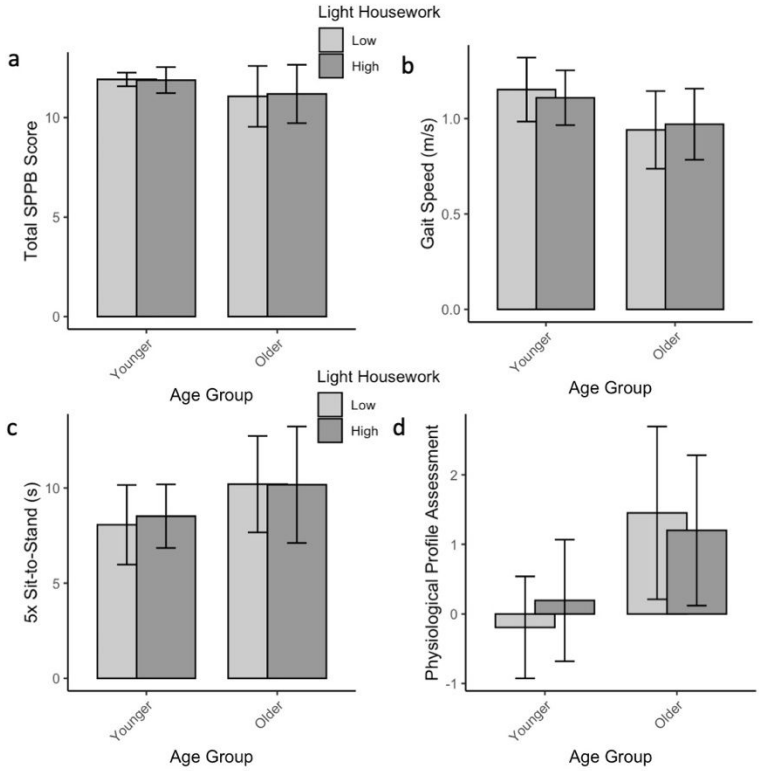

Figure 4. Mean (SD) of physical and sensorimotor function measures including total short physical performance battery score (a), 6m habitual gait speed (b), and five-times repeated chair sit-to-stand time (c), and physiological profile assessment (d), between high and low light housework groups, within younger and older adults. All p>0·05, adjusted for age, sex, height, years of education, transport-related physical activity and time spent on heavy housework per week.

Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

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		Reporting Item	Page Number
Title and abstract			
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	#3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	#4	Present key elements of study design early in the paper	7
Setting	#5	Describe the setting, locations, and relevant dates, including periods of	6

		recruitment, exposure, follow-up, and data collection	
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	7
	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-9
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	7-9
Bias	#9	Describe any efforts to address potential sources of bias	NA
Study size	#10	Explain how the study size was arrived at	10
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	10
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	10-11
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	10
Statistical methods	#12c	Explain how missing data were addressed	NA
Statistical methods	#12d	If applicable, describe analytical methods taking account of sampling strategy	NA
Statistical methods	#12e	Describe any sensitivity analyses	NA
Results			
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	10
Participants	#13b	Give reasons for non-participation at each stage	NA
Participants	#13c	Consider use of a flow diagram	NA

Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	10-11
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	NA
Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	12-13
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12-13
Main results	#16b	Report category boundaries when continuous variables were categorized	NA
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	#18	Summarise key results with reference to study objectives	13
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	17
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	14-16
Generalisability	#21	Discuss the generalisability (external validity) of the study results	17
Other Information			
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

BMJ Open

Cross-sectional associations between housework with cognitive, physical and sensorimotor functions in younger and older community-dwelling adults – the Yishun Study

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Title: Cross-sectional associations between housework with cognitive, physical and sensorimotor functions in younger and older community-dwelling adults – the Yishun Study

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Abstract

Objectives: Regular moderate-to-vigorous intensity recreational physical activity (PA) improves physical and cognitive functions. However, the age-associated relationships between non-recreational PA with functional ability remain less explored. We examined the associations between housework and functional health among younger and older Singaporean community-dwelling adults.

Design: Cross-sectional study

Setting and Participants: Younger (<65yrs, *n*=249) and older (≥65yrs, *n*=240) community-dwelling adults were randomly recruited from a large residential town in Singapore.

Outcome measures: Physical function was assessed using Short Physical Performance Battery, repeated-chair-sit-to-stand and gait speed. Cognitive and sensorimotor functions were assessed using Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) and Physiological Profile Assessment (PPA) respectively.

Methods: Light (LH) and heavy housework (HH), recreational, occupational, and transport-related PA were assessed using PA questionnaires. Participants were dichotomised into low- and high-volume LH and HH groups. Results were adjusted for level of recreational and other non-recreational PA.

Results: Among older but not younger adults, RBANS scores were 8% and 5% higher in high HH and LH groups compared with low HH and LH groups respectively (p=0·012 and p=0·016). Specifically, HH was associated with 14% higher attention score (p=0·014), and LH with 12% and 8% higher immediate and delayed memory scores respectively (p<0·001 and p=0·004). In older adults, sit-to-stand-time and PPA scores were 8% and 23% lower in high HH than low HH group respectively

(*p*=0·011 and *p*=0·040). SPPB and gait speed did not differ with age or HH. LH was not associated with physical or sensorimotor function.

Conclusions: Among older adults, housework is associated with higher cognitive function, specifically in attention and memory. Associations between housework with physical and sensorimotor performance were intensity-dependent. Housework PA is positively associated with functional health among community-dwelling older adults, independent of recreation and other non-recreational physical activities. Further longitudinal and intervention studies are needed to establish causality.

Key words: Housework intensity, Functional health, High-income countries, Ageing, Household chores, Non-recreational physical activity

Article Summary

Strengths and limitations of this study

- Representative sample of Singapore's adult population across age groups
- Comprehensive information about housework, recreational, occupational and transport-related physical activities using validated measures
- Analyses included comparison between younger and older age groups and adjustments for potential confounders
- This study is cross-sectional; therefore, associations between housework and functional health do not necessarily reflect causality.
- Housework and physical activities were self-reported and not objectively measured.

Introduction

Regular physical activity (PA) improves physical and mental health, mitigates the risks and effects of chronic diseases, and reduces falls, immobility, dependency and mortality among older adults [1-3]. Yet, global surveillance data indicate that in 2016, levels of insufficient PA remained high (27·5%) and stable across previous 10 years [4]. The prevalence of insufficient PA was also more than double in high-income countries than low-income countries (36·8% vs 16·2%), and was the highest in Singapore (36·5%), among high-income Asia Pacific countries [4]. In wealthier countries, transition towards more sedentary occupations and motorised transportation could explain the higher levels of inactivity. The majority of PA in high-income countries are from recreational PA, which differed from low-income countries where PA is predominantly from non-recreational activities, including transportation, occupational and housework [4,5]. Given the increasing prevalence of insufficient PA globally [5], better strategies and policies are required to increase PA levels, especially among older adults, due to their increased vulnerability to adverse health outcomes [6].

Earlier studies in high-income countries largely focused on the effects of recreational PA on physical and cognitive capacities, which are key risk factors for falls among older adults [7-9]. Few studies have examined the independent effects of non-recreational activity, such as housework tasks, on age-associated decline in functional ability [10-12]. Furthermore, although the effects of exercise intensity have been widely investigated [1], none of the studies investigated the associations between housework intensity and age-associated functional health. With the rapidly ageing population and increasing life expectancy worldwide, approaches to promote

healthy ageing, which centres upon the maintenance of functional ability, are urgently needed [13].

Housework activities are a large part of everyday activities in older people, and account for a significant proportion of self-reported PA [14]. Apart from a meaningful occupation, housework is also a component of instrumental activities of daily living – both key factors of successful ageing. Additionally, single bout of housework and chronic housework are associated with improved cognition, brain volume and executive function, and negatively associated with frailty [10-12]. Regardless of country income levels, higher levels of non-recreational PA were associated with a graded reduction in mortality and cardiovascular diseases, suggesting the potential role of non-recreational PA such as housework, on improving health outcomes even in high-income countries [5]. Housework may also confer benefits on physical and mental function among older adults in a high-income country such as Singapore. Therefore, we studied the associations between light and heavy housework activities, with cognitive, physical and sensorimotor function, among younger and older adults in Singapore.

Methods

Settings

Community-dwelling adults (≥21 years) were recruited from a large north-eastern residential town of Yishun in Singapore, with residential population of 220,320 (50·6% females), with 12·2% older adults (≥65 years). This is similar to the overall Singapore residential population of 4,044,200 (51·1% females), with 15·2% older adults (≥65 years) [15].

Participants

Participants were recruited cross-sectionally from the Yishun Study through random sampling, in quotas of 20 to 40 participants in each sex and age group (10-year age groups between 21–60 years old and 5-year age groups after 60 years), to obtain a representative sample of ~300 men and ~300 women [16]. Briefly, community-dwelling adults aged 21 years and above who were independent in performing activities of daily living, had <5 comorbidities, and no neuromuscular or cognitive disorders were recruited. Those between 21–64 years and 65–90 years in age were categorized as younger and older participants respectively. Participants self-reported their years of education and medical conditions and comorbidities. All assessments were based on standardized protocols and administered by trained researchers at the Geriatric Education & Research Institute Lab on Yishun Health Campus, mostly within one visit. Ethics approval was obtained from the National Healthcare Group DSRB (2017/00212), in accordance with the relevant guidelines from the Declaration of Helsinki and the ethical principles in the Belmont Report. All participants gave written informed consent.

Patient and public involvement

Neither patients nor the public were involved in the design, planning, conduct or reporting of this study.

Anthropometric assessment

Body weight and height were measured using an electronic scale and stadiometer respectively (SECA, Hamburg, Germany). Body mass index was calculated as body weight (kg) divided by height (m) squared.

Housework, recreational, transport and occupational PA

Data on housework were self-reported and collected according to the Longitudinal Ageing Study Amsterdam PA questionnaire (LAPAQ) [17], which consists of specific questions regarding frequency and time spent on light and heavy household tasks. Light housework tasks (LH) included washing the dishes, dusting, making the bed, doing the laundry, hanging out the laundry, ironing, tidying up, and cooking meals. Heavy housework tasks (HH) included window cleaning, changing beddings, beating the mat, vacuuming, washing or scrubbing the floor, and chores involving sawing, carpeting, repairing or painting. The median time spent per week on household activities was used to dichotomize participants into high and low groups for LH (315 min/week) and HH (15 min/week) groups. Light housework was assigned a metabolic equivalent of task (MET) of 2·5 and heavy housework was assigned a MET of 4·0 [18].

Recreational (sport, fitness or leisure time activities), transport (active commuting/travel) and occupational (work) PA were determined using the Global Physical Activity Questionnaire (GPAQ), which consists of questions assessing the frequency and duration of vigorous- or moderate-intensity activities during a typical week [19]. A cut-off of ≥600 MET min/week (≥150 min/week of moderate-intensity PA

or ≥75 min/week of vigorous-intensity PA) was used to determine percentage of participants who met the current PA guidelines [5,20].

Cognitive function

Cognitive performance was assessed by the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) score. RBANS is a standardized age-adjusted battery that is sensitive to cognitive impairment [21]. RBANS assesses global and specific cognitive domains including immediate and delayed memory, visuospatial-construction, language, and attention.

Physical function

Habitual gait speed was assessed using a 6m GAITRite Walkway (CIR Systems Inc, Sparta, NJ) with 2m lead in and out phase. Participants performed three trials and the average timing was recorded. The Short Physical Performance Battery (SPPB) consists of 3 subtests including balance, gait and sit-to-stand [22,23]. The balance subtest composed of 3 parts with progressive difficulty, including unaided feet-together stand, semi-tandem stand and full-tandem stand. Participants were timed until they moved or 10s elapsed time. Gait speed was assessed by participants walking 8ft at their usual pace, with a moving start [22]. The average timing was recorded over two trials. To assess sit-to-stand time, participants folded their arms across their chest and performed five chair stands as quickly as possible. Each of the 3 subtests was scored from 0–4 and the total score was the sum of 3 subtests, ranging from 0–12. Higher SPPB scores indicated better physical function [22].

Sensorimotor or Physiological falls risk assessments

Physiological falls risk was determined using the physiological profile assessment (PPA) short version, which has been shown to predict fall incidents and consists of five validated sensorimotor measures: visual contrast sensitivity, hand reaction time, knee extension strength, proprioception and postural sway [24,25]. The five measures were weighted to compute a composite PPA index score using the NeuRA FallScreen® Falls Risk Calculator (https://fbirc.neura.edu.au/fallscreen). Higher PPA scores indicates poorer sensorimotor performance and greater falls risk [24,25].

Statistical analysis

All statistical analyses were performed using R version 3·6·2 (R Foundation for statistical computing, Vienna, Austria). A sample size of 400 (100 per group) was needed for the trial to have 80% power to detect a two-sided hypothesis test at an α level of 0·05 (effect size of 0·2) (G*Power, version 3·1, Germany). All participants with completed outcome measures were included for analysis. Numerical variables are presented as mean (standard deviation, SD) in text and figures unless otherwise stated. Participant characteristics were analyzed using independent samples t-test to assess potential differences between high and low HH and LH groups. Sensorimotor, cognitive and physical function measures were analyzed using two-way analysis of variance (ANOVA) for HH and LH independently, with age group (younger vs older), housework groups (low vs high), and their interaction (age*housework) as fixed effects. Normality and homogeneity of variances assumptions were tested using Shapiro-Wilk and Levene's test respectively. Effect sizes are reported with partial eta squared (η^2_p) [26]. A value of $p<0·05$ was considered statistically significant.

Results

Participant characteristics

A total of 249 participants (57% women) with mean age of 44 years (SD 14 years) in the younger group, and 240 participants (57·1% women) with mean age of 75 years (SD 6 years) in the older group were included in the analysis. Ethnic distribution of participants (82·0% Chinese, 8·4% Malay, 6·7% Indians, and 2·9% from other ethnicities) was similar to that of Singapore's population [15]. A total of 36%(*n*=90) and 48%(*n*=116) of the participants in the younger and older group respectively, met the recommended PA level derived exclusively from recreational PA [20]. These values were lower than 61%(*n*=152) and 66(*n*=159) of the younger and older participants respectively, who attained the recommended PA level exclusively through housework activities.

Participant demographics between high and low HH and LH groups, such as age, education, anthropometric, PA and housework data, are summarised in Table 1. Compared with low HH and LH groups, majority of participants in high HH and LH groups were women, regardless of age groups. Within the younger group, high LH group were shorter and had less years of education than low LH group (all $p<0{\cdot}001$, Table 1). Total, recreational and occupational PA did not differ between high and low HH and LH groups in younger and older adults (all $p>0{\cdot}05$, Table 1). Within the younger but not the older group, transport-related PA was 39% lower in low LH than high LH group ($p=0{\cdot}003$, Table 1). Regardless of age group, compared with low HH and LH groups, participants in the high HH and LH groups spent more time on both

light and heavy housework activities per week and had higher total housework MET min/week (all $p<0{\cdot}001$, Table 1).

For subsequent light housework analyses, age, sex, height, education, transport PA and heavy housework were included in the model to adjust for confounding variables. To adjust for confounding factors, age, sex and light housework were included in model for subsequent heavy housework analyses. Adjusting for recreational and occupational PA in the analyses did not affect any of the results presented; hence, data are presented with recreational and occupational PA excluded from the model.

Association of heavy housework activities with cognitive function

Within the older group, RBANS global cognition score was 8% higher in the high HH than low HH group ($p=0{\cdot}012$) but did not differ between high and low HH groups among the younger individuals ($p=0{\cdot}630$) (age*housework; $p=0{\cdot}031$, $\eta^2_p=0{\cdot}01$, Fig 1a). Immediate memory index scores between high and low HH groups were not statistically significant among older ($p=0{\cdot}055$) and younger adults ($p=0{\cdot}332$), despite significant interaction effects (age*housework; $p=0{\cdot}038$, $\eta^2_p=0{\cdot}009$, Fig 1b). No significant interaction effects between age and HH groups were observed for delayed memory ($p=0{\cdot}108$, $\eta^2_p=0{\cdot}005$), visuospatial-construction ($p=0{\cdot}183$, $\eta^2_p=0{\cdot}004$), and language index scores ($p=0{\cdot}776$, $\eta^2_p=0{\cdot}0002$) (Fig 1c-e). Attention index score was 14% higher in the high HH than low HH group within the older ($p=0{\cdot}014$) but not the younger ($p=0{\cdot}304$) group (age*housework; $p=0{\cdot}012$, $\eta^2_p=0{\cdot}01$, Fig 1f).

Association of light housework activities with cognitive function

Compared with low LH group, high LH group had 5% higher RBANS global cognition score among the older but not the younger adults (p=0·016 vs p=0·335) (age*housework;p=0·015, η^2_p=0·01, Fig 2a). Within the older but not the younger individuals, immediate and delayed memory index scores were also 12% (p<0·001 vs p=0·165) and 8% (p=0·004 vs p=0·729) higher in high LH than low LH group respectively (age*housework;p<0·001, η^2_p=0·03 and p=0·022, η^2_p=0·01)(Fig 2b&c). No significant interaction effects between age and LH groups were observed for visuospatial-construction (p=0·781, η^2_p=0·0002), language (p=0·318, η^2_p=0·002) and attention (p=0·194, η^2_p=0·004) index scores (Fig 2d–f).

Association of heavy housework activities with physical and sensorimotor function

The interaction effects between age and HH groups were not significant for total SPPB score (p=0·155, η^2_p=0·004, Fig 3a) and gait speed (p=0·482, η^2_p=0·001, Fig 3b). Within the older but not the younger group, sit-to-stand time was 8% lower in the high HH than low HH group (p=0·011 vs p=0·722) (age*housework;p=0·036, η^2_p=0·009, Fig 3c). PPA index score, indicative of sensorimotor function, was 23% lower in the high HH than low HH group, among the older (p=0·040) but not the younger adults (p=0·477) (age*housework;p=0·046, η^2_p=0·008, Fig 3d).

Association of light housework activities with physical and sensorimotor function

The interaction effects between age and LH groups were not significant for total SPPB score (p=0·709, η^2_p=0·0003), gait speed (p=0·136, η^2_p=0·005), sit-to-stand (p=0·445, η^2_p=0·001) (Fig 4a–c). PPA index scores, indicative of sensorimotor function, were not significant between high and low LH groups among older

(*p*=0·067) and younger adults (*p*=0·178), despite significant interaction effects (age*housework;*p*=0·021, η^2_p=0·01, Fig 4d). Mean (SD) values of cognitive, physical and sensorimotor performance between age and housework groups are presented in Supplementary Table S1.

Discussion

The present study is the first to report that housework activity is associated with cognitive, physical and sensorimotor functions among older but not younger adults in Singapore. These positive associations of housework with functional performance in older adults were independent of recreational, occupational and transport-related physical activities. We also show that more adults attained recommended physical activity levels through housework than recreation.

Regardless of intensity, higher levels of housework activities were associated with higher global cognition, among our population of older adults. Earlier studies observed that lower levels of housework activities were associated with mild cognitive impairment, cognitive decline and lower grey matter volume among older adults [11,27,28], suggesting a positive association between housework activities and cognitive function, plausibly through an increase in brain volume, as observed with exercise interventions in older adults [29,30]. However, the positive associations between housework and cognition were not apparent in younger adults in our population. Differences in years of education between younger and older adults likely explain the disparity, as younger adults in this study had five more years of education on average than older adults. Since education level is positively associated with baseline cognitive function and slower cognitive decline [31], it is

plausible that higher education levels and cognitive function in younger adults decreases the potential for better cognitive function associated with housework activities.

Our results demonstrate, for the first time, that the intensity of housework was differentially associated with specific cognitive domains. Heavy housework was associated with higher scores in the attention domain, while light housework was associated with higher scores in both delayed and immediate memory domains in older adults. Earlier studies reported that aerobic exercise interventions of varying intensities improved specific cognitive function domains, including executive and motor function, attention and memory, through an increase in hippocampal volume and brain-derived neurotrophic factor expression [32-34]. Given that housework accounted for a significant proportion (~24–36% in women and ~19–28% in men) of self-reported moderate-to-vigorous-intensity PA among older adults aged above 60 [14], it is plausible that the higher cognitive function associated with housework occurs through a similar mechanism as PA or exercise [14]. More studies are required to understand the underlying mechanisms driving the age-associated differing associations of housework intensity with specific cognitive domains.

Poorer cognitive performance in attention and executive functions were associated with poorer physical function, slower gait, postural instability, and future falls among community-dwelling older adults [35-37]. We show that higher levels of heavy housework activities were also independently associated with better physical (chair-stand time) and sensorimotor (PPA) performance in older but not younger adults. Among older Swedish adults, longer chair-stand time and poorer cognitive

performance (processing speed and executive function) independently increased the risk of injurious falls over 3–10 years by 10–23%[38]. Unlike older adults, younger adults have higher functional abilities and are unlikely to experience decline in sensorimotor and physical function, potentially explaining the lack of associations between housework activities with physical and sensorimotor performance. These results collectively suggest that the higher cognitive, physical and sensorimotor functions related to heavy housework activities might plausibly be associated with lower physiological fall risk among community-dwelling older adults.

We compared the independent associations of light and heavy housework activities, and demonstrated that unlike heavy housework, light housework was not associated with physical or sensorimotor function. The lack of associations could be due to the already high functional ability of our study participants [23]. In support, compared with lower intensity exercise, greater improvements in functional ability and decreased fear of falling were observed after high intensity exercise in older adults [39-41]. These results indicate a dose-response effect for exercise intensity on physical and sensorimotor function and associated falls risk in older adults. Similarly, we propose that the positive associations between housework with physical and sensorimotor function is dependent on intensity, especially in community-dwelling older adults.

Notably in this present study, 25% and 18% more participants in the younger and older group, respectively, met the PA guidelines derived exclusively from housework, than that attained solely through recreational PA. This finding reflects the challenges inherent with recreational PA participation, which is by definition, done during discretionary hours of the day outside of occupational and domestic duties.

Incorporating PA into daily lifestyle through domestic duties (i.e., housework) has the potential to achieve higher PA, which is positively associated with functional health especially among older community-dwelling adults.

Our study recruited adults aged 21–80+ randomly from a large residential town representative of Singapore's population, suggesting a good degree of generalisability. We also included a comparison between older and younger adults in the study, to elucidate the age-associated effects of housework activities on cognitive, physical and sensorimotor function. However, although associations can be drawn from the study results, the cross-sectional design does not prove causality. It is plausible that healthier older adults with higher functional ability engaged in higher levels of housework. Nonetheless, in a 13-year follow-up study, productive housework activities such as cooking and shopping were associated with lower mortality risk in older adults [42], suggesting that housework activities are associated with better health outcomes in older adults. The study findings in community-dwelling individuals cannot be generalised to institutionalised older adults, such as those in nursing homes. In the present study, housework and PA measures were self-reported based on type, intensity, frequency and duration per week. Although the LAPAQ and GPAQ used in this study is valid and reliable [17,19], future studies using more objective measures of housework and PA should be undertaken. It is possible that socio-economic status may mediate the effects of housework on health [43], which should be further examined in the Asian cultural context. While we adjusted for sex in all analyses, compared with low housework groups, participants in high housework groups were mostly women, which is consistent with earlier studies showing greater

involvement in household chores among women than men [44]. Future studies should investigate the sex-specific effects of housework on functional health.

In conclusion, our study suggests that a combination of light and heavy housework is associated with higher cognitive function, specifically in attention and memory domains, among community-dwelling older adults. Furthermore, the positive associations of housework levels with physical and sensorimotor functions in older adults were intensity-dependent. Housework may also complement recreational physical activities among current older community-dwelling adults in high-income countries towards healthier ageing. Future longitudinal and intervention studies are required to establish causality between housework activities and functional health.

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Contributions

SYL performed the data analysis, interpretation, visualisation and wrote the manuscript. SLW, TPN, BWJP and LKL contributed to the study concept and design. BWJP, LKL, KAJ, WTS, KKC administered the project and collected the data. BWJP, LKL accessed and verified the underlying data. SLW, TPN contributed to the critical revision of the manuscript for important intellectual content. All authors read and approved the final manuscript.

Declaration of Interest

None declared.

Data sharing statement

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Ethics Approval Statement

This study involves human participants and was approved by an Ethics Committee(s) or Institutional Board(s) - [National Healthcare Group DSRB (2017/00212)].

References

1. McPhee JS, French DP, Jackson D, Nazroo J, Pendleton N, Degens H. Physical activity in older age: perspectives for healthy ageing and frailty. *Biogerontology* 2016; **17**(3): 567-80.

2. Geidl W, Schlesinger S, Mino E, Miranda L, Pfeifer K. Dose-response relationship between physical activity and mortality in adults with noncommunicable diseases: a systematic review and meta-analysis of prospective observational studies. *Int J Behav Nutr Phys Act* 2020; **17**(1): 109.

3. Sherrington C, Fairhall N, Kwok W, et al. Evidence on physical activity and falls prevention for people aged 65+ years: systematic review to inform the WHO guidelines on physical activity and sedentary behaviour. *Int J Behav Nutr Phys Act* 2020; **17**(1): 144.

4. Guthold R, Stevens GA, Riley LM, Bull FC. Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1·9 million participants. *The Lancet Global Health* 2018; **6**(10): e1077-e86.

5. Lear SA, Hu W, Rangarajan S, et al. The effect of physical activity on mortality and cardiovascular disease in 130 000 people from 17 high-income, middle-income, and low-income countries: the PURE study. *Lancet* 2017; **390**(10113): 2643-54.

6. Cunningham C, R OS, Caserotti P, Tully MA. Consequences of physical inactivity in older adults: A systematic review of reviews and meta-analyses. *Scand J Med Sci Sports* 2020; **30**(5): 816-27.

7. Sherrington C, Michaleff ZA, Fairhall N, et al. Exercise to prevent falls in older adults: an updated systematic review and meta-analysis. *Br J Sports Med* 2017; **51**(24): 1750-8.

8. Lam FM, Huang MZ, Liao LR, Chung RC, Kwok TC, Pang MY. Physical exercise improves strength, balance, mobility, and endurance in people with cognitive impairment and dementia: a systematic review. *J Physiother* 2018; **64**(1): 4-15.

9. García-Hermoso A, Ramirez-Vélez R, Sáez de Asteasu ML, et al. Safety and Effectiveness of Long-Term Exercise Interventions in Older Adults: A Systematic Review and Meta-analysis of Randomized Controlled Trials. *Sports Med* 2020; **50**(6): 1095-106.

10. Stephan AJ, Strobl R, Müller M, et al. A high level of household physical activity compensates for lack of leisure time physical activity with regard to deficit accumulation: Results from the KORA-Age study. *Prev Med* 2016; **86**: 64-9.

11. Koblinsky ND, Meusel L-AC, Greenwood CE, Anderson ND. Household physical activity is positively associated with gray matter volume in older adults. *BMC Geriatrics* 2021; **21**(1): 104.

12. Tsuchiya K, Mitsui S, Fukuyama R, et al. An acute bout of housework activities has beneficial effects on executive function. *Neuropsychiatr Dis Treat* 2018; **14**: 61-72.

13. Beard JR, Officer A, de Carvalho IA, et al. The World report on ageing and health: a policy framework for healthy ageing. *Lancet* 2016; **387**(10033): 2145-54.

14. Murphy MH, Donnelly P, Breslin G, Shibli S, Nevill AM. Does doing housework keep you healthy? The contribution of domestic physical activity to meeting current recommendations for health. *BMC Public Health* 2013; **13**: 966.

15. Department of Statistics Singapore. Population and Population Structure. 2020. https://www.singstat.gov.sg./find-data/search-by-theme/population/population-and-population-structure/latest-data (accessed 25 March 2021 2021).

16. Pang BWJ, Wee SL, Lau LK, et al. Prevalence and Associated Factors of Sarcopenia in Singaporean Adults-The Yishun Study. *J Am Med Dir Assoc* 2020.

17. Stel VS, Smit JH, Pluijm SM, Visser M, Deeg DJ, Lips P. Comparison of the LASA Physical Activity Questionnaire with a 7-day diary and pedometer. *J Clin Epidemiol* 2004; **57**(3): 252-8.

18. Siebeling L, Wiebers S, Beem L, Puhan MA, Ter Riet G. Validity and reproducibility of a physical activity questionnaire for older adults: questionnaire versus accelerometer for assessing physical activity in older adults. *Clin Epidemiol* 2012; **4**: 171-80.

19. Bull FC, Maslin TS, Armstrong T. Global physical activity questionnaire (GPAQ): nine country reliability and validity study. *J Phys Act Health* 2009; **6**(6): 790-804.

20. Haskell WL, Lee IM, Pate RR, et al. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Med Sci Sports Exerc* 2007; **39**(8): 1423-34.

21. Randolph C, Tierney MC, Mohr E, Chase TN. The Repeatable Battery for the Assessment of Neuropsychological Status (RBANS): preliminary clinical validity. *J Clin Exp Neuropsychol* 1998; **20**(3): 310-9.

22. Guralnik JM, Ferrucci L, Simonsick EM, Salive ME, Wallace RB. Lower-extremity function in persons over the age of 70 years as a predictor of subsequent disability. *N Engl J Med* 1995; **332**(9): 556-61.

23. Lee SY, Choo PL, Pang BWJ, et al. SPPB reference values and performance in assessing sarcopenia in community-dwelling Singaporeans – Yishun study. *BMC Geriatrics* 2021; **21**(1): 213.

24. Lord SR, Ward JA, Williams P, Anstey KJ. Physiological factors associated with falls in older community-dwelling women. *J Am Geriatr Soc* 1994; **42**(10): 1110-7.

25. Lord SR, Menz HB, Tiedemann A. A Physiological Profile Approach to Falls Risk Assessment and Prevention. *Physical Therapy* 2003; **83**(3): 237-52.

26. Lakens D. Calculating and reporting effect sizes to facilitate cumulative science: a practical primer for t-tests and ANOVAs. *Front Psychol* 2013; **4**: 863.

27. Jiang C, Xu Y. The association between mild cognitive impairment and doing housework. *Aging Ment Health* 2014; **18**(2): 212-6.

28. Peng Z, Jiang H, Wang X, et al. The Efficacy of Cognitive Training for Elderly Chinese Individuals with Mild Cognitive Impairment. *Biomed Res Int* 2019; **2019**: 4347281.

29. Colcombe SJ, Erickson KI, Scalf PE, et al. Aerobic Exercise Training Increases Brain Volume in Aging Humans. *The Journals of Gerontology: Series A* 2006; **61**(11): 1166-70.

30. Erickson KI, Leckie RL, Weinstein AM. Physical activity, fitness, and gray matter volume. *Neurobiology of Aging* 2014; **35**: S20-S8.

31. Clouston SAP, Smith DM, Mukherjee S, et al. Education and Cognitive Decline: An Integrative Analysis of Global Longitudinal Studies of Cognitive Aging. *The Journals of Gerontology: Series B* 2020; **75**(7): e151-e60.

32. Angevaren M, Aufdemkampe G, Verhaar HJ, Aleman A, Vanhees L. Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment. *Cochrane Database Syst Rev* 2008; (3): Cd005381.

33. Gomez-Pinilla F, Hillman C. The influence of exercise on cognitive abilities. *Compr Physiol* 2013; **3**(1): 403-28.

34. Smith PJ, Blumenthal JA, Hoffman BM, et al. Aerobic exercise and neurocognitive performance: a meta-analytic review of randomized controlled trials. *Psychosom Med* 2010; **72**(3): 239-52.

35. Tabbarah M, Crimmins EM, Seeman TE. The Relationship Between Cognitive and Physical Performance: MacArthur Studies of Successful Aging. *The Journals of Gerontology: Series A* 2002; **57**(4): M228-M35.

36. Montero-Odasso M, Speechley M. Falls in Cognitively Impaired Older Adults: Implications for Risk Assessment And Prevention. *J Am Geriatr Soc* 2018; **66**(2): 367-75.

37. Muir SW, Gopaul K, Montero Odasso MM. The role of cognitive impairment in fall risk among older adults: a systematic review and meta-analysis. *Age and Ageing* 2012; **41**(3): 299-308.

38. Welmer A-K, Rizzuto D, Laukka EJ, Johnell K, Fratiglioni L. Cognitive and Physical Function in Relation to the Risk of Injurious Falls in Older Adults: A Population-Based Study. *The Journals of Gerontology: Series A* 2017; **72**(5): 669-75.

39. Sanders LMJ, Hortobágyi T, Karssemeijer EGA, Van der Zee EA, Scherder EJA, van Heuvelen MJG. Effects of low- and high-intensity physical exercise on physical and cognitive function in older persons with dementia: a randomized controlled trial. *Alzheimers Res Ther* 2020; **12**(1): 28.

40. Jiménez-García JD, Hita-Contreras F, de la Torre-Cruz M, et al. Risk of Falls in Healthy Older Adults: Benefits of High-Intensity Interval Training Using Lower Body Suspension Exercises. *J Aging Phys Act* 2019; **27**(3): 325-33.

41. Edholm P, Nilsson A, Kadi F. Physical function in older adults: Impacts of past and present physical activity behaviors. *Scand J Med Sci Sports* 2019; **29**(3): 415-21.

42. Glass TA, de Leon CM, Marottoli RA, Berkman LF. Population based study of social and productive activities as predictors of survival among elderly Americans. *Bmj* 1999; **319**(7208): 478-83.

43. Rodriguez-Stanley J, Alonso-Ferres M, Zilioli S, Slatcher RB. Housework, health, and well-being in older adults: The role of socioeconomic status. *J Fam Psychol* 2020; **34**(5): 610-20.

44. Bianchi SM, Sayer LC, Milkie MA, Robinson JP. Housework: Who Did, Does or Will Do It, and How Much Does It Matter? *Soc Forces* 2012; **91**(1): 55-63.

Table 1. Mean (SD) Participant characteristics for high and low heavy housework and light housework groups, within younger and older groups.

	Heavy Housework (HH)			**Light Housework (LH)**		
	Low	High	*p* value	Low	High	*p* value
Younger						
n	100	149		137	112	
Sex, Female (n (%))	48 (48)	94 (63)		62 (45)	80 (71)	
Age (years)	43 (15)	44 (13)	0·516	42 (14)	46 (13)	**0·015**
Education (Years)	12 (4)	12 (4)	0·493	13 (4)	11 (4)	**<0·001**
Height (m)	1·64 (0·09)	1·62 (0·08)	0·115	1·65 (0·08)	1·60 (0·08)	**<0·001**
Weight (kg)	68·0 (15·2)	67·7 (17·3)	0·875	69·0 (17·2)	66·4 (15·5)	0·219
Body Mass Index	25·2 (4·8)	25·6 (5·6)	0·557	25·1 (5·4)	25·8 (5·2)	0·324
Physical Activity (GPAQ)						
Recreational (MET min/week)	576 (784)	774 (1302)	0·137	637 (933)	764 (1324)	0·393
Transport (MET min/week)	2065 (3010)	2003 (2228)	0·861	1577 (1955)	2579 (3075)	**0·003**
Occupational (MET min/week)	1686 (3619)	2408 (5658)	0·220	2052 (4252)	2199 (5699)	0·821
Total (MET min/week)	4327 (5151)	5185 (6903)	0·263	4266 (4971)	5543 (7511)	0·125
Housework Activity (LAPAQ)						
Heavy (min/week)	0 (2)	192 (292)	**<0·001**	47 (81)	198 (335)	**<0·001**
Light (min/week)	198 (363)	584 (593)	**<0·001**	95 (87)	838 (592)	**<0·001**
Total (MET min/week)	496 (908)	2228 (2079)	**<0·001**	425 (458)	2887 (2120)	**<0·001**
Older						
n	132	108		103	137	
Sex, Female (n (%))	63 (48)	74 (69)		39 (38)	98 (72)	
Age (Years)	77 (6)	73 (6)	**<0·001**	77 (7)	74 (6)	**0·004**
Education (Years)	6 (4)	7 (5)	0·168	7 (5)	7 (5)	0·764
Height (m)	1·57 (0·09)	1·57 (0·08)	0·987	1·58 (0·08)	1·56 (0·08)	0·064
Weight (kg)	60·1 (10·3)	58·5 (9·6)	0·192	60·4 (9·8)	58·6 (10·1)	0·161
Body Mass Index	24·5 (3·7)	23·8 (3·3)	0·102	24·2 (3·5)	24·1 (3·5)	0·778
Physical Activity (GPAQ)						
Recreational (MET min/week)	828 (1053)	890 (1047)	0·650	867 (1181)	847 (941)	0·884
Transport (MET min/week)	1561 (1565)	1836 (2050)	0·253	1554 (1964)	1783 (1667)	0·340
Occupational (MET min/week)	676 (2269)	401 (1397)	0·251	547 (2113)	557 (1783)	0·968
Total (MET min/week)	3065 (2731)	3127 (2531)	0·856	2968 (2968)	3187 (2366)	0·537
Housework Activity (LAPAQ)						

Heavy (min/week)	0 (0)	131 (140)	**<0·001**	31 (72)	80 (134)	**<0·001**
Light (min/week)	446 (508)	684 (568)	**<0·001**	89 (93)	902 (485)	**<0·001**
Total (MET min/week)	1116 (1270)	2236 (1584)	**<0·001**	347 (377)	2576 (1349)	**<0·001**

Figure captions

Figure 1. Mean (SD) of global cognitive function and specific domains between high and low heavy housework groups, within younger and older adults. *p<0·05, adjusted for age, sex and time spent on light housework per week.

Figure 2. Mean (SD) of global cognitive function and specific domains between high and low light housework groups, within younger and older adults. *p<0·05, **p<0·01, ***p<0·001, adjusted for age, sex, height, years of education, transport-related physical activity and time spent on heavy housework per week.

Figure 3. Mean (SD) of physical function measures including total short physical performance battery score (a), 6m habitual gait speed (b), and five-times repeated chair sit-to-stand time (c), and sensorimotor function measure including physiological profile assessment (d), between high and low heavy housework groups, within younger and older adults. *p<0·05, adjusted for age, sex and time spent on light housework per week.

Figure 4. Mean (SD) of physical function measures including total short physical performance battery score (a), 6m habitual gait speed (b), and five-times repeated chair sit-to-stand time (c), and sensorimotor function measure including physiological profile assessment (d), between high and low light housework groups, within younger and older adults. All p>0·05, adjusted for age, sex, height, years of education, transport-related physical activity and time spent on heavy housework per week.

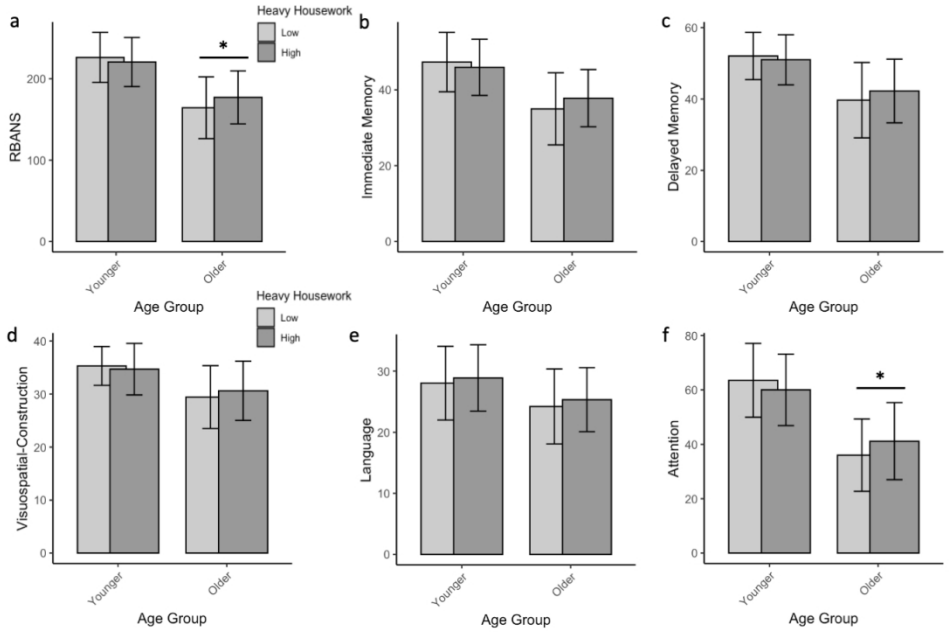

Figure 1. Mean (SD) of global cognitive function and specific domains between high and low heavy housework groups, within younger and older adults. *p<0·05, adjusted for age, sex and time spent on light housework per week.

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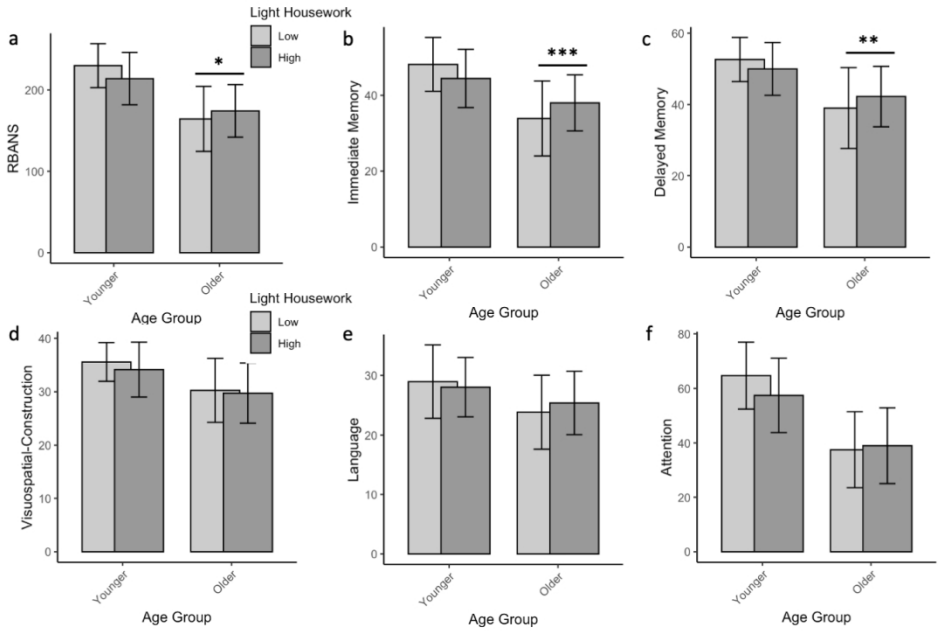

Figure 2. Mean (SD) of global cognitive function and specific domains between high and low light housework groups, within younger and older adults. *p<0·05, **p<0·01, ***p<0·001, adjusted for age, sex, height, years of education, transport-related physical activity and time spent on heavy housework per week.

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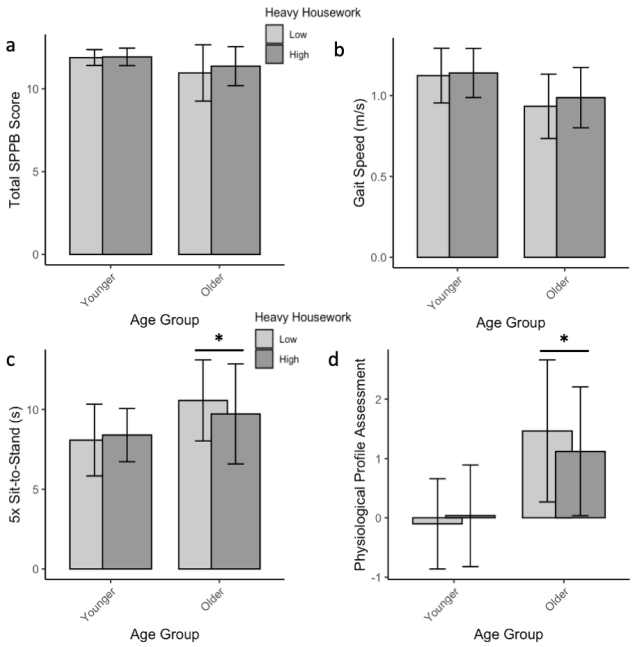

Figure 3. Mean (SD) of physical function measures including total short physical performance battery score (a), 6m habitual gait speed (b), and five-times repeated chair sit-to-stand time (c), and sensorimotor function measure including physiological profile assessment (d), between high and low heavy housework groups, within younger and older adults. *p<0·05, adjusted for age, sex and time spent on light housework per week.

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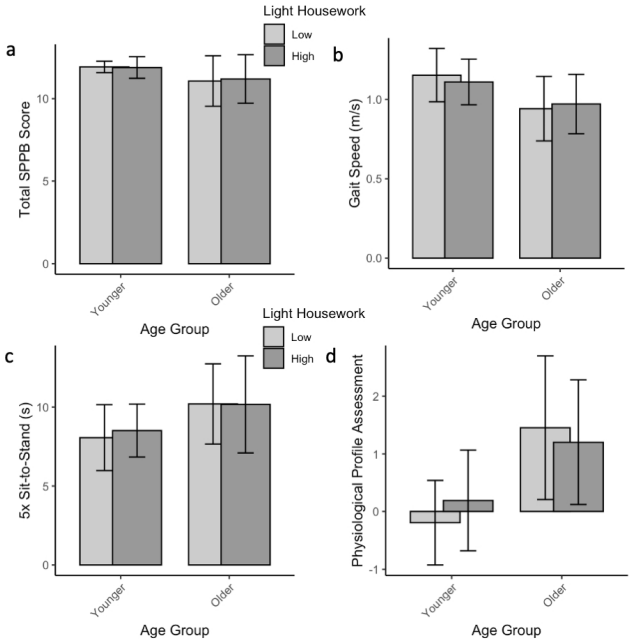

Figure 4. Mean (SD) of physical function measures including total short physical performance battery score (a), 6m habitual gait speed (b), and five-times repeated chair sit-to-stand time (c), and sensorimotor function measure including physiological profile assessment (d), between high and low light housework groups, within younger and older adults. All p>0·05, adjusted for age, sex, height, years of education, transport-related physical activity and time spent on heavy housework per week.

294x190mm (124 x 124 DPI)

Supplementary Table S1. Mean (SD) of cognitive, physical and sensorimotor functions stratified by heavy housework and light housework groups, between younger and older participants.

	Heavy Housework (HH)				Light Housework (LH)			
	Younger		Older		Younger		Older	
	Low	*High*	*Low*	*High*	*Low*	*High*	*Low*	*High*
n	100	149	132	108	137	112	103	137
Cognitive function (Scores)								
RBANS	226 (31)	220 (30)	164 (38)	177 (33)	230 (27)	214 (32)	165 (40)	174 (32)
Immediate-Memory	47 (8)	46 (7)	35 (10)	38 (8)	48 (7)	44 (8)	34 (10)	38 (7)
Delayed-Memory	52 (7)	51 (7)	40 (11)	42 (9)	53 (6)	50 (7)	39 (11)	42 (8)
Visuospatial-Construction	35 (4)	35 (5)	29 (6)	31 (6)	36 (4)	34 (5)	30 (6)	30 (6)
Language	28 (6)	29 (5)	24 (6)	25 (5)	29 (6)	28 (5)	24 (6)	25 (5)
Attention	64 (14)	60 (13)	36 (13)	41 (14)	65 (12)	57 (14)	38 (14)	39 (14)
Physical function								
SPPB score	11.9 (0.5)	11.9 (0.5)	11.0 (1.7)	11.4 (1.2)	11.9 (0.3)	11.9 (0.7)	11.1 (1.5)	11.2 (1.5)
Gait Speed (m/s)	1.1 (0.2)	1.1 (0.2)	0.9 (0.2)	1.0 (0.2)	1.2 (0.2)	1.1 (0.1)	0.9 (0.2)	1.0 (0.2)
5x Sit-to-stand (s)	8.1 (2.2)	8.4 (1.7)	10.6 (2.5)	9.7 (3.1)	8.1 (2.1)	8.5 (1.7)	10.2 (2.5)	10.2 (3.1)
Sensorimotor function								
Physiological Profile Assessment	-0.10 (0.76)	0.04 (0.86)	1.46 (1.20)	1.12 (1.09)	-0.19 (0.73)	0.19 (0.87)	1.45 (1.24)	1.20 (1.08)

Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

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		Reporting Item	Page Number
Title and abstract			
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	#3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	#4	Present key elements of study design early in the paper	7
Setting	#5	Describe the setting, locations, and relevant dates, including periods of	6

		recruitment, exposure, follow-up, and data collection	
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	7
	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-10
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	7-10
Bias	#9	Describe any efforts to address potential sources of bias	NA
Study size	#10	Explain how the study size was arrived at	10
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	10
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	10, 12
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	10
Statistical methods	#12c	Explain how missing data were addressed	NA
Statistical methods	#12d	If applicable, describe analytical methods taking account of sampling strategy	NA
Statistical methods	#12e	Describe any sensitivity analyses	NA
Results			
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	11
Participants	#13b	Give reasons for non-participation at each stage	NA
Participants	#13c	Consider use of a flow diagram	NA

Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	11
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	NA
Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	12-14
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12-14
Main results	#16b	Report category boundaries when continuous variables were categorized	NA
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	#18	Summarise key results with reference to study objectives	14
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	17
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	14-17
Generalisability	#21	Discuss the generalisability (external validity) of the study results	17
Other Information			
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

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BMJ Open

Cross-sectional associations of housework with cognitive, physical and sensorimotor functions in younger and older community-dwelling adults – the Yishun Study

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Title: Cross-sectional associations of housework with cognitive, physical and sensorimotor functions in younger and older community-dwelling adults – the Yishun Study

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Abstract

Objectives: Regular moderate-to-vigorous intensity recreational physical activity (PA) improves physical and cognitive functions. However, the age-associated relationships between non-recreational PA and functional ability remain less explored. We examined the associations between housework and functional health among younger and older Singaporean community-dwelling adults.

Design: Cross-sectional study

Setting and Participants: Younger (<65yrs, *n*=249) and older (≥65yrs, *n*=240) community-dwelling adults were randomly recruited from a large residential town in Singapore.

Outcome measures: Physical function was assessed using Short Physical Performance Battery, repeated-chair-sit-to-stand and gait speed. Cognitive and sensorimotor functions were assessed using Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) and Physiological Profile Assessment (PPA) respectively.

Methods: Light (LH) and heavy housework (HH), recreational, occupational, and transport-related PA were assessed using PA questionnaires. Participants were dichotomised into low- and high-volume LH and HH groups. Results were adjusted for level of recreational and other non-recreational PA.

Results: Among older but not younger adults, RBANS scores were 8% and 5% higher in high HH and LH groups compared with low HH and LH groups respectively (p=0·012 and p=0·016). Specifically, HH was associated with 14% higher attention score (p=0·014), and LH with 12% and 8% higher immediate and delayed memory scores respectively (p<0·001 and p=0·004). In older adults, sit-to-stand-time and PPA scores were 8% and 23% lower in high HH than low HH group respectively

(*p*=0·011 and *p*=0·040). SPPB and gait speed did not differ with age or HH. LH was not associated with physical or sensorimotor function.

Conclusions: Among older adults, housework is associated with higher cognitive function, specifically in attention and memory. Associations of housework with physical function and sensorimotor performance were intensity-dependent. Housework PA is positively associated with functional health among community-dwelling older adults, independent of recreation and other non-recreational physical activities. Further longitudinal and intervention studies are needed to establish causality.

Key words: Housework intensity, Functional health, High-income countries, Ageing, Household chores, Non-recreational physical activity

Article Summary

Strengths and limitations of this study

- Representative sample of Singapore's adult population across age groups
- Comprehensive information about housework, recreational, occupational and transport-related physical activities using validated measures
- Analyses included comparison between younger and older age groups and adjustments for potential confounders
- This study is cross-sectional; therefore, associations between housework and functional health do not necessarily reflect causality.
- Housework and physical activities were self-reported and not objectively measured.

Introduction

Regular physical activity (PA) improves physical and mental health, mitigates the risks and effects of chronic diseases, and reduces falls, immobility, dependency and mortality among older adults [1-3]. Yet, global surveillance data indicate that in 2016, levels of insufficient PA remained high (27·5%) and stable across previous 10 years [4]. The prevalence of insufficient PA was also more than double in high-income countries than low-income countries (36·8% vs 16·2%), and was the highest in Singapore (36·5%), among high-income Asia Pacific countries [4]. In wealthier countries, transition towards more sedentary occupations and motorised transportation could explain the higher levels of inactivity. The majority of PA in high-income countries are from recreational PA, which differed from low-income countries where PA is predominantly from non-recreational activities, including transportation, occupational and housework [4,5]. Given the increasing prevalence of insufficient PA globally [5], better strategies and policies are required to increase PA levels, especially among older adults, due to their increased vulnerability to adverse health outcomes [6].

Earlier studies in high-income countries largely focused on the effects of recreational PA on physical and cognitive capacities, which are key risk factors for falls among older adults [7-9]. Few studies have examined the independent effects of non-recreational activity, such as housework tasks, on age-associated decline in functional ability [10-12]. Furthermore, although the effects of exercise intensity have been widely investigated [1], none of the studies investigated the associations between housework intensity and age-associated functional health. With the rapidly ageing population and increasing life expectancy worldwide, approaches to promote

healthy ageing, which centres upon the maintenance of functional ability, are urgently needed [13].

Housework activities are a large part of everyday activities in older people, and account for a significant proportion of self-reported PA [14]. Apart from a meaningful occupation, housework is also a component of instrumental activities of daily living – both key factors of successful ageing. Additionally, single bout of housework and chronic housework are associated with improved cognition, brain volume and executive function, and negatively associated with frailty [10-12]. Regardless of country income levels, higher levels of non-recreational PA were associated with a graded reduction in mortality and cardiovascular diseases, suggesting the potential role of non-recreational PA such as housework, on improving health outcomes even in high-income countries [5]. Housework may also confer benefits on physical and mental functions among older adults in a high-income country such as Singapore. Therefore, we studied the associations of light and heavy housework activities with cognitive, physical and sensorimotor functions, among younger and older adults in Singapore.

Methods

Settings

Community-dwelling adults (≥21 years) were recruited from a large north-eastern residential town of Yishun in Singapore, with residential population of 220,320 (50·6% females), with 12·2% older adults (≥65 years). This is similar to the overall Singapore residential population of 4,044,200 (51·1% females), with 15·2% older adults (≥65 years) [15].

Participants

Participants were recruited cross-sectionally from the Yishun Study through random sampling, in quotas of 20 to 40 participants in each sex and age group (10-year age groups between 21–60 years old and 5-year age groups after 60 years), to obtain a representative sample of ~300 men and ~300 women [16]. Briefly, community-dwelling adults aged 21 years and above who were independent in performing activities of daily living, had <5 comorbidities, and no neuromuscular or cognitive disorders were recruited. Those between 21–64 years and 65–90 years in age were categorized as younger and older participants respectively. Participants self-reported their years of education and medical conditions and comorbidities. All assessments were based on standardized protocols and administered by trained researchers at the Geriatric Education & Research Institute Lab on Yishun Health Campus, mostly within one visit. Ethics approval was obtained from the National Healthcare Group DSRB (2017/00212), in accordance with the relevant guidelines from the Declaration of Helsinki and the ethical principles in the Belmont Report. All participants gave written informed consent.

Patient and public involvement

Neither patients nor the public were involved in the design, planning, conduct or reporting of this study.

Anthropometric assessment

Body weight and height were measured using an electronic scale and stadiometer respectively (SECA, Hamburg, Germany). Body mass index was calculated as body weight (kg) divided by height (m) squared.

Housework, recreational, transport and occupational PA

Data on housework were self-reported and collected according to the Longitudinal Ageing Study Amsterdam PA questionnaire (LAPAQ) [17], which consists of specific questions regarding frequency and time spent on light and heavy household tasks. Light housework tasks (LH) included washing the dishes, dusting, making the bed, doing the laundry, hanging out the laundry, ironing, tidying up, and cooking meals. Heavy housework tasks (HH) included window cleaning, changing beddings, beating the mat, vacuuming, washing or scrubbing the floor, and chores involving sawing, carpeting, repairing or painting. The median time spent per week on household activities was used to dichotomize participants into high and low groups for LH (315 min/week) and HH (15 min/week) groups. Light housework was assigned a metabolic equivalent of task (MET) of 2·5 and heavy housework was assigned a MET of 4·0 [18].

Recreational (sport, fitness or leisure time activities), transport (active commuting/travel) and occupational (work) PA were determined using the Global Physical Activity Questionnaire (GPAQ), which consists of questions assessing the frequency and duration of vigorous- or moderate-intensity activities during a typical week [19]. A cut-off of ≥600 MET min/week (≥150 min/week of moderate-intensity PA

or ≥75 min/week of vigorous-intensity PA) was used to determine percentage of participants who met the current PA guidelines [5,20].

Cognitive function

Cognitive performance was assessed by the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) score. RBANS is a standardized age-adjusted battery that is sensitive to cognitive impairment [21]. RBANS assesses global and specific cognitive domains including immediate and delayed memory, visuospatial-construction, language, and attention.

Physical function

Habitual gait speed was assessed using a 6m GAITRite Walkway (CIR Systems Inc, Sparta, NJ) with 2m lead in and out phase. Participants performed three trials and the average timing was recorded. The Short Physical Performance Battery (SPPB) consists of 3 subtests including balance, gait and sit-to-stand [22,23]. The balance subtest composed of 3 parts with progressive difficulty, including unaided feet-together stand, semi-tandem stand and full-tandem stand. Participants were timed until they moved or 10s elapsed time. Gait speed was assessed by participants walking 8ft at their usual pace, with a moving start [22]. The average timing was recorded over two trials. To assess sit-to-stand time, participants folded their arms across their chest and performed five chair stands as quickly as possible. Each of the 3 subtests was scored from 0–4 and the total score was the sum of 3 subtests, ranging from 0–12. Higher SPPB scores indicated better physical function [22].

Sensorimotor or Physiological falls risk assessments

Physiological falls risk was determined using the physiological profile assessment (PPA) short version, which has been shown to predict fall incidents and consists of five validated sensorimotor measures: visual contrast sensitivity, hand reaction time, knee extension strength, proprioception and postural sway [24,25]. The five measures were weighted to compute a composite PPA index score using the NeuRA FallScreen® Falls Risk Calculator (https://fbirc.neura.edu.au/fallscreen). Higher PPA scores indicates poorer sensorimotor performance and greater falls risk [24,25].

Statistical analysis

All statistical analyses were performed using R version 3·6·2 (R Foundation for statistical computing, Vienna, Austria). A sample size of 400 (100 per group) was needed for the trial to have 80% power to detect a two-sided hypothesis test at an α level of 0·05 (effect size of 0·2) (G*Power, version 3·1, Germany). All participants with completed outcome measures were included for analysis. Numerical variables are presented as mean (standard deviation, SD) in text and figures unless otherwise stated. Participant characteristics were analyzed using independent samples t-test to assess potential differences between high and low HH and LH groups. Sensorimotor, cognitive and physical function measures were analyzed using two-way analysis of variance (ANOVA) for HH and LH independently, with age group (younger vs older), housework groups (low vs high), and their interaction (age*housework) as fixed effects. Normality and homogeneity of variances assumptions were tested using Shapiro-Wilk and Levene's test respectively. Effect sizes are reported with partial eta squared (η^2_p) [26]. A value of $p<0·05$ was considered statistically significant.

Results

Participant characteristics

A total of 249 participants (57% women) with mean age of 44 years (SD 14 years) in the younger group, and 240 participants (57·1% women) with mean age of 75 years (SD 6 years) in the older group, had housework (LAPAQ) data available and were included in the analysis. Ethnic distribution of participants (82·0% Chinese, 8·4% Malay, 6·7% Indians, and 2·9% from other ethnicities) was similar to that of Singapore's population [15]. A total of 36%(*n*=90) and 48%(*n*=116) of the participants in the younger and older group respectively, met the recommended PA level derived exclusively from recreational PA [20]. These values were lower than 61%(*n*=152) and 66(*n*=159) of the younger and older participants respectively, who attained the recommended PA level exclusively through housework activities.

Participant demographics between high and low HH and LH groups, such as age, education, anthropometric, PA and housework data, are summarised in Table 1. Compared with low HH and LH groups, majority of participants in high HH and LH groups were women, regardless of age groups. Within the younger group, high LH group were shorter and had less years of education than low LH group (all $p<0{\cdot}001$, Table 1). Total, recreational and occupational PA did not differ between high and low HH and LH groups in younger and older adults (all $p>0{\cdot}05$, Table 1). Within the younger but not the older group, transport-related PA was 39% lower in low LH than high LH group ($p=0{\cdot}003$, Table 1). Regardless of age group, compared with low HH and LH groups, participants in the high HH and LH groups spent more time on both

light and heavy housework activities per week and had higher total housework MET min/week (all $p<0{\cdot}001$, Table 1).

For subsequent light housework analyses, age, sex, height, education, transport PA and heavy housework were included in the model to adjust for confounding variables. To adjust for confounding factors, age, sex and light housework were included in model for subsequent heavy housework analyses. Adjusting for recreational and occupational PA in the analyses did not affect any of the results presented; hence, data are presented with recreational and occupational PA excluded from the model.

Associations of heavy housework activities with cognitive function

Within the older group, RBANS global cognition score was 8% higher in the high HH than low HH group ($p=0{\cdot}012$) but did not differ between high and low HH groups among the younger individuals ($p=0{\cdot}630$) (age*housework; $p=0{\cdot}031$, $\eta^2_p=0{\cdot}01$, Fig 1a). Immediate memory index scores between high and low HH groups were not statistically significant among older ($p=0{\cdot}055$) and younger adults ($p=0{\cdot}332$), despite significant interaction effects (age*housework; $p=0{\cdot}038$, $\eta^2_p=0{\cdot}009$, Fig 1b). No significant interaction effects between age and HH groups were observed for delayed memory ($p=0{\cdot}108$, $\eta^2_p=0{\cdot}005$), visuospatial-construction ($p=0{\cdot}183$, $\eta^2_p=0{\cdot}004$), and language index scores ($p=0{\cdot}776$, $\eta^2_p=0{\cdot}0002$) (Fig 1c-e). Attention index score was 14% higher in the high HH than low HH group within the older ($p=0{\cdot}014$) but not the younger ($p=0{\cdot}304$) group (age*housework; $p=0{\cdot}012$, $\eta^2_p=0{\cdot}01$, Fig 1f).

Associations of light housework activities with cognitive function

Compared with low LH group, high LH group had 5% higher RBANS global cognition score among the older but not the younger adults (p=0·016 vs p=0·335) (age*housework;p=0·015, η^2_p=0·01, Fig 2a). Within the older but not the younger individuals, immediate and delayed memory index scores were also 12% (p<0·001 vs p=0·165) and 8% (p=0·004 vs p=0·729) higher in high LH than low LH group respectively (age*housework;p<0·001, η^2_p=0·03 and p=0·022, η^2_p=0·01)(Fig 2b&c). No significant interaction effects between age and LH groups were observed for visuospatial-construction (p=0·781, η^2_p=0·0002), language (p=0·318, η^2_p=0·002) and attention (p=0·194, η^2_p=0·004) index scores (Fig 2d–f).

Associations of heavy housework activities with physical and sensorimotor functions

The interaction effects between age and HH groups were not significant for total SPPB score (p=0·155, η^2_p=0·004, Fig 3a) and gait speed (p=0·482, η^2_p=0·001, Fig 3b). Within the older but not the younger group, sit-to-stand time was 8% lower in the high HH than low HH group (p=0·011 vs p=0·722) (age*housework;p=0·036, η^2_p=0·009, Fig 3c). PPA index score, indicative of sensorimotor function, was 23% lower in the high HH than low HH group, among the older (p=0·040) but not the younger adults (p=0·477) (age*housework;p=0·046, η^2_p=0·008, Fig 3d).

Associations of light housework activities with physical and sensorimotor functions

The interaction effects between age and LH groups were not significant for total SPPB score (p=0·709, η^2_p=0·0003), gait speed (p=0·136, η^2_p=0·005), sit-to-stand (p=0·445, η^2_p=0·001) (Fig 4a–c). PPA index scores, indicative of sensorimotor function, were not significant between high and low LH groups among older

(*p*=0·067) and younger adults (*p*=0·178), despite significant interaction effects (age*housework;*p*=0·021, η^2_p=0·01, Fig 4d). Mean (SD) values of cognitive, physical and sensorimotor performances between age and housework groups are presented in Supplementary Table S1.

Discussion

The present study is the first to report that housework activity is associated with cognitive, physical and sensorimotor functions among older but not younger adults in Singapore. These positive associations of housework with functional performance in older adults were independent of recreational, occupational and transport-related physical activities. We also show that more adults attained recommended physical activity levels through housework than recreation.

Regardless of intensity, higher levels of housework activities were associated with higher global cognition, among our population of older adults. Earlier studies observed that lower levels of housework activities were associated with mild cognitive impairment, cognitive decline and lower grey matter volume among older adults [11,27,28], suggesting a positive association between housework activities and cognitive function, plausibly through an increase in brain volume, as observed with exercise interventions in older adults [29,30]. However, the positive associations between housework and cognition were not apparent in younger adults in our population. Differences in years of education between younger and older adults likely explain the disparity, as younger adults in this study had five more years of education on average than older adults. Since education level is positively associated with baseline cognitive function and slower cognitive decline [31], it is

plausible that higher education levels and cognitive function in younger adults decreases the potential for better cognitive function associated with housework activities.

Our results demonstrate, for the first time, that the intensity of housework was differentially associated with specific cognitive domains. Heavy housework was associated with higher scores in the attention domain, while light housework was associated with higher scores in both delayed and immediate memory domains in older adults. Earlier studies reported that aerobic exercise interventions of varying intensities improved specific cognitive function domains, including executive and motor function, attention and memory, through an increase in hippocampal volume and brain-derived neurotrophic factor expression [32-34]. Given that housework accounted for a significant proportion (~24–36% in women and ~19–28% in men) of self-reported moderate-to-vigorous-intensity PA among older adults aged above 60 [14], it is plausible that the higher cognitive function associated with housework occurs through a similar mechanism as PA or exercise [14]. More studies are required to understand the underlying mechanisms driving the age-associated differing associations of housework intensity with specific cognitive domains.

Poorer cognitive performance in attention and executive functions were associated with poorer physical function, slower gait, postural instability, and future falls among community-dwelling older adults [35-37]. We show that higher levels of heavy housework activities were also independently associated with better physical function (chair-stand time) and sensorimotor (PPA) performance in older but not younger adults. Among older Swedish adults, longer chair-stand time and poorer

cognitive performance (processing speed and executive function) independently increased the risk of injurious falls over 3–10 years by 10–23%[38]. Unlike older adults, younger adults have higher functional abilities and are unlikely to experience decline in sensorimotor and physical functions, potentially explaining the lack of associations between housework activities and physical and sensorimotor performances. These results collectively suggest that the higher cognitive, physical and sensorimotor functions related to heavy housework activities might plausibly be associated with lower physiological fall risk among community-dwelling older adults.

We demonstrated that unlike heavy housework, light housework was not associated with physical or sensorimotor function. The lack of associations could be due to the already high functional ability of our study participants [23]. In support, compared with lower intensity exercise, greater improvements in functional ability and decreased fear of falling were observed after high intensity exercise in older adults [39-41]. These results indicate a dose-response effect for exercise intensity on physical and sensorimotor functions and associated falls risk in older adults. Similarly, we propose that the positive associations of housework with physical and sensorimotor functions are dependent on intensity, especially in community-dwelling older adults.

Notably in this present study, 25% and 18% more participants in the younger and older group, respectively, met the PA guidelines derived exclusively from housework, than that attained solely through recreational PA. This finding reflects the challenges inherent with recreational PA participation, which is by definition, done during discretionary hours of the day outside of occupational and domestic duties. Incorporating PA into daily lifestyle through domestic duties (i.e., housework) has the

potential to achieve higher PA, which is positively associated with functional health especially among older community-dwelling adults.

Our study recruited adults aged 21–80+ randomly from a large residential town representative of Singapore's population, suggesting a good degree of generalisability. We also included a comparison between older and younger adults in the study, to elucidate the age-associated effects of housework activities on cognitive, physical and sensorimotor functions. However, although associations can be drawn from the study results, the cross-sectional design does not prove causality. It is plausible that healthier older adults with higher functional ability engaged in higher levels of housework. Nonetheless, in a 13-year follow-up study, productive housework activities such as cooking and shopping were associated with lower mortality risk in older adults [42], suggesting that housework activities are associated with better health outcomes in older adults. Another potential limitation included the lack of patient or public involvement in the design, planning, conduct or reporting of the study. The study findings in community-dwelling individuals cannot be generalised to institutionalised older adults, such as those in nursing homes. In the present study, housework and PA measures were self-reported based on type, intensity, frequency and duration per week. Although the LAPAQ and GPAQ used in this study is valid and reliable [17,19], future studies using more objective measures of housework and PA should be undertaken. It is possible that socio-economic status may mediate the effects of housework on health [43], which should be further examined in the Asian cultural context. While we adjusted for sex in all analyses, compared with low housework groups, participants in high housework groups were mostly women, which is consistent with earlier studies showing greater involvement

in household chores among women than men [44]. Future studies should investigate the sex-specific effects of housework on functional health.

In conclusion, our study suggests that a combination of light and heavy housework is associated with higher cognitive function, specifically in attention and memory domains, among community-dwelling older adults. Furthermore, the positive associations of housework levels with physical and sensorimotor functions in older adults were intensity-dependent. Housework may also complement recreational physical activities among current older community-dwelling adults in high-income countries towards healthier ageing. Future longitudinal and intervention studies are required to establish causality between housework activities and functional health.

Funding

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Contributions

SYL performed the data analysis, interpretation, visualisation and wrote the manuscript. SLW, TPN, BWJP and LKL contributed to the study concept and design. BWJP, LKL, KAJ, WTS, KKC administered the project and collected the data. BWJP, LKL accessed and verified the underlying data. SLW, TPN contributed to the critical revision of the manuscript for important intellectual content. All authors read and approved the final manuscript.

Declaration of Interest

None declared.

Data sharing statement

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Ethics Approval Statement

This study involves human participants and was approved by an Ethics Committee(s) or Institutional Board(s) - [National Healthcare Group DSRB (2017/00212)].

References

1. McPhee JS, French DP, Jackson D, Nazroo J, Pendleton N, Degens H. Physical activity in older age: perspectives for healthy ageing and frailty. *Biogerontology* 2016; **17**(3): 567-80.

2. Geidl W, Schlesinger S, Mino E, Miranda L, Pfeifer K. Dose-response relationship between physical activity and mortality in adults with noncommunicable diseases: a systematic review and meta-analysis of prospective observational studies. *Int J Behav Nutr Phys Act* 2020; **17**(1): 109.

3. Sherrington C, Fairhall N, Kwok W, et al. Evidence on physical activity and falls prevention for people aged 65+ years: systematic review to inform the WHO guidelines on physical activity and sedentary behaviour. *Int J Behav Nutr Phys Act* 2020; **17**(1): 144.

4. Guthold R, Stevens GA, Riley LM, Bull FC. Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1·9 million participants. *The Lancet Global Health* 2018; **6**(10): e1077-e86.

5. Lear SA, Hu W, Rangarajan S, et al. The effect of physical activity on mortality and cardiovascular disease in 130 000 people from 17 high-income, middle-income, and low-income countries: the PURE study. *Lancet* 2017; **390**(10113): 2643-54.

6. Cunningham C, R OS, Caserotti P, Tully MA. Consequences of physical inactivity in older adults: A systematic review of reviews and meta-analyses. *Scand J Med Sci Sports* 2020; **30**(5): 816-27.

7. Sherrington C, Michaleff ZA, Fairhall N, et al. Exercise to prevent falls in older adults: an updated systematic review and meta-analysis. *Br J Sports Med* 2017; **51**(24): 1750-8.

8. Lam FM, Huang MZ, Liao LR, Chung RC, Kwok TC, Pang MY. Physical exercise improves strength, balance, mobility, and endurance in people with cognitive impairment and dementia: a systematic review. *J Physiother* 2018; **64**(1): 4-15.

9. García-Hermoso A, Ramirez-Vélez R, Sáez de Asteasu ML, et al. Safety and Effectiveness of Long-Term Exercise Interventions in Older Adults: A Systematic Review and Meta-analysis of Randomized Controlled Trials. *Sports Med* 2020; **50**(6): 1095-106.

10. Stephan AJ, Strobl R, Müller M, et al. A high level of household physical activity compensates for lack of leisure time physical activity with regard to deficit accumulation: Results from the KORA-Age study. *Prev Med* 2016; **86**: 64-9.

11. Koblinsky ND, Meusel L-AC, Greenwood CE, Anderson ND. Household physical activity is positively associated with gray matter volume in older adults. *BMC Geriatrics* 2021; **21**(1): 104.

12. Tsuchiya K, Mitsui S, Fukuyama R, et al. An acute bout of housework activities has beneficial effects on executive function. *Neuropsychiatr Dis Treat* 2018; **14**: 61-72.

13. Beard JR, Officer A, de Carvalho IA, et al. The World report on ageing and health: a policy framework for healthy ageing. *Lancet* 2016; **387**(10033): 2145-54.

14. Murphy MH, Donnelly P, Breslin G, Shibli S, Nevill AM. Does doing housework keep you healthy? The contribution of domestic physical activity to meeting current recommendations for health. *BMC Public Health* 2013; **13**: 966.

15. Department of Statistics Singapore. Population and Population Structure. 2020. https://www.singstat.gov.sg./find-data/search-by-theme/population/population-and-population-structure/latest-data (accessed 25 March 2021 2021).

16. Pang BWJ, Wee SL, Lau LK, et al. Prevalence and Associated Factors of Sarcopenia in Singaporean Adults-The Yishun Study. *J Am Med Dir Assoc* 2020.

17. Stel VS, Smit JH, Pluijm SM, Visser M, Deeg DJ, Lips P. Comparison of the LASA Physical Activity Questionnaire with a 7-day diary and pedometer. *J Clin Epidemiol* 2004; **57**(3): 252-8.

18. Siebeling L, Wiebers S, Beem L, Puhan MA, Ter Riet G. Validity and reproducibility of a physical activity questionnaire for older adults: questionnaire versus accelerometer for assessing physical activity in older adults. *Clin Epidemiol* 2012; **4**: 171-80.

19. Bull FC, Maslin TS, Armstrong T. Global physical activity questionnaire (GPAQ): nine country reliability and validity study. *J Phys Act Health* 2009; **6**(6): 790-804.

20. Haskell WL, Lee IM, Pate RR, et al. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Med Sci Sports Exerc* 2007; **39**(8): 1423-34.

21. Randolph C, Tierney MC, Mohr E, Chase TN. The Repeatable Battery for the Assessment of Neuropsychological Status (RBANS): preliminary clinical validity. *J Clin Exp Neuropsychol* 1998; **20**(3): 310-9.

22. Guralnik JM, Ferrucci L, Simonsick EM, Salive ME, Wallace RB. Lower-extremity function in persons over the age of 70 years as a predictor of subsequent disability. *N Engl J Med* 1995; **332**(9): 556-61.

23. Lee SY, Choo PL, Pang BWJ, et al. SPPB reference values and performance in assessing sarcopenia in community-dwelling Singaporeans – Yishun study. *BMC Geriatrics* 2021; **21**(1): 213.

24. Lord SR, Ward JA, Williams P, Anstey KJ. Physiological factors associated with falls in older community-dwelling women. *J Am Geriatr Soc* 1994; **42**(10): 1110-7.

25. Lord SR, Menz HB, Tiedemann A. A Physiological Profile Approach to Falls Risk Assessment and Prevention. *Physical Therapy* 2003; **83**(3): 237-52.

26. Lakens D. Calculating and reporting effect sizes to facilitate cumulative science: a practical primer for t-tests and ANOVAs. *Front Psychol* 2013; **4**: 863.

27. Jiang C, Xu Y. The association between mild cognitive impairment and doing housework. *Aging Ment Health* 2014; **18**(2): 212-6.

28. Peng Z, Jiang H, Wang X, et al. The Efficacy of Cognitive Training for Elderly Chinese Individuals with Mild Cognitive Impairment. *Biomed Res Int* 2019; **2019**: 4347281.

29. Colcombe SJ, Erickson KI, Scalf PE, et al. Aerobic Exercise Training Increases Brain Volume in Aging Humans. *The Journals of Gerontology: Series A* 2006; **61**(11): 1166-70.

30. Erickson KI, Leckie RL, Weinstein AM. Physical activity, fitness, and gray matter volume. *Neurobiology of Aging* 2014; **35**: S20-S8.

31. Clouston SAP, Smith DM, Mukherjee S, et al. Education and Cognitive Decline: An Integrative Analysis of Global Longitudinal Studies of Cognitive Aging. *The Journals of Gerontology: Series B* 2020; **75**(7): e151-e60.

32. Angevaren M, Aufdemkampe G, Verhaar HJ, Aleman A, Vanhees L. Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment. *Cochrane Database Syst Rev* 2008; (3): Cd005381.

33. Gomez-Pinilla F, Hillman C. The influence of exercise on cognitive abilities. *Compr Physiol* 2013; **3**(1): 403-28.

34. Smith PJ, Blumenthal JA, Hoffman BM, et al. Aerobic exercise and neurocognitive performance: a meta-analytic review of randomized controlled trials. *Psychosom Med* 2010; **72**(3): 239-52.

35. Tabbarah M, Crimmins EM, Seeman TE. The Relationship Between Cognitive and Physical Performance: MacArthur Studies of Successful Aging. *The Journals of Gerontology: Series A* 2002; **57**(4): M228-M35.

36. Montero-Odasso M, Speechley M. Falls in Cognitively Impaired Older Adults: Implications for Risk Assessment And Prevention. *J Am Geriatr Soc* 2018; **66**(2): 367-75.

37. Muir SW, Gopaul K, Montero Odasso MM. The role of cognitive impairment in fall risk among older adults: a systematic review and meta-analysis. *Age and Ageing* 2012; **41**(3): 299-308.

38. Welmer A-K, Rizzuto D, Laukka EJ, Johnell K, Fratiglioni L. Cognitive and Physical Function in Relation to the Risk of Injurious Falls in Older Adults: A Population-Based Study. *The Journals of Gerontology: Series A* 2017; **72**(5): 669-75.

39. Sanders LMJ, Hortobágyi T, Karssemeijer EGA, Van der Zee EA, Scherder EJA, van Heuvelen MJG. Effects of low- and high-intensity physical exercise on physical and cognitive function in older persons with dementia: a randomized controlled trial. *Alzheimers Res Ther* 2020; **12**(1): 28.

40. Jiménez-García JD, Hita-Contreras F, de la Torre-Cruz M, et al. Risk of Falls in Healthy Older Adults: Benefits of High-Intensity Interval Training Using Lower Body Suspension Exercises. *J Aging Phys Act* 2019; **27**(3): 325-33.

41. Edholm P, Nilsson A, Kadi F. Physical function in older adults: Impacts of past and present physical activity behaviors. *Scand J Med Sci Sports* 2019; **29**(3): 415-21.

42. Glass TA, de Leon CM, Marottoli RA, Berkman LF. Population based study of social and productive activities as predictors of survival among elderly Americans. *Bmj* 1999; **319**(7208): 478-83.

43. Rodriguez-Stanley J, Alonso-Ferres M, Zilioli S, Slatcher RB. Housework, health, and well-being in older adults: The role of socioeconomic status. *J Fam Psychol* 2020; **34**(5): 610-20.

44. Bianchi SM, Sayer LC, Milkie MA, Robinson JP. Housework: Who Did, Does or Will Do It, and How Much Does It Matter? *Soc Forces* 2012; **91**(1): 55-63.

Table 1. Mean (SD) Participant characteristics for high and low heavy housework and light housework groups, within younger and older groups.

	Heavy Housework (HH)			**Light Housework (LH)**		
	Low	High	*p* value	Low	High	*p* value
Younger						
n	100	149		137	112	
Sex, Female (n (%))	48 (48)	94 (63)		62 (45)	80 (71)	
Age (years)	43 (15)	44 (13)	0·516	42 (14)	46 (13)	**0·015**
Education (Years)	12 (4)	12 (4)	0·493	13 (4)	11 (4)	**<0·001**
Height (m)	1·64 (0·09)	1·62 (0·08)	0·115	1·65 (0·08)	1·60 (0·08)	**<0·001**
Weight (kg)	68·0 (15·2)	67·7 (17·3)	0·875	69·0 (17·2)	66·4 (15·5)	0·219
Body Mass Index	25·2 (4·8)	25·6 (5·6)	0·557	25·1 (5·4)	25·8 (5·2)	0·324
Physical Activity (GPAQ)						
Recreational (MET min/week)	576 (784)	774 (1302)	0·137	637 (933)	764 (1324)	0·393
Transport (MET min/week)	2065 (3010)	2003 (2228)	0·861	1577 (1955)	2579 (3075)	**0·003**
Occupational (MET min/week)	1686 (3619)	2408 (5658)	0·220	2052 (4252)	2199 (5699)	0·821
Total (MET min/week)	4327 (5151)	5185 (6903)	0·263	4266 (4971)	5543 (7511)	0·125
Housework Activity (LAPAQ)						
Heavy (min/week)	0 (2)	192 (292)	**<0·001**	47 (81)	198 (335)	**<0·001**
Light (min/week)	198 (363)	584 (593)	**<0·001**	95 (87)	838 (592)	**<0·001**
Total (MET min/week)	496 (908)	2228 (2079)	**<0·001**	425 (458)	2887 (2120)	**<0·001**
Older						
n	132	108		103	137	
Sex, Female (n (%))	63 (48)	74 (69)		39 (38)	98 (72)	
Age (Years)	77 (6)	73 (6)	**<0·001**	77 (7)	74 (6)	**0·004**
Education (Years)	6 (4)	7 (5)	0·168	7 (5)	7 (5)	0·764
Height (m)	1·57 (0·09)	1·57 (0·08)	0·987	1·58 (0·08)	1·56 (0·08)	0·064
Weight (kg)	60·1 (10·3)	58·5 (9·6)	0·192	60·4 (9·8)	58·6 (10·1)	0·161
Body Mass Index	24·5 (3·7)	23·8 (3·3)	0·102	24·2 (3·5)	24·1 (3·5)	0·778
Physical Activity (GPAQ)						
Recreational (MET min/week)	828 (1053)	890 (1047)	0·650	867 (1181)	847 (941)	0·884
Transport (MET min/week)	1561 (1565)	1836 (2050)	0·253	1554 (1964)	1783 (1667)	0·340
Occupational (MET min/week)	676 (2269)	401 (1397)	0·251	547 (2113)	557 (1783)	0·968
Total (MET min/week)	3065 (2731)	3127 (2531)	0·856	2968 (2968)	3187 (2366)	0·537
Housework Activity (LAPAQ)						

Heavy (min/week)	0 (0)	131 (140)	**<0·001**	31 (72)	80 (134)	**<0·001**
Light (min/week)	446 (508)	684 (568)	**<0·001**	89 (93)	902 (485)	**<0·001**
Total (MET min/week)	1116 (1270)	2236 (1584)	**<0·001**	347 (377)	2576 (1349)	**<0·001**

Figure captions

Figure 1. Mean (SD) of global cognitive function and specific domains between high and low heavy housework groups, within younger and older adults. *p<0·05, adjusted for age, sex and time spent on light housework per week.

Figure 2. Mean (SD) of global cognitive function and specific domains between high and low light housework groups, within younger and older adults. *p<0·05, **p<0·01, ***p<0·001, adjusted for age, sex, height, years of education, transport-related physical activity and time spent on heavy housework per week.

Figure 3. Mean (SD) of physical function measures including total short physical performance battery score (a), 6m habitual gait speed (b), and five-times repeated chair sit-to-stand time (c), and sensorimotor function measure including physiological profile assessment (d), between high and low heavy housework groups, within younger and older adults. *p<0·05, adjusted for age, sex and time spent on light housework per week.

Figure 4. Mean (SD) of physical function measures including total short physical performance battery score (a), 6m habitual gait speed (b), and five-times repeated chair sit-to-stand time (c), and sensorimotor function measure including physiological profile assessment (d), between high and low light housework groups, within younger and older adults. All p>0·05, adjusted for age, sex, height, years of education, transport-related physical activity and time spent on heavy housework per week.

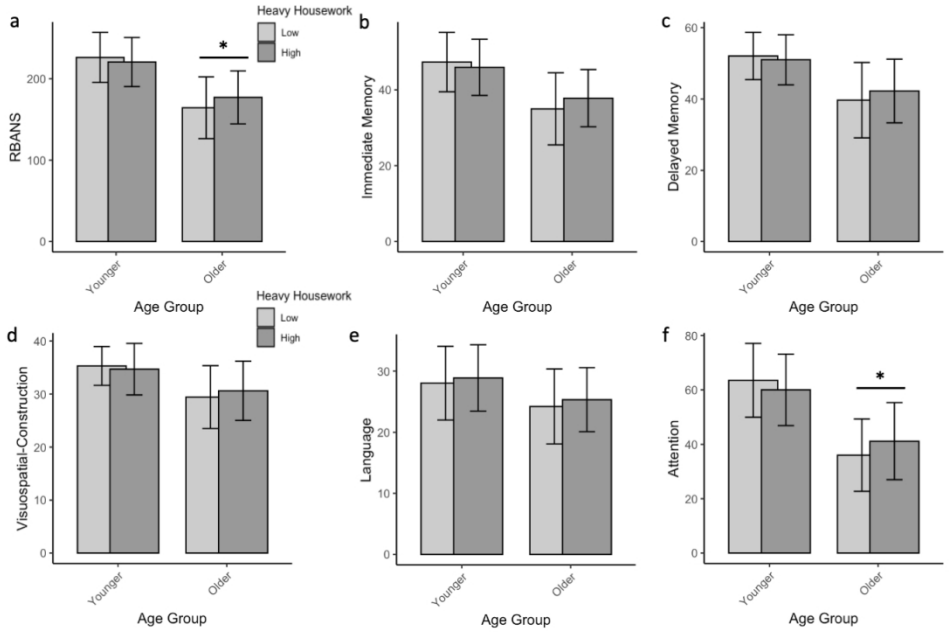

Figure 1. Mean (SD) of global cognitive function and specific domains between high and low heavy housework groups, within younger and older adults. *p<0·05, adjusted for age, sex and time spent on light housework per week.

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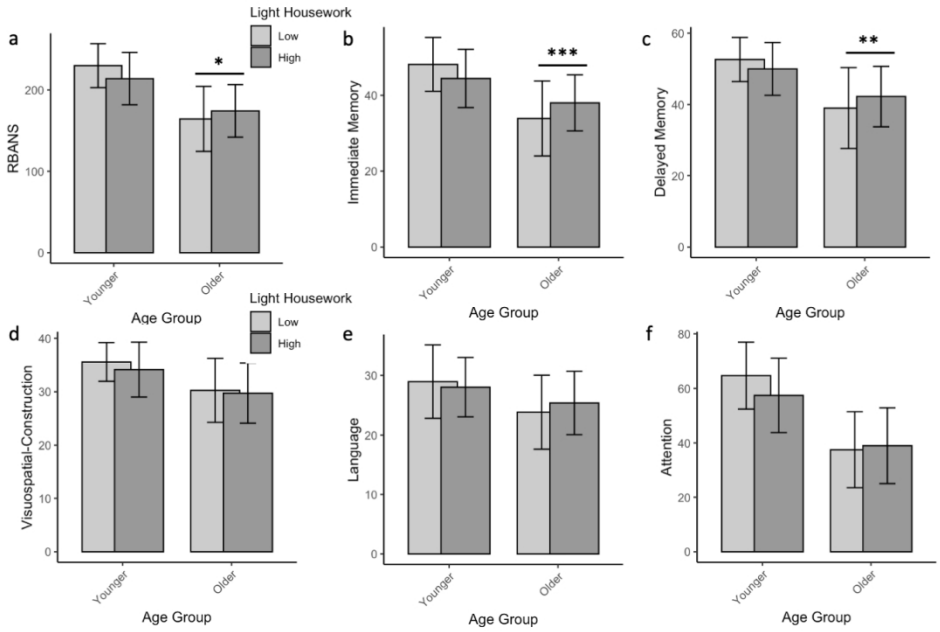

Figure 2. Mean (SD) of global cognitive function and specific domains between high and low light housework groups, within younger and older adults. *p<0·05, **p<0·01, ***p<0·001, adjusted for age, sex, height, years of education, transport-related physical activity and time spent on heavy housework per week.

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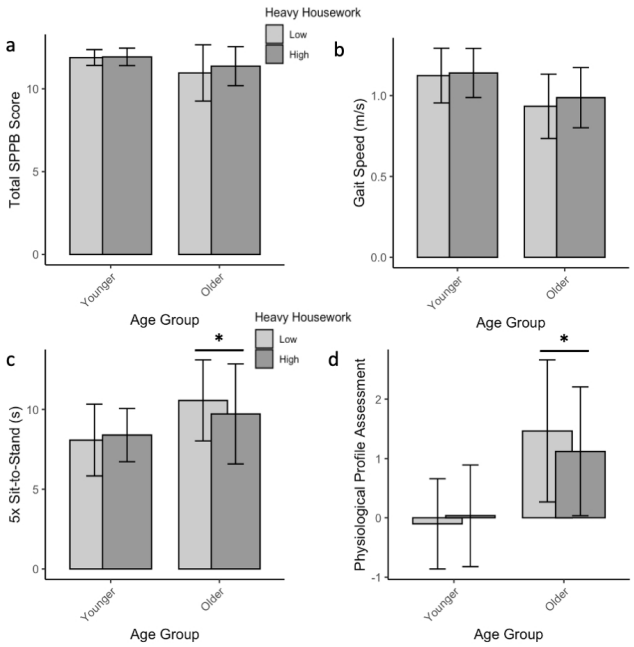

Figure 3. Mean (SD) of physical function measures including total short physical performance battery score (a), 6m habitual gait speed (b), and five-times repeated chair sit-to-stand time (c), and sensorimotor function measure including physiological profile assessment (d), between high and low heavy housework groups, within younger and older adults. *p<0·05, adjusted for age, sex and time spent on light housework per week.

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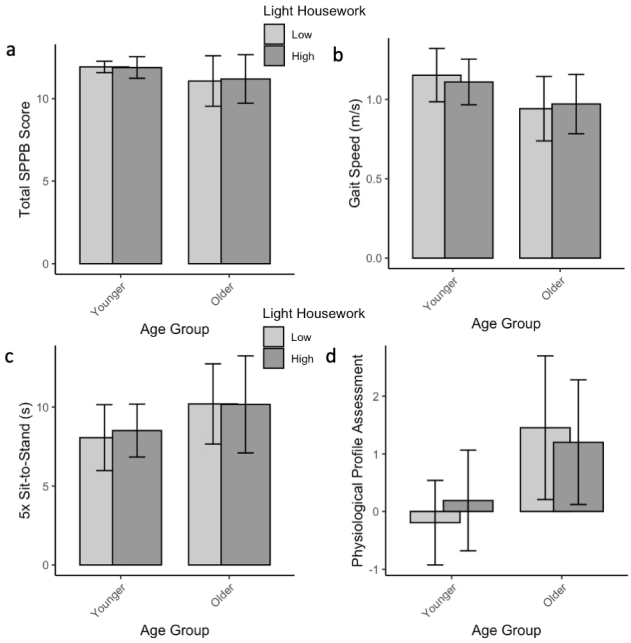

Figure 4. Mean (SD) of physical function measures including total short physical performance battery score (a), 6m habitual gait speed (b), and five-times repeated chair sit-to-stand time (c), and sensorimotor function measure including physiological profile assessment (d), between high and low light housework groups, within younger and older adults. All p>0·05, adjusted for age, sex, height, years of education, transport-related physical activity and time spent on heavy housework per week.

294x190mm (124 x 124 DPI)

Supplementary Table S1. Mean (SD) of cognitive, physical and sensorimotor functions stratified by heavy housework and light housework groups, between younger and older participants.

	Heavy Housework (HH)				Light Housework (LH)			
	Younger		Older		Younger		Older	
	Low	*High*	*Low*	*High*	*Low*	*High*	*Low*	*High*
n	100	149	132	108	137	112	103	137
Cognitive function (Scores)								
RBANS	226 (31)	220 (30)	164 (38)	177 (33)	230 (27)	214 (32)	165 (40)	174 (32)
Immediate-Memory	47 (8)	46 (7)	35 (10)	38 (8)	48 (7)	44 (8)	34 (10)	38 (7)
Delayed-Memory	52 (7)	51 (7)	40 (11)	42 (9)	53 (6)	50 (7)	39 (11)	42 (8)
Visuospatial-Construction	35 (4)	35 (5)	29 (6)	31 (6)	36 (4)	34 (5)	30 (6)	30 (6)
Language	28 (6)	29 (5)	24 (6)	25 (5)	29 (6)	28 (5)	24 (6)	25 (5)
Attention	64 (14)	60 (13)	36 (13)	41 (14)	65 (12)	57 (14)	38 (14)	39 (14)
Physical function								
SPPB score	11.9 (0.5)	11.9 (0.5)	11.0 (1.7)	11.4 (1.2)	11.9 (0.3)	11.9 (0.7)	11.1 (1.5)	11.2 (1.5)
Gait Speed (m/s)	1.1 (0.2)	1.1 (0.2)	0.9 (0.2)	1.0 (0.2)	1.2 (0.2)	1.1 (0.1)	0.9 (0.2)	1.0 (0.2)
5x Sit-to-stand (s)	8.1 (2.2)	8.4 (1.7)	10.6 (2.5)	9.7 (3.1)	8.1 (2.1)	8.5 (1.7)	10.2 (2.5)	10.2 (3.1)
Sensorimotor function								
Physiological Profile Assessment	-0.10 (0.76)	0.04 (0.86)	1.46 (1.20)	1.12 (1.09)	-0.19 (0.73)	0.19 (0.87)	1.45 (1.24)	1.20 (1.08)

Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cross sectionalreporting guidelines, and cite them as:

von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

		Reporting Item	Page Number
Title and abstract			
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	#3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	#4	Present key elements of study design early in the paper	7
Setting	#5	Describe the setting, locations, and relevant dates, including periods of	6

		recruitment, exposure, follow-up, and data collection	
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	7
	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-10
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	7-10
Bias	#9	Describe any efforts to address potential sources of bias	NA
Study size	#10	Explain how the study size was arrived at	10
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	10
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	10, 12
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	10
Statistical methods	#12c	Explain how missing data were addressed	NA
Statistical methods	#12d	If applicable, describe analytical methods taking account of sampling strategy	NA
Statistical methods	#12e	Describe any sensitivity analyses	NA
Results			
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	11
Participants	#13b	Give reasons for non-participation at each stage	NA
Participants	#13c	Consider use of a flow diagram	NA

Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	11
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	NA
Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	12-14
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12-14
Main results	#16b	Report category boundaries when continuous variables were categorized	NA
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	#18	Summarise key results with reference to study objectives	14
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	17
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	14-17
Generalisability	#21	Discuss the generalisability (external validity) of the study results	17
Other Information			
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

This checklist was completed on 05. April 2021 using https://www.goodreports.org/, a tool made by the EQUATOR Network in collaboration with Penelope.ai