

BMJ Open

BMJ Open is committed to open peer review. As part of this commitment we make the peer review history of every article we publish publicly available.

When an article is published we post the peer reviewers' comments and the authors' responses online. We also post the versions of the paper that were used during peer review. These are the versions that the peer review comments apply to.

The versions of the paper that follow are the versions that were submitted during the peer review process. They are not the versions of record or the final published versions. They should not be cited or distributed as the published version of this manuscript.

BMJ Open is an open access journal and the full, final, typeset and author-corrected version of record of the manuscript is available on our site with no access controls, subscription charges or pay-per-view fees (<http://bmjopen.bmj.com>).

If you have any questions on BMJ Open's open peer review process please email info.bmjopen@bmj.com

BMJ Open

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

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2021-052557
Article Type:	Original research
Date Submitted by the Author:	19-Apr-2021
Complete List of Authors:	Lee, Shuen Yee; Singapore Institute of Technology Pang, Benedict Wei Jun; Geriatric Education and Research Institute Ltd Lau, Lay Khoon; Geriatric Education and Research Institute Ltd Jabbar, Khalid Abdul; Geriatric Education and Research Institute Ltd Seah, Wei Ting; Geriatric Education and Research Institute Ltd Chen, Kenneth Kexun; Geriatric Education and Research Institute Ltd Ng, Tze Pin; National University of Singapore, Department of Psychological Medicine; Geriatric Education and Research Institute Ltd Wee, Shiou-Liang; Singapore Institute of Technology; Geriatric Education and Research Institute Ltd
Keywords:	Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, GERIATRIC MEDICINE, PREVENTIVE MEDICINE, PUBLIC HEALTH

SCHOLARONE™
Manuscripts



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our [licence](#).

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which [Creative Commons](#) licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

1
2
3
4 **Title:** Housework is associated with better cognitive, physical and sensorimotor
5
6 functions in community-dwelling older adults – the Yishun Study.
7
8
9

10
11 Shuen Yee Lee, PhD^a, Benedict Wei Jun Pang, BSc^b, Lay Khoon Lau, PhD^b, Khalid
12
13 Abdul Jabbar, MSc^b, Wei Ting Seah, MSc^b, Kenneth Kexun Chen, BSc^b, Tze Pin Ng,
14
15 MD^{b,c}, Shiou-Liang Wee, PhD^{a,b}
16
17
18
19

20 ^aFaculty of Health and Social Sciences, Singapore Institute of Technology, 10 Dover
21
22 Drive, Singapore 138683, Singapore, Singapore
23
24

25 ^bGeriatric Education and Research Institute, 2 Yishun Central 2, Singapore 768024,
26
27 Singapore, Singapore
28

29 ^cDepartment of Psychological Medicine, National University of Singapore, 21 Lower
30
31 Kent Ridge Rd, Singapore 119077, Singapore, Singapore
32
33
34
35
36

37 **Corresponding author:** Shiou-Liang Wee, Geriatric Education and Research
38
39 Institute (GERI), 2 Yishun Central 2, Tower E Level 4 GERI Admin, 768024,
40
41 Singapore. Phone: +65 65924606, Email: weeshiuliang@gmail.com
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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,

1
2
3 housework PA may improve functional health among community-dwelling older
4
5 adults, independent of recreation and other non-recreational physical activities.
6
7

8
9 **Key words:** Housework intensity, Functional health, High-income countries, Ageing,
10
11 Household chores, Non-recreational physical activity
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

For peer review only

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

1
2
3 and increasing life expectancy worldwide, approaches to promote healthy ageing,
4 which centres upon the maintenance of functional ability, are urgently needed ⁸.
5
6
7
8
9

10 Housework activities are a large part of everyday activities in older people, and
11 account for a significant proportion of self-reported PA ⁹. Other than a meaningful
12 occupation, housework is also a component of instrumental activities of daily living –
13 both key factors of successful ageing. Additionally, acute and chronic housework are
14 associated with improved cognition, brain volume and executive function, and
15 negatively associated with frailty ¹⁰⁻¹². Regardless of country income levels, higher
16 levels of non-recreational PA were associated with a graded reduction in mortality
17 and cardiovascular diseases, suggesting the important role of non-recreational PA
18 such as housework, on improving health outcomes even in high-income countries ³.
19 Housework may also confer benefits on physical and mental function among older
20 adults in a high-income country such as Singapore. Therefore, we studied the
21 associations between light and heavy housework activities, with cognitive, physical
22 and sensorimotor function, among younger and older adults in Singapore.
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42

43 **Methods**

44 Settings

45
46 Community-dwelling adults (≥ 21 years) were recruited from a large north-eastern
47 residential town of Yishun in Singapore, with residential population of 220,320
48 (50.6% females), with 12.2% older adults (≥ 65 years). This is similar to the overall
49 Singapore residential population of 4,044,200 (51.1% females), with 15.2% older
50 adults (≥ 65 years) ¹³.
51
52
53
54
55
56
57
58
59
60

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 women¹⁴. 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 4.0¹⁶.

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 week¹⁷. 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

1
2
3 battery that is sensitive to cognitive impairment¹⁹. RBANS assesses global and
4
5 specific cognitive domains including immediate and delayed memory, visuospatial-
6
7 construction, language, and attention.
8
9

10 11 12 Physical function

13
14 Habitual gait speed was assessed using a 6m GAITRite Walkway (CIR Systems Inc,
15
16 Sparta, NJ) with 2m lead in and out phase. Participants performed three trials and
17
18 the average timing was recorded. The Short Physical Performance Battery (SPPB)
19
20 consists of 3 subtests including balance, gait and sit-to-stand^{14,20}. The balance
21
22 subtest composed of 3 parts with progressive difficulty, including unaided feet-
23
24 together stand, semi-tandem stand and full-tandem stand. Participants were timed
25
26 until they moved or 10s elapsed time. Gait speed was assessed by participants
27
28 walking 8ft at their usual pace, with a moving start²⁰. The average timing was
29
30 recorded over two trials. To assess sit-to-stand time, participants folded their arms
31
32 across their chest and performed five chair stands as quickly as possible. Each of
33
34 the 3 subtests was scored from 0–4 and the total score was the sum of 3 subtests,
35
36 ranging from 0–12. Higher SPPB scores indicated better physical function²⁰.
37
38
39
40
41
42
43
44

45 Sensorimotor or Physiological falls risk assessments

46
47 Physiological falls risk was determined using the physiological profile assessment
48
49 (PPA) short version, which has been shown to predict fall incidents and consists of
50
51 five validated sensorimotor measures: visual contrast sensitivity, hand reaction time,
52
53 knee extension strength, proprioception and postural sway^{21,22}. The five measures
54
55 were weighted to compute a composite PPA index score using the NeuRA
56
57
58
59
60

1
2
3 FallScreen® Falls Risk Calculator (<https://fbirc.neura.edu.au/fallscreen>). Higher PPA
4
5 scores indicates poorer sensorimotor performance and greater falls risk ^{21,22}.
6
7
8
9

10 Statistical analysis

11
12 All statistical analyses were performed using R version 3.6.2 (R Foundation for
13
14 statistical computing, Vienna, Austria). A sample size of 400 (100 per group) was
15
16 needed for the trial to have 80% power to detect a two-sided hypothesis test at an α
17
18 level of 0.05 (effect size of 0.2) (G*Power, version 3.1, Germany). All participants
19
20 with completed outcome measures were included for analysis. Numerical variables
21
22 are presented as mean (standard deviation, SD) in text and figures unless otherwise
23
24 stated. Participant characteristics were analyzed using independent samples t-test to
25
26 assess potential differences between high and low HH and LH groups.
27
28

29
30 Sensorimotor, cognitive and physical function measures were analyzed using two-
31
32 way analysis of variance (ANOVA) for HH and LH independently, with age group
33
34 (younger vs older), housework groups (low vs high), and their interaction
35
36 (age*housework) as fixed effects. A value of $p < 0.05$ was considered statistically
37
38 significant.
39
40
41
42
43
44
45

46 **Results**

47 Participant characteristics

48
49 A total of 249 participants (57% women) with mean age of 44 years (SD 14 years) in
50
51 the younger group, and 240 participants (57.1% women) with mean age of 75 years
52
53 (SD 6 years) in the older group were included in the analysis. Ethnic distribution of
54
55 participants (82.0% Chinese, 8.4% Malay, 6.7% Indians, and 2.9% from other races)
56
57 was similar to that of Singapore's population ¹³. A total of 36% and 48% of the
58
59
60

1
2
3 participants in the younger and older group respectively, met the recommended PA
4 level derived exclusively from recreational PA¹⁸. These values were lower than 61%
5 and 66% of the younger and older participants respectively, who attained the
6 recommended PA level exclusively through housework activities.
7
8
9
10
11
12

13
14 Participant demographics between high and low HH and LH groups, such as age,
15 education, anthropometric, PA and housework data, are summarised in Table 1.

16
17 Within the younger group, high LH group were shorter and had less years of
18 education than low LH group (all $p < 0.001$, Table 1). Total, recreational and
19 occupational PA did not differ between high and low HH and LH groups in younger
20 and older adults (all $p > 0.05$, Table 1). Within the younger but not the older group,
21 transport-related PA was 39% lower in low LH than high LH group ($p = 0.003$, Table
22 1). Regardless of age group, compared with low HH and LH groups, participants in
23 the high HH and LH groups spent more time on both light and heavy housework
24 activities per week and had higher total housework MET min/week (all $p < 0.001$,
25 Table 1).
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41

42 For subsequent light housework analyses, age, sex, height, education, transport PA
43 and heavy housework were included in the model to adjust for confounding
44 variables. To adjust for confounding factors, age, sex and light housework were
45 included in model for subsequent heavy housework analyses. Adjusting for
46 recreational and occupational PA in the analyses did not affect any of the results
47 presented; hence, data are presented with recreational and occupational PA
48 excluded from the model.
49
50
51
52
53
54
55
56
57
58
59
60

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,

1
2
3 immediate and delayed memory index scores were also 12% ($p < 0.001$ vs $p = 0.165$)
4 and 8% ($p = 0.004$ vs $p = 0.729$) higher in high LH than low LH group respectively
5
6 (age*housework; $p < 0.001$ and $p = 0.022$, Fig 3b&c). No significant interaction effects
7
8 between age and LH groups were observed for attention ($p = 0.194$), visuospatial-
9
10 construction ($p = 0.781$) and language index scores ($p = 0.318$) (Fig 3d–f).
11
12
13
14
15
16

17 Association of light housework activities with physical and sensorimotor function

18
19 The interaction effects between age and LH groups were not significant for total
20
21 SPPB score ($p = 0.709$), gait speed ($p = 0.136$), sit-to-stand ($p = 0.445$) (Fig 4a–c). PPA
22
23 index scores between high and low LH groups were not statistically significant
24
25 among older ($p = 0.067$) and younger adults ($p = 0.178$), despite significant interaction
26
27 effects (age*housework; $p = 0.021$, Fig 4d).
28
29
30
31
32
33

34 **Discussion**

35
36 The present study is the first to report that housework activity is associated with
37
38 cognitive, physical and sensorimotor functions among older but not younger adults in
39
40 Singapore. We show that more adults attained recommended physical activity levels
41
42 through housework than recreation. Furthermore, higher levels of housework activity
43
44 are associated with better cognition in older adults. Higher levels of heavy, but not
45
46 light housework, were independently associated with better physical and
47
48 sensorimotor functions in older adults only. These positive associations of
49
50 housework with functional performance in older adults were independent of
51
52 recreational, occupational and transport-related physical activities. Our results
53
54 suggest that in addition to other forms of PA, housework may also confer benefits on
55
56 functional health in older adults from a high-income country.
57
58
59
60

1
2
3
4
5
6 Regardless of intensity, higher levels of housework activities were associated with
7 improved global cognition, among our population of older adults. In agreement with
8 our findings, lower levels of housework activities were associated with mild cognitive
9 impairment, cognitive decline and lower grey matter volume among older adults
10 ^{11,23,24}, suggesting that housework activities may have cognitive benefits, possibly
11 through an increase in brain volume, as observed with exercise ²⁵. However, the
12 positive associations between housework and cognition were not apparent in
13 younger adults in our population. Differences in years of education between younger
14 and older adults likely explain the disparity. Compared with older adults, younger
15 adults in this study had five more years of education on average. Since education
16 level is positively associated with baseline cognitive function and slower cognitive
17 decline ²⁶, it is plausible that higher education levels and cognitive function in
18 younger adults decreases the potential for housework-related cognitive
19 improvements. Our study findings support that among the community-dwelling older
20 adults with fewer education years, housework might ameliorate age-associated
21 cognitive decline, even in high-income countries.

22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45 Nonetheless, our results demonstrate that the intensity of housework affected
46 different cognitive domains. Heavy housework was associated with improvements in
47 the attention domain, while light housework was associated with improvements in
48 both delayed and immediate memory domains in older adults. While none of the
49 studies have investigated the associations between housework intensity and specific
50 cognitive domains, earlier studies reported that aerobic exercise interventions of
51 varying intensities improved specific cognitive function domains, including executive
52
53
54
55
56
57
58
59
60

1
2
3 and motor function, attention and memory, through an increase in hippocampal
4 volume and brain-derived neurotrophic factor expression ²⁷⁻²⁹. Given that housework
5 accounted for a significant proportion (~24–36%) of self-reported moderate-to-
6 vigorous-intensity PA among older adults, it is plausible that housework improves
7 cognition through a similar mechanism as PA or exercise ⁹. These results support
8 that a combination of light and heavy housework tasks may improve age-associated
9 decline in cognitive function, specifically for attention and memory domains. More
10 studies are required to understand the underlying mechanisms driving the differing
11 associations of housework intensity with specific cognitive domains.
12
13
14
15
16
17
18
19
20
21
22
23
24
25

26 Poorer cognitive performance in attention and executive functions were associated
27 with poorer physical function, slower gait, postural instability and future falls among
28 community-dwelling older adults ³⁰⁻³². We show that higher levels of heavy
29 housework activities were also independently associated with better sensorimotor
30 performance and chair-stand time in older but not younger adults. Our results
31 suggest that apart from improving cognitive function, heavy housework likely benefits
32 physical and sensorimotor performance, which could in turn reduce physiological
33 falls risk. While the effects of housework on falls are less clear, exercise
34 interventions improved both physical and cognitive functions, and reduced rate of
35 falls in community-dwelling older adults with or without cognitive impairment,
36 suggesting that the favourable effects of exercise on physical function and falls were
37 independent of cognitive function ⁵⁻⁷. Furthermore, longer chair-stand time and
38 poorer cognitive performance (processing speed and executive function)
39 independently increased the risk of injurious falls over 3–10 years by 10–23%,
40 among older Swedish adults ³³. These results collectively suggest that similar to
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 exercise, the associated improvement in physical and cognitive functions with heavy
4
5 housework may independently reduce risk of falls among community-dwelling older
6
7 adults.
8
9

10
11
12 We compared the independent associations of light and heavy housework activities,
13
14 and demonstrated that unlike heavy housework, light housework was not associated
15
16 with better physical or sensorimotor function. The lack of associations could be due
17
18 to the already high functional ability of our study participants ¹⁴. In support, compared
19
20 with lower intensity exercise, greater improvements in functional ability and
21
22 decreased fear of falling were observed after high intensity exercise in older adults
23
24 ³⁴⁻³⁶. These results indicate a dose-response effect for exercise intensity on physical
25
26 function and falls risk in older adults. Similarly, we propose that the associations
27
28 between housework with better physical and sensorimotor function is dependent on
29
30 intensity, especially in community-dwelling older adults.
31
32
33
34
35
36
37

38 Notably, regardless of age group, a higher percentage (18–25%) of study
39
40 participants met the PA guidelines derived exclusively from housework, than that
41
42 attained solely through recreational PA. This finding reflects the challenges inherent
43
44 with recreational PA participation, which is by definition, done during discretionary
45
46 hours of the day outside of occupational and domestic duties. Incorporating PA into
47
48 daily lifestyle through domestic duties (i.e., housework) has the potential to achieve
49
50 higher PA, which is associated with improved functional health especially among
51
52 older community-dwelling adults.
53
54
55
56
57
58
59
60

1
2
3 Our study recruited adults aged 21–80+ randomly from a large residential town
4 representative of Singapore’s population, suggesting a good degree of
5
6 generalisability. We also included a comparison between older and younger adults in
7
8 the study, to elucidate the age-associated effects of housework activities on
9
10 cognitive, physical and sensorimotor function. However, although associations can
11
12 be drawn from the study results, the cross-sectional design does not prove causality.
13
14 It is plausible that healthier older adults with higher functional ability engaged in
15
16 higher levels of housework. Nonetheless, in a 13-year follow-up study, productive
17
18 housework activities such as cooking and shopping were associated with lower
19
20 mortality risk in older adults ³⁷, suggesting that housework activities likely improve
21
22 health in older adults. The study findings cannot be generalised to people living in
23
24 institutions. In the present study, housework and PA measures were self-reported
25
26 based on type, intensity, frequency and duration per week. Although the LAPAQ and
27
28 GPAQ used in this study is valid and reliable ^{15,17}, future studies using more
29
30 objective measures of housework and PA should be undertaken. It is possible that
31
32 socio-economic status may mediate the effects of housework on health ³⁸, which
33
34 should be further examined in the Asian cultural context.
35
36
37
38
39
40
41
42
43
44
45

46 In conclusion, our study suggests that a combination of light and heavy housework is
47
48 associated with better cognition, specifically in attention and memory domains,
49
50 among community-dwelling older adults. Furthermore, the associations of housework
51
52 levels with better physical and sensorimotor functions in older adults were intensity-
53
54 dependent. Housework may also complement recreational physical activities among
55
56 current older community-dwelling adults in high-income countries towards healthier
57
58 aging.
59
60

Funding

This research was supported by Geriatric Education and Research Institute (GERI) intramural funding - GERI 1609.

Acknowledgements

The authors gratefully acknowledge the strong support of Prof. Pang Weng Sun in making this Yishun Study possible, and the support of Daniella Ng, Queenie Tan, Dr. Lilian Chye, Sylvia Ngu Siew Ching, Aizuriah Mohamed Ali, Mary Ng Pei Ern, Chua Xing Ying and Shermaine Thein in this study.

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.

For peer review only

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.

- 1
2
3 8. Beard JR, Officer A, de Carvalho IA, et al. The World report on ageing and
4 health: a policy framework for healthy ageing. *Lancet* 2016; **387**(10033): 2145-
5
6 54.
7
- 8
9
10 9. Murphy MH, Donnelly P, Breslin G, Shibli S, Nevill AM. Does doing housework
11 keep you healthy? The contribution of domestic physical activity to meeting
12 current recommendations for health. *BMC Public Health* 2013; **13**: 966.
13
14
- 15
16 10. Stephan AJ, Strobl R, Müller M, et al. A high level of household physical activity
17 compensates for lack of leisure time physical activity with regard to deficit
18 accumulation: Results from the KORA-Age study. *Prev Med* 2016; **86**: 64-9.
19
20
- 21
22 11. Koblinsky ND, Meusel L-AC, Greenwood CE, Anderson ND. Household physical
23 activity is positively associated with gray matter volume in older adults. *BMC*
24 *Geriatrics* 2021; **21**(1): 104.
25
26
- 27
28 12. Tsuchiya K, Mitsui S, Fukuyama R, et al. An acute bout of housework activities
29 has beneficial effects on executive function. *Neuropsychiatr Dis Treat* 2018; **14**:
30
31 61-72.
32
33
- 34
35 13. Singapore DoS. Population and Population Structure. 2020.
36
37
38 [https://www.singstat.gov.sg/find-data/search-by-theme/population/population-](https://www.singstat.gov.sg/find-data/search-by-theme/population/population-and-population-structure/latest-data)
39
40 [and-population-structure/latest-data](https://www.singstat.gov.sg/find-data/search-by-theme/population/population-and-population-structure/latest-data) (accessed 25 March 2021 2021).
41
42
43
- 44
45 14. Lee SY, Choo PL, Pang BWJ, et al. SPPB reference values and performance in
46 assessing sarcopenia in community-dwelling Singaporeans – Yishun study. *BMC*
47 *Geriatrics* 2021; **21**(1): 213.
48
49
- 50
51 15. Stel VS, Smit JH, Pluijm SM, Visser M, Deeg DJ, Lips P. Comparison of the
52 LASA Physical Activity Questionnaire with a 7-day diary and pedometer. *J Clin*
53 *Epidemiol* 2004; **57**(3): 252-8.
54
55
56
57
58
59
60

- 1
2
3 16. Siebeling L, Wiebers S, Beem L, Puhan MA, Ter Riet G. Validity and
4
5 reproducibility of a physical activity questionnaire for older adults: questionnaire
6
7 versus accelerometer for assessing physical activity in older adults. *Clin*
8
9 *Epidemiol* 2012; **4**: 171-80.
- 10
11
12 17. Bull FC, Maslin TS, Armstrong T. Global physical activity questionnaire (GPAQ):
13
14 nine country reliability and validity study. *J Phys Act Health* 2009; **6**(6): 790-804.
- 15
16
17 18. Haskell WL, Lee IM, Pate RR, et al. Physical activity and public health: updated
18
19 recommendation for adults from the American College of Sports Medicine and
20
21 the American Heart Association. *Med Sci Sports Exerc* 2007; **39**(8): 1423-34.
- 22
23
24 19. Randolph C, Tierney MC, Mohr E, Chase TN. The Repeatable Battery for the
25
26 Assessment of Neuropsychological Status (RBANS): preliminary clinical validity.
27
28 *J Clin Exp Neuropsychol* 1998; **20**(3): 310-9.
- 29
30
31 20. Guralnik JM, Ferrucci L, Simonsick EM, Salive ME, Wallace RB. Lower-extremity
32
33 function in persons over the age of 70 years as a predictor of subsequent
34
35 disability. *N Engl J Med* 1995; **332**(9): 556-61.
- 36
37
38 21. Lord SR, Ward JA, Williams P, Anstey KJ. Physiological factors associated with
39
40 falls in older community-dwelling women. *J Am Geriatr Soc* 1994; **42**(10): 1110-
41
42 7.
- 43
44
45 22. Lord SR, Menz HB, Tiedemann A. A Physiological Profile Approach to Falls Risk
46
47 Assessment and Prevention. *Physical Therapy* 2003; **83**(3): 237-52.
- 48
49
50 23. Jiang C, Xu Y. The association between mild cognitive impairment and doing
51
52 housework. *Aging Ment Health* 2014; **18**(2): 212-6.
- 53
54
55 24. Peng Z, Jiang H, Wang X, et al. The Efficacy of Cognitive Training for Elderly
56
57 Chinese Individuals with Mild Cognitive Impairment. *Biomed Res Int* 2019; **2019**:
58
59 4347281.
- 60

- 1
2
3 25. Erickson KI, Leckie RL, Weinstein AM. Physical activity, fitness, and gray matter
4 volume. *Neurobiology of Aging* 2014; **35**: S20-S8.
5
6
- 7
8 26. Clouston SAP, Smith DM, Mukherjee S, et al. Education and Cognitive Decline:
9 An Integrative Analysis of Global Longitudinal Studies of Cognitive Aging. *The
10 Journals of Gerontology: Series B* 2020; **75**(7): e151-e60.
11
12
- 13
14 27. Angevaren M, Aufdemkampe G, Verhaar HJ, Aleman A, Vanhees L. Physical
15 activity and enhanced fitness to improve cognitive function in older people
16 without known cognitive impairment. *Cochrane Database Syst Rev* 2008; (3):
17 Cd005381.
18
19
- 20
21 28. Gomez-Pinilla F, Hillman C. The influence of exercise on cognitive abilities.
22 *Compr Physiol* 2013; **3**(1): 403-28.
23
24
- 25
26 29. Smith PJ, Blumenthal JA, Hoffman BM, et al. Aerobic exercise and
27 neurocognitive performance: a meta-analytic review of randomized controlled
28 trials. *Psychosom Med* 2010; **72**(3): 239-52.
29
30
- 31
32 30. Tabbarah M, Crimmins EM, Seeman TE. The Relationship Between Cognitive
33 and Physical Performance: MacArthur Studies of Successful Aging. *The
34 Journals of Gerontology: Series A* 2002; **57**(4): M228-M35.
35
36
- 37
38 31. Montero-Odasso M, Speechley M. Falls in Cognitively Impaired Older Adults:
39 Implications for Risk Assessment And Prevention. *J Am Geriatr Soc* 2018; **66**(2):
40 367-75.
41
42
- 43
44 32. Muir SW, Gopaul K, Montero Odasso MM. The role of cognitive impairment in
45 fall risk among older adults: a systematic review and meta-analysis. *Age and
46 Ageing* 2012; **41**(3): 299-308.
47
48
- 49
50 33. Welmer A-K, Rizzuto D, Laukka EJ, Johnell K, Fratiglioni L. Cognitive and
51 Physical Function in Relation to the Risk of Injurious Falls in Older Adults: A
52
53
54
55
56
57
58
59
60

- 1
2
3 Population-Based Study. *The Journals of Gerontology: Series A* 2017; **72**(5):
4 669-75.
5
6
7
8 34. Sanders LMJ, Hortobágyi T, Karssemeijer EGA, Van der Zee EA, Scherder EJA,
9 van Heuvelen MJG. Effects of low- and high-intensity physical exercise on
10 physical and cognitive function in older persons with dementia: a randomized
11 controlled trial. *Alzheimers Res Ther* 2020; **12**(1): 28.
12
13
14
15
16
17 35. Jiménez-García JD, Hita-Contreras F, de la Torre-Cruz M, et al. Risk of Falls in
18 Healthy Older Adults: Benefits of High-Intensity Interval Training Using Lower
19 Body Suspension Exercises. *J Aging Phys Act* 2019; **27**(3): 325-33.
20
21
22
23
24 36. Edholm P, Nilsson A, Kadi F. Physical function in older adults: Impacts of past
25 and present physical activity behaviors. *Scand J Med Sci Sports* 2019; **29**(3):
26 415-21.
27
28
29
30
31 37. Glass TA, de Leon CM, Marottoli RA, Berkman LF. Population based study of
32 social and productive activities as predictors of survival among elderly
33 Americans. *Bmj* 1999; **319**(7208): 478-83.
34
35
36
37
38 38. Rodriguez-Stanley J, Alonso-Ferres M, Zilioli S, Slatcher RB. Housework, health,
39 and well-being in older adults: The role of socioeconomic status. *J Fam Psychol*
40 2020; **34**(5): 610-20.
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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	<i>p</i> value	Low	High	<i>p</i> value
Younger						
<i>n</i>	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)						
<i>Recreational</i>	576 (784)	774 (1302)	0.137	637 (933)	764 (1324)	0.393
<i>Transport</i>	2065 (3010)	2003 (2228)	0.861	1577 (1955)	2579 (3075)	0.003
<i>Occupational</i>	1686 (3619)	2408 (5658)	0.220	2052 (4252)	2199 (5699)	0.821
<i>Total</i>	4327 (5151)	5185 (6903)	0.263	4266 (4971)	5543 (7511)	0.125
Housework						
<i>Heavy (min/week)</i>	0 (2)	192 (292)	<0.001	47 (81)	198 (335)	<0.001
<i>Light (min/week)</i>	198 (363)	584 (593)	<0.001	95 (87)	838 (592)	<0.001
<i>Total (MET min/week)</i>	496 (908)	2228 (2079)	<0.001	425 (458)	2887 (2120)	<0.001
Older						
<i>n</i>	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)						
<i>Recreational</i>	828 (1053)	890 (1047)	0.650	867 (1181)	847 (941)	0.884
<i>Transport</i>	1561 (1565)	1836 (2050)	0.253	1554 (1964)	1783 (1667)	0.340
<i>Occupational</i>	676 (2269)	401 (1397)	0.251	547 (2113)	557 (1783)	0.968
<i>Total</i>	3065 (2731)	3127 (2531)	0.856	2968 (2968)	3187 (2366)	0.537
Housework						

1							
2							
3							
4	<i>Heavy</i>	0 (0)	131 (140)	<0.001	31 (72)	80 (134)	<0.001
5	<i>(min/week)</i>						
6	<i>Light</i>	446 (508)	684 (568)	<0.001	89 (93)	902 (485)	<0.001
7	<i>(min/week)</i>						
8	<i>Total (MET</i>						
9	<i>min/week)</i>	1116 (1270)	2236 (1584)	<0.001	347 (377)	2576 (1349)	<0.001
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							
32							
33							
34							
35							
36							
37							
38							
39							
40							
41							
42							
43							
44							
45							
46							
47							
48							
49							
50							
51							
52							
53							
54							
55							
56							
57							
58							
59							
60							

For peer review only

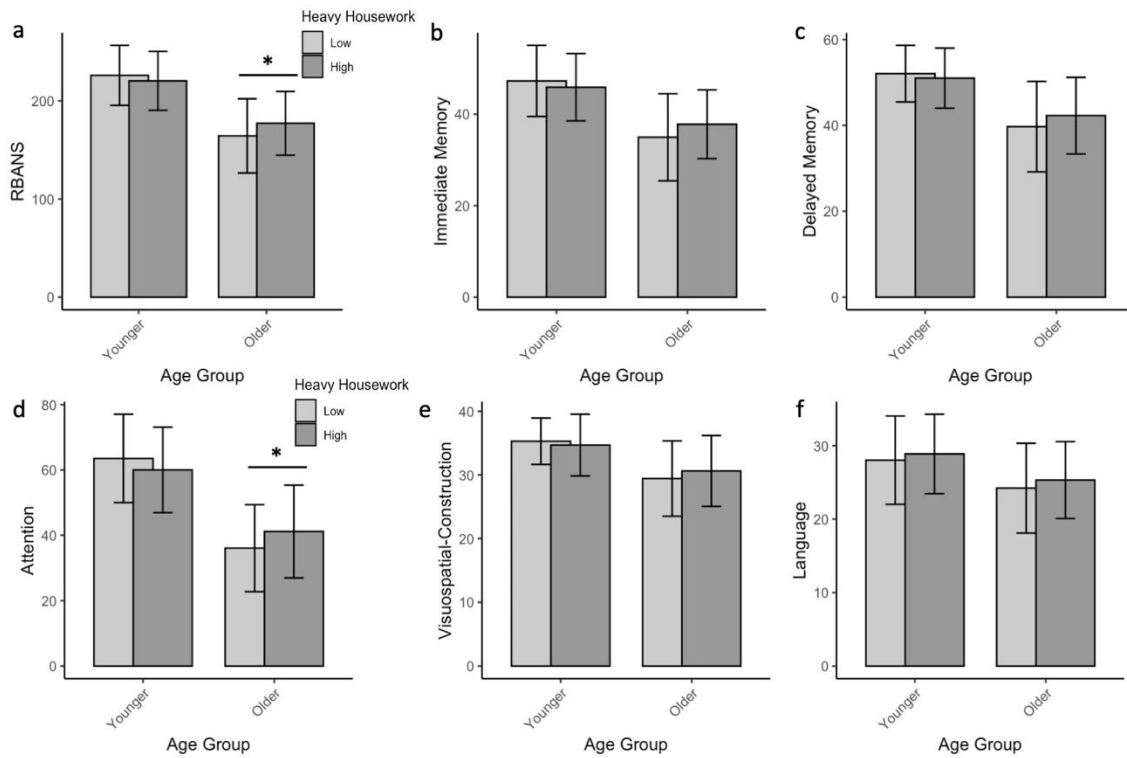


Figure 1. Mean (SD) of global cognitive function and specific domains between high and low heavy housework groups, within younger and older adults. * $p < 0.05$, adjusted for age, sex and time spent on light housework per week.

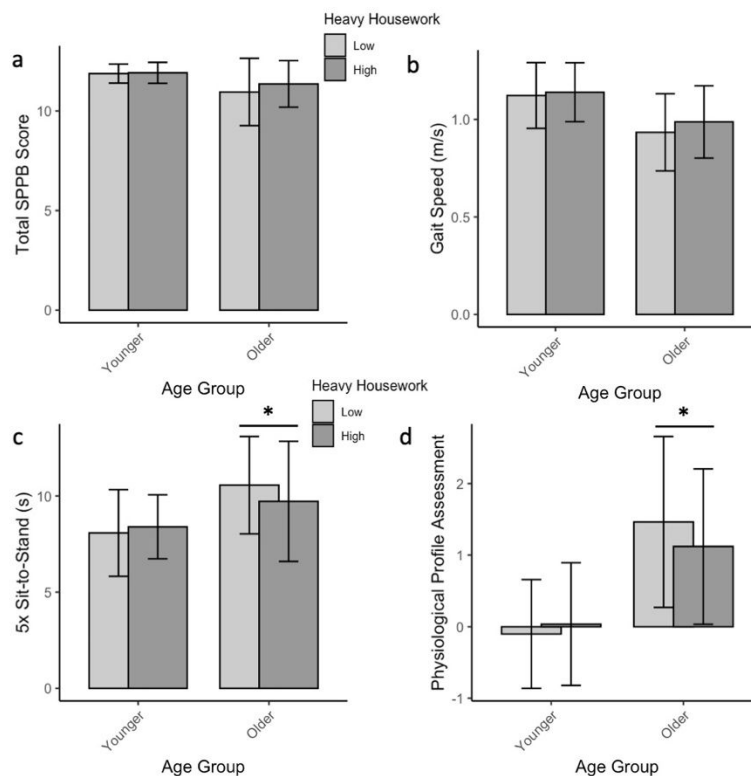


Figure 2. Mean (SD) of physical and sensorimotor function measures including total short physical performance battery score (a), 6m habitual gait speed (b), and five-times repeated chair sit-to-stand time (c), and physiological profile assessment (d), between high and low heavy housework groups, within younger and older adults.

* $p < 0.05$, adjusted for age, sex and time spent on light housework per week.

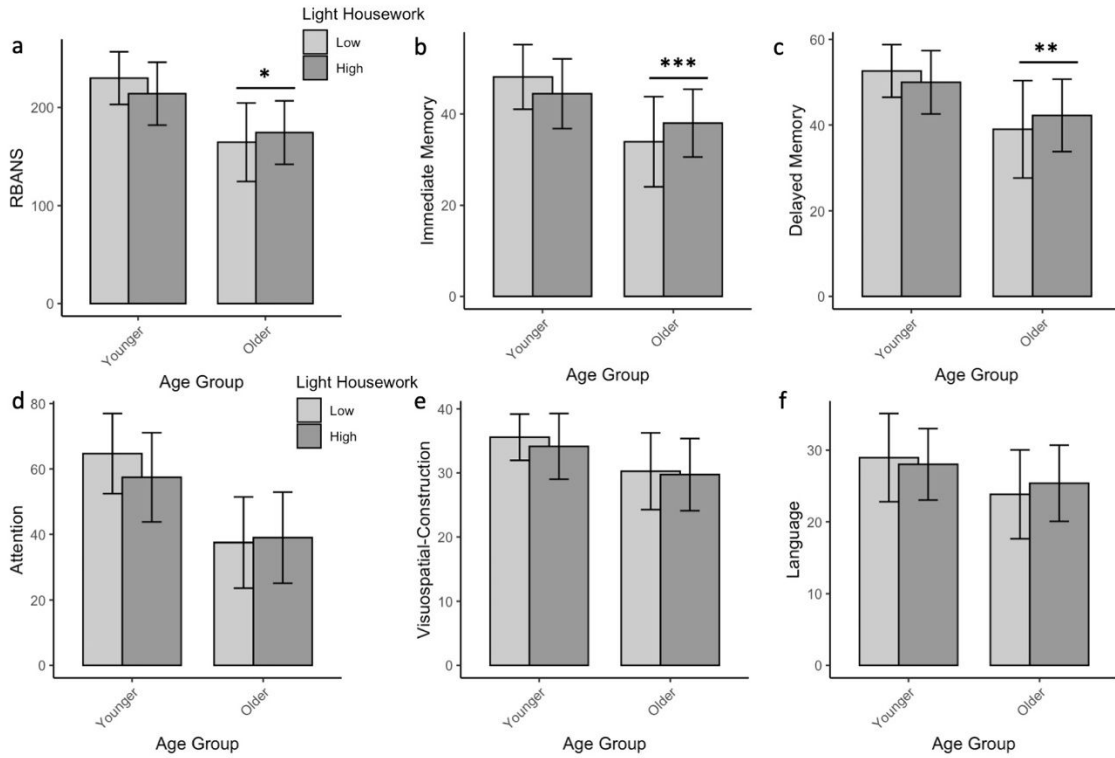


Figure 3. Mean (SD) of global cognitive function and specific domains between high and low light housework groups, within younger and older adults. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, adjusted for age, sex, height, years of education, transport-related physical activity and time spent on heavy housework per week.

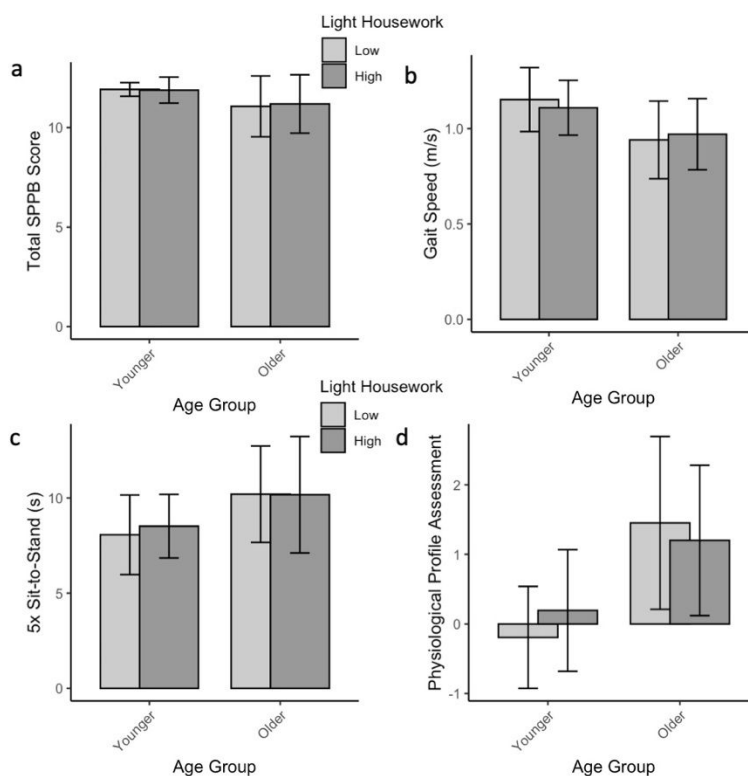


Figure 4. Mean (SD) of physical and sensorimotor function measures including total short physical performance battery score (a), 6m habitual gait speed (b), and five-times repeated chair sit-to-stand time (c), and physiological profile assessment (d), between high and low light housework groups, within 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.

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

von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche 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	
1			
2			
3	Eligibility criteria	#6a Give the eligibility criteria, and the sources and methods of selection of participants.	7
4			
5			
6		#7 Clearly define all outcomes, exposures, predictors, potential	7-9
7		confounders, and effect modifiers. Give diagnostic criteria, if applicable	
8			
9			
10	Data sources /	#8 For each variable of interest give sources of data and details of methods	7-9
11	measurement	of assessment (measurement). Describe comparability of assessment	
12		methods if there is more than one group. Give information separately	
13		for for exposed and unexposed groups if applicable.	
14			
15			
16			
17	Bias	#9 Describe any efforts to address potential sources of bias	NA
18			
19	Study size	#10 Explain how the study size was arrived at	10
20			
21	Quantitative	#11 Explain how quantitative variables were handled in the analyses. If	10
22	variables	applicable, describe which groupings were chosen, and why	
23			
24			
25	Statistical	#12a Describe all statistical methods, including those used to control for	10-11
26	methods	confounding	
27			
28			
29	Statistical	#12b Describe any methods used to examine subgroups and interactions	10
30	methods		
31			
32			
33	Statistical	#12c Explain how missing data were addressed	NA
34	methods		
35			
36			
37	Statistical	#12d If applicable, describe analytical methods taking account of sampling	NA
38	methods	strategy	
39			
40			
41	Statistical	#12e Describe any sensitivity analyses	NA
42	methods		
43			
44	Results		
45			
46	Participants	#13a Report numbers of individuals at each stage of study—eg numbers	10
47		potentially eligible, examined for eligibility, confirmed eligible,	
48		included in the study, completing follow-up, and analysed. Give	
49		information separately for for exposed and unexposed groups if	
50		applicable.	
51			
52			
53			
54			
55	Participants	#13b Give reasons for non-participation at each stage	NA
56			
57	Participants	#13c Consider use of a flow diagram	NA
58			
59			
60			

1	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
2				
3				
4				
5				
6	Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	NA
7				
8				
9				
10	Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	12-13
11				
12				
13				
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	12-13
15				
16				
17				
18				
19	Main results	#16b	Report category boundaries when continuous variables were categorized	NA
20				
21	Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
22				
23				
24				
25	Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	NA
26				
27				
28				
29	Discussion			
30				
31	Key results	#18	Summarise key results with reference to study objectives	13
32				
33				
34	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
35				
36				
37				
38				
39	Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	14-16
40				
41				
42				
43				
44	Generalisability	#21	Discuss the generalisability (external validity) of the study results	17
45				
46				
47	Other			
48	Information			
49				
50				
51	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
52				
53				
54				
55				

The STROBE checklist is distributed under the terms of the Creative Commons Attribution License CC-BY.

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](#)

For peer review only - <http://bmjopen.bmj.com/site/about/guidelines.xhtml>

BMJ Open

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

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2021-052557.R1
Article Type:	Original research
Date Submitted by the Author:	23-Aug-2021
Complete List of Authors:	Lee, Shuen Yee; Singapore Institute of Technology Pang, Benedict Wei Jun; Geriatric Education and Research Institute Ltd Lau, Lay Khoon; Geriatric Education and Research Institute Ltd Jabbar, Khalid Abdul; Geriatric Education and Research Institute Ltd Seah, Wei Ting; Geriatric Education and Research Institute Ltd Chen, Kenneth Kexun; Geriatric Education and Research Institute Ltd Ng, Tze Pin; National University of Singapore, Department of Psychological Medicine; Geriatric Education and Research Institute Ltd Wee, Shiou-Liang; Singapore Institute of Technology; Geriatric Education and Research Institute Ltd
Primary Subject Heading:	Public health
Secondary Subject Heading:	Geriatric medicine, Health policy, Sports and exercise medicine
Keywords:	Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, PREVENTIVE MEDICINE, Physiology < NATURAL SCIENCE DISCIPLINES, GERIATRIC MEDICINE, PUBLIC HEALTH, SPORTS MEDICINE

SCHOLARONE™
Manuscripts



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our [licence](#).

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which [Creative Commons](#) licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

1
2
3
4 **Title: Cross-sectional associations between housework with cognitive,**
5
6 **physical and sensorimotor functions in younger and older community-**
7
8 **dwelling adults – the Yishun Study**
9
10

11
12
13 Shuen Yee Lee, PhD^a, Benedict Wei Jun Pang, BSc^b, Lay Khoon Lau, PhD^b, Khalid
14
15 Abdul Jabbar, MSc^b, Wei Ting Seah, MSc^b, Kenneth Kexun Chen, BSc^b, Tze Pin Ng,
16
17 MD^{b,c}, Shiou-Liang Wee, PhD^{a,b}
18
19

20
21
22 ^aFaculty of Health and Social Sciences, Singapore Institute of Technology, 10 Dover
23
24 Drive, Singapore 138683, Singapore, Singapore
25
26

27 ^bGeriatric Education and Research Institute, 2 Yishun Central 2, Singapore 768024,
28
29 Singapore, Singapore
30
31

32 ^cDepartment of Psychological Medicine, National University of Singapore, 21 Lower
33
34 Kent Ridge Rd, Singapore 119077, Singapore, Singapore
35
36

37
38
39 **Corresponding author:** Shiou-Liang Wee, Geriatric Education and Research
40
41 Institute (GERI), 2 Yishun Central 2, Tower E Level 4 GERI Admin, 768024,
42
43 Singapore. Phone: +65 65924606, Email: weeshiouliang@gmail.com
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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 (≥ 65 yrs, $n=240$) 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

1
2
3 (p=0.011 and p=0.040). SPPB and gait speed did not differ with age or HH. LH was
4
5 not associated with physical or sensorimotor function.
6
7

8 **Conclusions:** Among older adults, housework is associated with higher cognitive
9
10 function, specifically in attention and memory. Associations between housework with
11
12 physical and sensorimotor performance were intensity-dependent. Housework PA is
13
14 positively associated with functional health among community-dwelling older adults,
15
16 independent of recreation and other non-recreational physical activities. Further
17
18 longitudinal and intervention studies are needed to establish causality.
19
20
21

22 **Key words:** Housework intensity, Functional health, High-income countries, Ageing,
23
24 Household chores, Non-recreational physical activity
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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 adults¹⁻³. Yet, global surveillance data indicate that in 2016, levels of insufficient PA remained high (27·5%) and stable across previous 10 years⁴. 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 countries⁴. 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 globally⁵, better strategies and policies are required to increase PA levels, especially among older adults, due to their increased vulnerability to adverse health outcomes⁶.

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 adults⁷⁻⁹. Few studies have examined the independent effects of non-recreational activity, such as housework tasks, on age-associated decline in functional ability¹⁰⁻¹². Furthermore, although the effects of exercise intensity have been widely investigated¹, 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

1
2
3 healthy ageing, which centres upon the maintenance of functional ability, are
4 urgently needed ¹³.
5
6
7
8
9

10 Housework activities are a large part of everyday activities in older people, and
11 account for a significant proportion of self-reported PA ¹⁴. Apart from a meaningful
12 occupation, housework is also a component of instrumental activities of daily living –
13 both key factors of successful ageing. Additionally, single bout of housework and
14 chronic housework are associated with improved cognition, brain volume and
15 executive function, and negatively associated with frailty ¹⁰⁻¹². Regardless of country
16 income levels, higher levels of non-recreational PA were associated with a graded
17 reduction in mortality and cardiovascular diseases, suggesting the potential role of
18 non-recreational PA such as housework, on improving health outcomes even in high-
19 income countries ⁵. Housework may also confer benefits on physical and mental
20 function among older adults in a high-income country such as Singapore. Therefore,
21 we studied the associations between light and heavy housework activities, with
22 cognitive, physical and sensorimotor function, among younger and older adults in
23 Singapore.
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47

48 **Methods**

49 Settings

50 Community-dwelling adults (≥ 21 years) were recruited from a large north-eastern
51 residential town of Yishun in Singapore, with residential population of 220,320
52 (50.6% females), with 12.2% older adults (≥ 65 years). This is similar to the overall
53 Singapore residential population of 4,044,200 (51.1% females), with 15.2% older
54 adults (≥ 65 years) ¹⁵.
55
56
57
58
59
60

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 women¹⁶. 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

1
2
3 or ≥ 75 min/week of vigorous-intensity PA) was used to determine percentage of
4
5 participants who met the current PA guidelines ^{5,20}.
6
7
8
9

10 Cognitive function

11
12 Cognitive performance was assessed by the Repeatable Battery for the Assessment
13 of Neuropsychological Status (RBANS) score. RBANS is a standardized age-
14 adjusted battery that is sensitive to cognitive impairment ²¹. RBANS assesses global
15 and specific cognitive domains including immediate and delayed memory,
16
17 visuospatial-construction, language, and attention.
18
19
20
21
22
23
24
25
26

27 Physical function

28
29 Habitual gait speed was assessed using a 6m GAITRite Walkway (CIR Systems Inc,
30 Sparta, NJ) with 2m lead in and out phase. Participants performed three trials and
31 the average timing was recorded. The Short Physical Performance Battery (SPPB)
32 consists of 3 subtests including balance, gait and sit-to-stand ^{22,23}. The balance
33 subtest composed of 3 parts with progressive difficulty, including unaided feet-
34 together stand, semi-tandem stand and full-tandem stand. Participants were timed
35 until they moved or 10s elapsed time. Gait speed was assessed by participants
36 walking 8ft at their usual pace, with a moving start ²². The average timing was
37 recorded over two trials. To assess sit-to-stand time, participants folded their arms
38 across their chest and performed five chair stands as quickly as possible. Each of
39 the 3 subtests was scored from 0–4 and the total score was the sum of 3 subtests,
40 ranging from 0–12. Higher SPPB scores indicated better physical function ²².
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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 population¹⁵. 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 PA²⁰. 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 $p<0.001$, Table 1). Total, recreational and occupational PA did not differ between high and low HH and LH groups in younger and older adults (all $p>0.05$, Table 1). Within the younger but not the older group, transport-related PA was 39% lower in low LH than high LH group ($p=0.003$, 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

1
2
3 light and heavy housework activities per week and had higher total housework MET
4 min/week (all $p < 0.001$, Table 1).
5
6
7
8
9

10 For subsequent light housework analyses, age, sex, height, education, transport PA
11 and heavy housework were included in the model to adjust for confounding
12 variables. To adjust for confounding factors, age, sex and light housework were
13 included in model for subsequent heavy housework analyses. Adjusting for
14 recreational and occupational PA in the analyses did not affect any of the results
15 presented; hence, data are presented with recreational and occupational PA
16 excluded from the model.
17
18
19
20
21
22
23
24
25
26
27

28 Association of heavy housework activities with cognitive function

29
30 Within the older group, RBANS global cognition score was 8% higher in the high HH
31 than low HH group ($p = 0.012$) but did not differ between high and low HH groups
32 among the younger individuals ($p = 0.630$) (age*housework; $p = 0.031$, $\eta^2_p = 0.01$, Fig
33 1a). Immediate memory index scores between high and low HH groups were not
34 statistically significant among older ($p = 0.055$) and younger adults ($p = 0.332$), despite
35 significant interaction effects (age*housework; $p = 0.038$, $\eta^2_p = 0.009$, Fig 1b). No
36 significant interaction effects between age and HH groups were observed for
37 delayed memory ($p = 0.108$, $\eta^2_p = 0.005$), visuospatial-construction ($p = 0.183$,
38 $\eta^2_p = 0.004$), and language index scores ($p = 0.776$, $\eta^2_p = 0.0002$) (Fig 1c-e). Attention
39 index score was 14% higher in the high HH than low HH group within the older
40 ($p = 0.014$) but not the younger ($p = 0.304$) group (age*housework; $p = 0.012$, $\eta^2_p = 0.01$,
41 Fig 1f).
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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; $p=0.015$, $\eta^2_p=0.01$, 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; $p<0.001$, $\eta^2_p=0.03$ and $p=0.022$, $\eta^2_p=0.01$)(Fig 2b&c). No significant interaction effects between age and LH groups were observed for visuospatial-construction ($p=0.781$, $\eta^2_p=0.0002$), language ($p=0.318$, $\eta^2_p=0.002$) and attention ($p=0.194$, $\eta^2_p=0.004$) 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 ($p=0.155$, $\eta^2_p=0.004$, Fig 3a) and gait speed ($p=0.482$, $\eta^2_p=0.001$, 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; $p=0.036$, $\eta^2_p=0.009$, 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; $p=0.046$, $\eta^2_p=0.008$, 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 ($p=0.709$, $\eta^2_p=0.0003$), gait speed ($p=0.136$, $\eta^2_p=0.005$), sit-to-stand ($p=0.445$, $\eta^2_p=0.001$) (Fig 4a–c). PPA index scores, indicative of sensorimotor function, were not significant between high and low LH groups among older

1
2
3 ($p=0.067$) and younger adults ($p=0.178$), despite significant interaction effects
4
5 ($\text{age} \times \text{housework}; p=0.021, \eta^2_p=0.01$, Fig 4d). Mean (SD) values of cognitive, physical
6
7 and sensorimotor performance between age and housework groups are presented in
8
9 Supplementary Table S1.
10
11
12
13
14

15 Discussion

16
17 The present study is the first to report that housework activity is associated with
18
19 cognitive, physical and sensorimotor functions among older but not younger adults in
20
21 Singapore. These positive associations of housework with functional performance in
22
23 older adults were independent of recreational, occupational and transport-related
24
25 physical activities. We also show that more adults attained recommended physical
26
27 activity levels through housework than recreation.
28
29
30
31

32
33
34 Regardless of intensity, higher levels of housework activities were associated with
35
36 higher global cognition, among our population of older adults. Earlier studies
37
38 observed that lower levels of housework activities were associated with mild
39
40 cognitive impairment, cognitive decline and lower grey matter volume among older
41
42 adults^{11,27,28}, suggesting a positive association between housework activities and
43
44 cognitive function, plausibly through an increase in brain volume, as observed with
45
46 exercise interventions in older adults^{29,30}. However, the positive associations
47
48 between housework and cognition were not apparent in younger adults in our
49
50 population. Differences in years of education between younger and older adults likely
51
52 explain the disparity, as younger adults in this study had five more years of
53
54 education on average than older adults. Since education level is positively
55
56 associated with baseline cognitive function and slower cognitive decline³¹, it is
57
58
59
60

1
2
3 plausible that higher education levels and cognitive function in younger adults
4
5 decreases the potential for better cognitive function associated with housework
6
7
8 activities.
9

10
11
12 Our results demonstrate, for the first time, that the intensity of housework was
13
14 differentially associated with specific cognitive domains. Heavy housework was
15
16 associated with higher scores in the attention domain, while light housework was
17
18 associated with higher scores in both delayed and immediate memory domains in
19
20 older adults. Earlier studies reported that aerobic exercise interventions of varying
21
22 intensities improved specific cognitive function domains, including executive and
23
24 motor function, attention and memory, through an increase in hippocampal volume
25
26 and brain-derived neurotrophic factor expression ³²⁻³⁴. Given that housework
27
28 accounted for a significant proportion (~24–36% in women and ~19–28% in men) of
29
30 self-reported moderate-to-vigorous-intensity PA among older adults aged above 60
31
32 ¹⁴, it is plausible that the higher cognitive function associated with housework occurs
33
34 through a similar mechanism as PA or exercise ¹⁴. More studies are required to
35
36 understand the underlying mechanisms driving the age-associated differing
37
38 associations of housework intensity with specific cognitive domains.
39
40
41
42
43
44
45
46

47 Poorer cognitive performance in attention and executive functions were associated
48
49 with poorer physical function, slower gait, postural instability, and future falls among
50
51 community-dwelling older adults ³⁵⁻³⁷. We show that higher levels of heavy
52
53 housework activities were also independently associated with better physical (chair-
54
55 stand time) and sensorimotor (PPA) performance in older but not younger adults.

56
57
58 Among older Swedish adults, longer chair-stand time and poorer cognitive
59
60

1
2
3 performance (processing speed and executive function) independently increased the
4 risk of injurious falls over 3–10 years by 10–23%³⁸. Unlike older adults, younger
5 adults have higher functional abilities and are unlikely to experience decline in
6 sensorimotor and physical function, potentially explaining the lack of associations
7 between housework activities with physical and sensorimotor performance. These
8 results collectively suggest that the higher cognitive, physical and sensorimotor
9 functions related to heavy housework activities might plausibly be associated with
10 lower physiological fall risk among community-dwelling older adults.
11
12
13
14
15
16
17
18
19
20
21
22
23

24 We compared the independent associations of light and heavy housework activities,
25 and demonstrated that unlike heavy housework, light housework was not associated
26 with physical or sensorimotor function. The lack of associations could be due to the
27 already high functional ability of our study participants ²³. In support, compared with
28 lower intensity exercise, greater improvements in functional ability and decreased
29 fear of falling were observed after high intensity exercise in older adults ³⁹⁻⁴¹. These
30 results indicate a dose-response effect for exercise intensity on physical and
31 sensorimotor function and associated falls risk in older adults. Similarly, we propose
32 that the positive associations between housework with physical and sensorimotor
33 function is dependent on intensity, especially in community-dwelling older adults.
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48

49 Notably in this present study, 25% and 18% more participants in the younger and
50 older group, respectively, met the PA guidelines derived exclusively from housework,
51 than that attained solely through recreational PA. This finding reflects the challenges
52 inherent with recreational PA participation, which is by definition, done during
53 discretionary hours of the day outside of occupational and domestic duties.
54
55
56
57
58
59
60

1
2
3 Incorporating PA into daily lifestyle through domestic duties (i.e., housework) has the
4 potential to achieve higher PA, which is positively associated with functional health
5 especially among older community-dwelling adults.
6
7
8
9
10

11
12 Our study recruited adults aged 21–80+ randomly from a large residential town
13 representative of Singapore's population, suggesting a good degree of
14 generalisability. We also included a comparison between older and younger adults in
15 the study, to elucidate the age-associated effects of housework activities on
16 cognitive, physical and sensorimotor function. However, although associations can
17 be drawn from the study results, the cross-sectional design does not prove causality.
18 It is plausible that healthier older adults with higher functional ability engaged in
19 higher levels of housework. Nonetheless, in a 13-year follow-up study, productive
20 housework activities such as cooking and shopping were associated with lower
21 mortality risk in older adults ⁴², suggesting that housework activities are associated
22 with better health outcomes in older adults. The study findings in community-dwelling
23 individuals cannot be generalised to institutionalised older adults, such as those in
24 nursing homes. In the present study, housework and PA measures were self-
25 reported based on type, intensity, frequency and duration per week. Although the
26 LAPAQ and GPAQ used in this study is valid and reliable ^{17,19}, future studies using
27 more objective measures of housework and PA should be undertaken. It is possible
28 that socio-economic status may mediate the effects of housework on health ⁴³, which
29 should be further examined in the Asian cultural context. While we adjusted for sex
30 in all analyses, compared with low housework groups, participants in high housework
31 groups were mostly women, which is consistent with earlier studies showing greater
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 involvement in household chores among women than men ⁴⁴. Future studies should
4
5 investigate the sex-specific effects of housework on functional health.
6
7
8
9

10 In conclusion, our study suggests that a combination of light and heavy housework is
11
12 associated with higher cognitive function, specifically in attention and memory
13
14 domains, among community-dwelling older adults. Furthermore, the positive
15
16 associations of housework levels with physical and sensorimotor functions in older
17
18 adults were intensity-dependent. Housework may also complement recreational
19
20 physical activities among current older community-dwelling adults in high-income
21
22 countries towards healthier ageing. Future longitudinal and intervention studies are
23
24 required to establish causality between housework activities and functional health.
25
26
27
28
29
30
31

32 **Funding**

33
34 This work was supported by Geriatric Education and Research Institute (GERI)
35
36 intramural funding grant number [GERI 1609].
37
38
39
40
41

42 **Acknowledgements**

43
44 The authors gratefully acknowledge the strong support of Prof. Pang Weng Sun in
45
46 making this Yishun Study possible, and the support of Daniella Ng, Queenie Tan, Dr.
47
48 Lilian Chye, Sylvia Ngu Siew Ching, Aizuriah Mohamed Ali, Mary Ng Pei Ern, Chua
49
50 Xing Ying and Shermaine Thein in this study.
51
52
53
54
55
56
57
58
59
60

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.

- 1
2
3 8. Lam FM, Huang MZ, Liao LR, Chung RC, Kwok TC, Pang MY. Physical
4 exercise improves strength, balance, mobility, and endurance in people with
5 cognitive impairment and dementia: a systematic review. *J Physiother* 2018; **64**(1):
6 4-15.
7
- 8
9
10
11
12 9. García-Hermoso A, Ramirez-Vélez R, Sáez de Asteasu ML, et al. Safety and
13 Effectiveness of Long-Term Exercise Interventions in Older Adults: A Systematic
14 Review and Meta-analysis of Randomized Controlled Trials. *Sports Med* 2020; **50**(6):
15 1095-106.
16
- 17
18
19
20
21 10. Stephan AJ, Strobl R, Müller M, et al. A high level of household physical
22 activity compensates for lack of leisure time physical activity with regard to deficit
23 accumulation: Results from the KORA-Age study. *Prev Med* 2016; **86**: 64-9.
24
- 25
26
27
28
29 11. Koblinsky ND, Meusel L-AC, Greenwood CE, Anderson ND. Household
30 physical activity is positively associated with gray matter volume in older adults. *BMC*
31 *Geriatrics* 2021; **21**(1): 104.
32
- 33
34
35
36
37 12. Tsuchiya K, Mitsui S, Fukuyama R, et al. An acute bout of housework
38 activities has beneficial effects on executive function. *Neuropsychiatr Dis Treat* 2018;
39 **14**: 61-72.
40
- 41
42
43
44
45 13. Beard JR, Officer A, de Carvalho IA, et al. The World report on ageing and
46 health: a policy framework for healthy ageing. *Lancet* 2016; **387**(10033): 2145-54.
47
- 48
49
50
51
52 14. Murphy MH, Donnelly P, Breslin G, Shibli S, Nevill AM. Does doing
53 housework keep you healthy? The contribution of domestic physical activity to
54 meeting current recommendations for health. *BMC Public Health* 2013; **13**: 966.
55
- 56
57
58
59 15. Department of Statistics Singapore. Population and Population Structure.
60 2020. [https://www.singstat.gov.sg/find-data/search-by-theme/population/population-
and-population-structure/latest-data](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.

- 1
2
3 24. Lord SR, Ward JA, Williams P, Anstey KJ. Physiological factors associated
4 with falls in older community-dwelling women. *J Am Geriatr Soc* 1994; **42**(10): 1110-
5
6
7
8 7.
- 9
10 25. Lord SR, Menz HB, Tiedemann A. A Physiological Profile Approach to Falls
11 Risk Assessment and Prevention. *Physical Therapy* 2003; **83**(3): 237-52.
- 12
13 26. Lakens D. Calculating and reporting effect sizes to facilitate cumulative
14 science: a practical primer for t-tests and ANOVAs. *Front Psychol* 2013; **4**: 863.
- 15
16 27. Jiang C, Xu Y. The association between mild cognitive impairment and doing
17 housework. *Aging Ment Health* 2014; **18**(2): 212-6.
- 18
19 28. Peng Z, Jiang H, Wang X, et al. The Efficacy of Cognitive Training for Elderly
20 Chinese Individuals with Mild Cognitive Impairment. *Biomed Res Int* 2019; **2019**:
21 4347281.
- 22
23 29. Colcombe SJ, Erickson KI, Scalf PE, et al. Aerobic Exercise Training
24 Increases Brain Volume in Aging Humans. *The Journals of Gerontology: Series A*
25 2006; **61**(11): 1166-70.
- 26
27 30. Erickson KI, Leckie RL, Weinstein AM. Physical activity, fitness, and gray
28 matter volume. *Neurobiology of Aging* 2014; **35**: S20-S8.
- 29
30 31. Clouston SAP, Smith DM, Mukherjee S, et al. Education and Cognitive
31 Decline: An Integrative Analysis of Global Longitudinal Studies of Cognitive Aging.
32 *The Journals of Gerontology: Series B* 2020; **75**(7): e151-e60.
- 33
34 32. Angevaren M, Aufdemkampe G, Verhaar HJ, Aleman A, Vanhees L. Physical
35 activity and enhanced fitness to improve cognitive function in older people without
36 known cognitive impairment. *Cochrane Database Syst Rev* 2008; (3): Cd005381.
- 37
38 33. Gomez-Pinilla F, Hillman C. The influence of exercise on cognitive abilities.
39 *Compr Physiol* 2013; **3**(1): 403-28.
- 40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

- 1
2
3 34. Smith PJ, Blumenthal JA, Hoffman BM, et al. Aerobic exercise and
4 neurocognitive performance: a meta-analytic review of randomized controlled trials.
5
6 *Psychosom Med* 2010; **72**(3): 239-52.
7
8
9
10 35. Tabbarah M, Crimmins EM, Seeman TE. The Relationship Between Cognitive
11 and Physical Performance: MacArthur Studies of Successful Aging. *The Journals of*
12 *Gerontology: Series A* 2002; **57**(4): M228-M35.
13
14
15
16 36. Montero-Odasso M, Speechley M. Falls in Cognitively Impaired Older Adults:
17 Implications for Risk Assessment And Prevention. *J Am Geriatr Soc* 2018; **66**(2):
18 367-75.
19
20
21
22
23 37. Muir SW, Gopaul K, Montero Odasso MM. The role of cognitive impairment in
24 fall risk among older adults: a systematic review and meta-analysis. *Age and Ageing*
25 2012; **41**(3): 299-308.
26
27
28
29 38. Welmer A-K, Rizzuto D, Laukka EJ, Johnell K, Fratiglioni L. Cognitive and
30 Physical Function in Relation to the Risk of Injurious Falls in Older Adults: A
31 Population-Based Study. *The Journals of Gerontology: Series A* 2017; **72**(5): 669-75.
32
33
34
35 39. Sanders LMJ, Hortobágyi T, Karssemeijer EGA, Van der Zee EA, Scherder
36 EJA, van Heuvelen MJG. Effects of low- and high-intensity physical exercise on
37 physical and cognitive function in older persons with dementia: a randomized
38 controlled trial. *Alzheimers Res Ther* 2020; **12**(1): 28.
39
40
41
42
43 40. Jiménez-García JD, Hita-Contreras F, de la Torre-Cruz M, et al. Risk of Falls
44 in Healthy Older Adults: Benefits of High-Intensity Interval Training Using Lower
45 Body Suspension Exercises. *J Aging Phys Act* 2019; **27**(3): 325-33.
46
47
48
49 41. Edholm P, Nilsson A, Kadi F. Physical function in older adults: Impacts of past
50 and present physical activity behaviors. *Scand J Med Sci Sports* 2019; **29**(3): 415-
51 21.
52
53
54
55
56
57
58
59
60

- 1
2
3 42. Glass TA, de Leon CM, Marottoli RA, Berkman LF. Population based study of
4 social and productive activities as predictors of survival among elderly Americans.
5
6
7 *Bmj* 1999; **319**(7208): 478-83.
8
9
10 43. Rodriguez-Stanley J, Alonso-Ferres M, Zilioli S, Slatcher RB. Housework,
11 health, and well-being in older adults: The role of socioeconomic status. *J Fam*
12
13
14 *Psychol* 2020; **34**(5): 610-20.
15
16
17 44. Bianchi SM, Sayer LC, Milkie MA, Robinson JP. Housework: Who Did, Does
18 or Will Do It, and How Much Does It Matter? *Soc Forces* 2012; **91**(1): 55-63.
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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	<i>p</i> value	Low	High	<i>p</i> value
Younger						
<i>n</i>	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)						
<i>Recreational (MET min/week)</i>	576 (784)	774 (1302)	0.137	637 (933)	764 (1324)	0.393
<i>Transport (MET min/week)</i>	2065 (3010)	2003 (2228)	0.861	1577 (1955)	2579 (3075)	0.003
<i>Occupational (MET min/week)</i>	1686 (3619)	2408 (5658)	0.220	2052 (4252)	2199 (5699)	0.821
<i>Total (MET min/week)</i>	4327 (5151)	5185 (6903)	0.263	4266 (4971)	5543 (7511)	0.125
Housework Activity (LAPAQ)						
<i>Heavy (min/week)</i>	0 (2)	192 (292)	<0.001	47 (81)	198 (335)	<0.001
<i>Light (min/week)</i>	198 (363)	584 (593)	<0.001	95 (87)	838 (592)	<0.001
<i>Total (MET min/week)</i>	496 (908)	2228 (2079)	<0.001	425 (458)	2887 (2120)	<0.001
Older						
<i>n</i>	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)						
<i>Recreational (MET min/week)</i>	828 (1053)	890 (1047)	0.650	867 (1181)	847 (941)	0.884
<i>Transport (MET min/week)</i>	1561 (1565)	1836 (2050)	0.253	1554 (1964)	1783 (1667)	0.340
<i>Occupational (MET min/week)</i>	676 (2269)	401 (1397)	0.251	547 (2113)	557 (1783)	0.968
<i>Total (MET min/week)</i>	3065 (2731)	3127 (2531)	0.856	2968 (2968)	3187 (2366)	0.537
Housework Activity (LAPAQ)						

1							
2							
3							
4	<i>Heavy (min/week)</i>	0 (0)	131 (140)	<0.001	31 (72)	80 (134)	<0.001
5	<i>Light (min/week)</i>	446 (508)	684 (568)	<0.001	89 (93)	902 (485)	<0.001
6							
7	<i>Total (MET</i>		2236 (1584			2576 (1349	<0.001
8	<i>min/week)</i>	1116 (1270))	<0.001	347 (377))	<0.001
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							
32							
33							
34							
35							
36							
37							
38							
39							
40							
41							
42							
43							
44							
45							
46							
47							
48							
49							
50							
51							
52							
53							
54							
55							
56							
57							
58							
59							
60							

For peer review only

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.

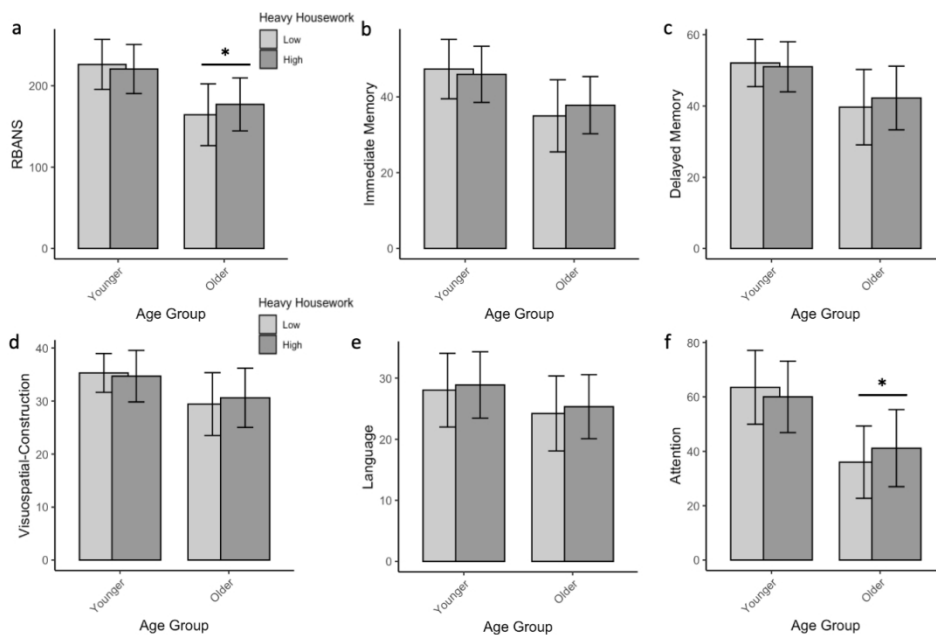


Figure 1. Mean (SD) of global cognitive function and specific domains between high and low heavy housework groups, within younger and older adults. * $p < 0.05$, adjusted for age, sex and time spent on light housework per week.

294x190mm (124 x 124 DPI)

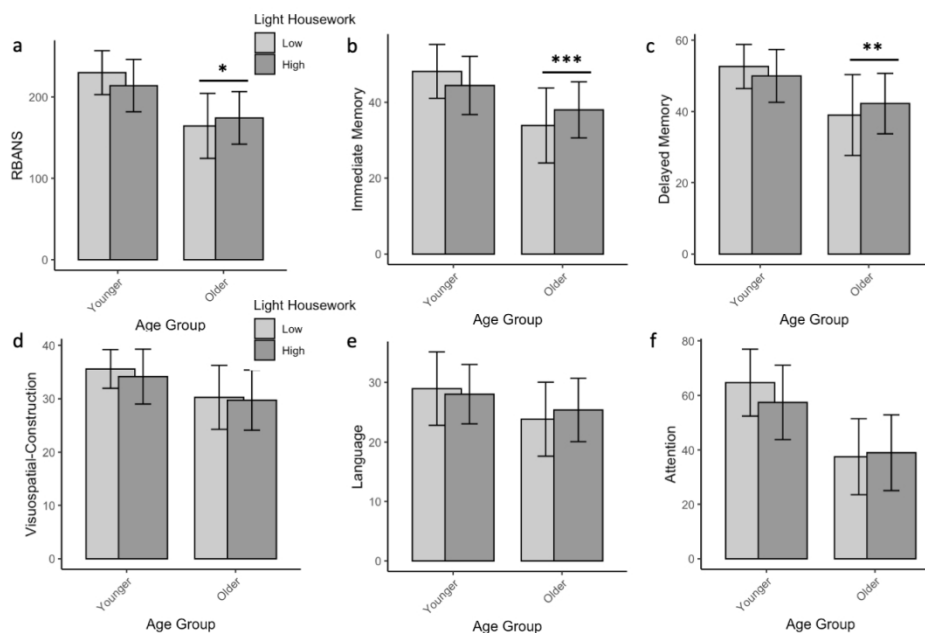


Figure 2. Mean (SD) of global cognitive function and specific domains between high and low light housework groups, within younger and older adults. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, adjusted for age, sex, height, years of education, transport-related physical activity and time spent on heavy housework per week.

294x190mm (124 x 124 DPI)

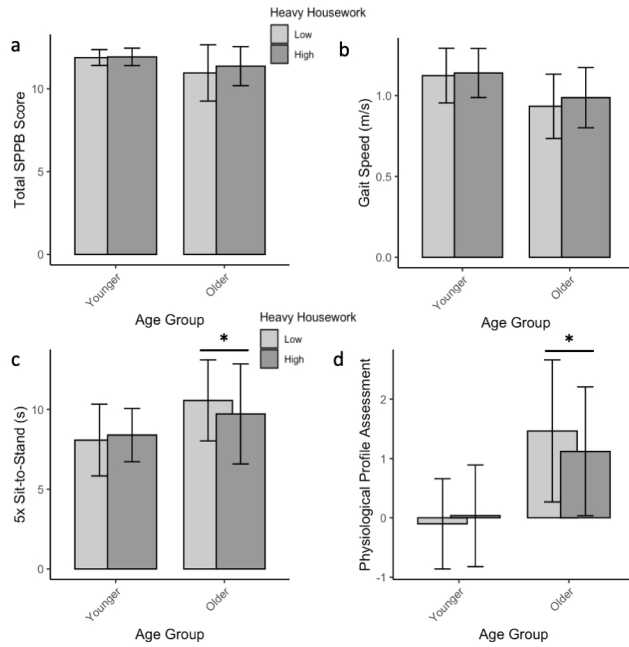


Figure 3. Mean (SD) of physical function measures including total short physical performance battery score (a), 6m habitual gait speed (b), and five-times repeated chair sit-to-stand time (c), and sensorimotor function measure including physiological profile assessment (d), between high and low heavy housework groups, within younger and older adults. *p<0.05, adjusted for age, sex and time spent on light housework per week.

294x190mm (124 x 124 DPI)

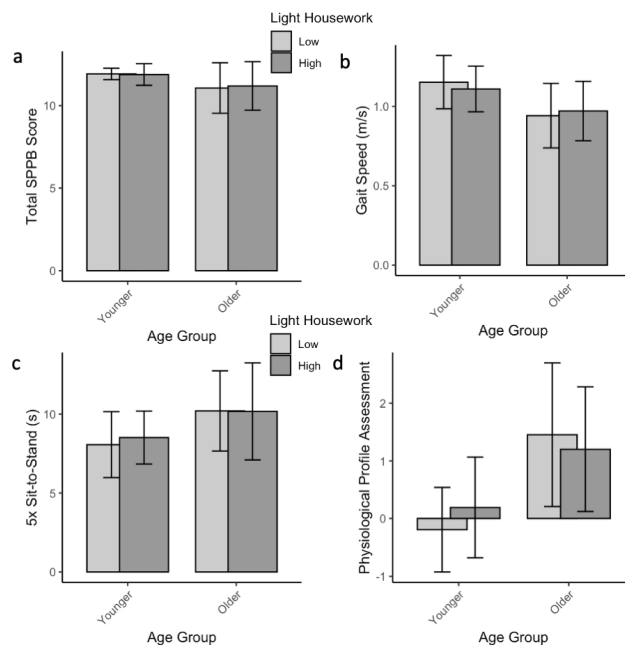


Figure 4. Mean (SD) of physical function measures including total short physical performance battery score (a), 6m habitual gait speed (b), and five-times repeated chair sit-to-stand time (c), and sensorimotor function measure including physiological profile assessment (d), between high and low light 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	
	<i>Low</i>	<i>High</i>	<i>Low</i>	<i>High</i>	<i>Low</i>	<i>High</i>	<i>Low</i>	<i>High</i>
<i>n</i>	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 sectional reporting guidelines, and cite them as:

von Elm E, Altman DG, Egger M, Pocock SJ, Gotsche 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	
1			
2			
3	Eligibility criteria	#6a Give the eligibility criteria, and the sources and methods of selection of participants.	7
4			
5			
6		#7 Clearly define all outcomes, exposures, predictors, potential	7-10
7		confounders, and effect modifiers. Give diagnostic criteria, if applicable	
8			
9			
10	Data sources /	#8 For each variable of interest give sources of data and details of methods	7-10
11	measurement	of assessment (measurement). Describe comparability of assessment	
12		methods if there is more than one group. Give information separately	
13		for for exposed and unexposed groups if applicable.	
14			
15			
16			
17	Bias	#9 Describe any efforts to address potential sources of bias	NA
18			
19	Study size	#10 Explain how the study size was arrived at	10
20			
21	Quantitative	#11 Explain how quantitative variables were handled in the analyses. If	10
22	variables	applicable, describe which groupings were chosen, and why	
23			
24			
25	Statistical	#12a Describe all statistical methods, including those used to control for	10, 12
26	methods	confounding	
27			
28			
29	Statistical	#12b Describe any methods used to examine subgroups and interactions	10
30	methods		
31			
32			
33	Statistical	#12c Explain how missing data were addressed	NA
34	methods		
35			
36			
37	Statistical	#12d If applicable, describe analytical methods taking account of sampling	NA
38	methods	strategy	
39			
40			
41	Statistical	#12e Describe any sensitivity analyses	NA
42	methods		
43			
44	Results		
45			
46	Participants	#13a Report numbers of individuals at each stage of study—eg numbers	11
47		potentially eligible, examined for eligibility, confirmed eligible,	
48		included in the study, completing follow-up, and analysed. Give	
49		information separately for for exposed and unexposed groups if	
50		applicable.	
51			
52			
53			
54			
55	Participants	#13b Give reasons for non-participation at each stage	NA
56			
57	Participants	#13c Consider use of a flow diagram	NA
58			
59			
60			

1	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
2				
3				
4				
5				
6	Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	NA
7				
8				
9				
10	Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	12-14
11				
12				
13				
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
15				
16				
17				
18				
19	Main results	#16b	Report category boundaries when continuous variables were categorized	NA
20				
21	Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
22				
23				
24				
25	Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	NA
26				
27				
28				
29	Discussion			
30				
31	Key results	#18	Summarise key results with reference to study objectives	14
32				
33				
34	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
35				
36				
37				
38				
39	Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	14-17
40				
41				
42				
43				
44	Generalisability	#21	Discuss the generalisability (external validity) of the study results	17
45				
46				
47	Other			
48	Information			
49				
50				
51	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
52				
53				
54				
55				

The STROBE checklist is distributed under the terms of the Creative Commons Attribution License CC-BY.

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](#)

For peer review only - <http://bmjopen.bmj.com/site/about/guidelines.xhtml>

BMJ Open

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

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2021-052557.R2
Article Type:	Original research
Date Submitted by the Author:	02-Oct-2021
Complete List of Authors:	Lee, Shuen Yee; Singapore Institute of Technology Pang, Benedict Wei Jun; Geriatric Education and Research Institute Ltd Lau, Lay Khoon; Geriatric Education and Research Institute Ltd Jabbar, Khalid Abdul; Geriatric Education and Research Institute Ltd Seah, Wei Ting; Geriatric Education and Research Institute Ltd Chen, Kenneth Kexun; Geriatric Education and Research Institute Ltd Ng, Tze Pin; National University of Singapore, Department of Psychological Medicine; Geriatric Education and Research Institute Ltd Wee, Shiou-Liang; Singapore Institute of Technology; Geriatric Education and Research Institute Ltd
Primary Subject Heading:	Public health
Secondary Subject Heading:	Geriatric medicine, Health policy, Sports and exercise medicine
Keywords:	Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, PREVENTIVE MEDICINE, Physiology < NATURAL SCIENCE DISCIPLINES, GERIATRIC MEDICINE, PUBLIC HEALTH, SPORTS MEDICINE

SCHOLARONE™
Manuscripts



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our [licence](#).

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which [Creative Commons](#) licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

1
2
3
4 **Title: Cross-sectional associations of housework with cognitive, physical and**
5
6 **sensorimotor functions in younger and older community-dwelling adults – the**
7
8 **Yishun Study**
9

10
11
12
13 Shuen Yee Lee, PhD^a, Benedict Wei Jun Pang, BSc^b, Lay Khoon Lau, PhD^b, Khalid
14
15 Abdul Jabbar, MSc^b, Wei Ting Seah, MSc^b, Kenneth Kexun Chen, BSc^b, Tze Pin Ng,
16
17 MD^{b,c}, Shiou-Liang Wee, PhD^{a,b}
18
19

20
21
22
23 ^aHealth and Social Sciences Cluster, Singapore Institute of Technology, 10 Dover
24
25 Drive, Singapore 138683, Singapore, Singapore
26

27 ^bGeriatric Education and Research Institute, 2 Yishun Central 2, Singapore 768024,
28
29 Singapore, Singapore
30

31
32 ^cDepartment of Psychological Medicine, National University of Singapore, 21 Lower
33
34 Kent Ridge Rd, Singapore 119077, Singapore, Singapore
35
36

37
38
39 **Corresponding author:** Shiou-Liang Wee, Geriatric Education and Research
40
41 Institute (GERI), 2 Yishun Central 2, Tower E Level 4 GERI Admin, 768024,
42
43 Singapore. Phone: +65 65924606, Email: weeshiouliang@gmail.com
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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 (≥ 65 yrs, $n=240$) 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

1
2
3 (p=0.011 and p=0.040). SPPB and gait speed did not differ with age or HH. LH was
4
5 not associated with physical or sensorimotor function.
6
7

8 **Conclusions:** Among older adults, housework is associated with higher cognitive
9
10 function, specifically in attention and memory. Associations of housework with
11
12 physical function and sensorimotor performance were intensity-dependent.
13

14 Housework PA is positively associated with functional health among community-
15
16 dwelling older adults, independent of recreation and other non-recreational physical
17
18 activities. Further longitudinal and intervention studies are needed to establish
19
20 causality.
21
22

23
24
25 **Key words:** Housework intensity, Functional health, High-income countries, Ageing,
26
27 Household chores, Non-recreational physical activity
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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 adults¹⁻³. Yet, global surveillance data indicate that in 2016, levels of insufficient PA remained high (27·5%) and stable across previous 10 years⁴. 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 countries⁴. 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 globally⁵, better strategies and policies are required to increase PA levels, especially among older adults, due to their increased vulnerability to adverse health outcomes⁶.

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 adults⁷⁻⁹. Few studies have examined the independent effects of non-recreational activity, such as housework tasks, on age-associated decline in functional ability¹⁰⁻¹². Furthermore, although the effects of exercise intensity have been widely investigated¹, 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

1
2
3 healthy ageing, which centres upon the maintenance of functional ability, are
4 urgently needed ¹³.
5
6
7
8
9

10 Housework activities are a large part of everyday activities in older people, and
11 account for a significant proportion of self-reported PA ¹⁴. Apart from a meaningful
12 occupation, housework is also a component of instrumental activities of daily living –
13 both key factors of successful ageing. Additionally, single bout of housework and
14 chronic housework are associated with improved cognition, brain volume and
15 executive function, and negatively associated with frailty ¹⁰⁻¹². Regardless of country
16 income levels, higher levels of non-recreational PA were associated with a graded
17 reduction in mortality and cardiovascular diseases, suggesting the potential role of
18 non-recreational PA such as housework, on improving health outcomes even in high-
19 income countries ⁵. Housework may also confer benefits on physical and mental
20 functions among older adults in a high-income country such as Singapore.
21
22
23
24
25
26
27
28
29
30
31
32
33

34
35 Therefore, we studied the associations of light and heavy housework activities with
36 cognitive, physical and sensorimotor functions, among younger and older adults in
37 Singapore.
38
39
40
41
42
43
44
45
46
47

48 **Methods**

49 Settings

50 Community-dwelling adults (≥ 21 years) were recruited from a large north-eastern
51 residential town of Yishun in Singapore, with residential population of 220,320
52 (50.6% females), with 12.2% older adults (≥ 65 years). This is similar to the overall
53 Singapore residential population of 4,044,200 (51.1% females), with 15.2% older
54 adults (≥ 65 years) ¹⁵.
55
56
57
58
59
60

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 women¹⁶. 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

1
2
3 or ≥ 75 min/week of vigorous-intensity PA) was used to determine percentage of
4
5 participants who met the current PA guidelines ^{5,20}.
6
7

8 9 10 Cognitive function

11
12 Cognitive performance was assessed by the Repeatable Battery for the Assessment
13 of Neuropsychological Status (RBANS) score. RBANS is a standardized age-
14 adjusted battery that is sensitive to cognitive impairment ²¹. RBANS assesses global
15 and specific cognitive domains including immediate and delayed memory,
16
17 visuospatial-construction, language, and attention.
18
19
20
21
22
23
24
25

26 Physical function

27
28 Habitual gait speed was assessed using a 6m GAITRite Walkway (CIR Systems Inc,
29 Sparta, NJ) with 2m lead in and out phase. Participants performed three trials and
30 the average timing was recorded. The Short Physical Performance Battery (SPPB)
31 consists of 3 subtests including balance, gait and sit-to-stand ^{22,23}. The balance
32 subtest composed of 3 parts with progressive difficulty, including unaided feet-
33 together stand, semi-tandem stand and full-tandem stand. Participants were timed
34 until they moved or 10s elapsed time. Gait speed was assessed by participants
35 walking 8ft at their usual pace, with a moving start ²². The average timing was
36 recorded over two trials. To assess sit-to-stand time, participants folded their arms
37 across their chest and performed five chair stands as quickly as possible. Each of
38 the 3 subtests was scored from 0–4 and the total score was the sum of 3 subtests,
39 ranging from 0–12. Higher SPPB scores indicated better physical function ²².
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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 population¹⁵. 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 PA²⁰. 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 $p<0.001$, Table 1). Total, recreational and occupational PA did not differ between high and low HH and LH groups in younger and older adults (all $p>0.05$, Table 1). Within the younger but not the older group, transport-related PA was 39% lower in low LH than high LH group ($p=0.003$, 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

1
2
3 light and heavy housework activities per week and had higher total housework MET
4
5 min/week (all $p < 0.001$, Table 1).
6
7
8
9

10 For subsequent light housework analyses, age, sex, height, education, transport PA
11 and heavy housework were included in the model to adjust for confounding
12 variables. To adjust for confounding factors, age, sex and light housework were
13 included in model for subsequent heavy housework analyses. Adjusting for
14 recreational and occupational PA in the analyses did not affect any of the results
15 presented; hence, data are presented with recreational and occupational PA
16 excluded from the model.
17
18
19
20
21
22
23
24
25
26
27

28 Associations of heavy housework activities with cognitive function

29
30 Within the older group, RBANS global cognition score was 8% higher in the high HH
31 than low HH group ($p = 0.012$) but did not differ between high and low HH groups
32 among the younger individuals ($p = 0.630$) (age*housework; $p = 0.031$, $\eta^2_p = 0.01$, Fig
33 1a). Immediate memory index scores between high and low HH groups were not
34 statistically significant among older ($p = 0.055$) and younger adults ($p = 0.332$), despite
35 significant interaction effects (age*housework; $p = 0.038$, $\eta^2_p = 0.009$, Fig 1b). No
36 significant interaction effects between age and HH groups were observed for
37 delayed memory ($p = 0.108$, $\eta^2_p = 0.005$), visuospatial-construction ($p = 0.183$,
38 $\eta^2_p = 0.004$), and language index scores ($p = 0.776$, $\eta^2_p = 0.0002$) (Fig 1c-e). Attention
39 index score was 14% higher in the high HH than low HH group within the older
40 ($p = 0.014$) but not the younger ($p = 0.304$) group (age*housework; $p = 0.012$, $\eta^2_p = 0.01$,
41 Fig 1f).
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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; $p=0.015$, $\eta^2_p=0.01$, 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; $p<0.001$, $\eta^2_p=0.03$ and $p=0.022$, $\eta^2_p=0.01$)(Fig 2b&c). No significant interaction effects between age and LH groups were observed for visuospatial-construction ($p=0.781$, $\eta^2_p=0.0002$), language ($p=0.318$, $\eta^2_p=0.002$) and attention ($p=0.194$, $\eta^2_p=0.004$) 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 ($p=0.155$, $\eta^2_p=0.004$, Fig 3a) and gait speed ($p=0.482$, $\eta^2_p=0.001$, 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; $p=0.036$, $\eta^2_p=0.009$, 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; $p=0.046$, $\eta^2_p=0.008$, 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 ($p=0.709$, $\eta^2_p=0.0003$), gait speed ($p=0.136$, $\eta^2_p=0.005$), sit-to-stand ($p=0.445$, $\eta^2_p=0.001$) (Fig 4a–c). PPA index scores, indicative of sensorimotor function, were not significant between high and low LH groups among older

1
2
3 ($p=0.067$) and younger adults ($p=0.178$), despite significant interaction effects
4
5 ($\text{age} \times \text{housework}; p=0.021, \eta^2_p=0.01$, Fig 4d). Mean (SD) values of cognitive, physical
6
7 and sensorimotor performances between age and housework groups are presented
8
9 in Supplementary Table S1.
10
11
12
13
14

15 Discussion

16
17 The present study is the first to report that housework activity is associated with
18
19 cognitive, physical and sensorimotor functions among older but not younger adults in
20
21 Singapore. These positive associations of housework with functional performance in
22
23 older adults were independent of recreational, occupational and transport-related
24
25 physical activities. We also show that more adults attained recommended physical
26
27 activity levels through housework than recreation.
28
29
30
31

32
33
34 Regardless of intensity, higher levels of housework activities were associated with
35
36 higher global cognition, among our population of older adults. Earlier studies
37
38 observed that lower levels of housework activities were associated with mild
39
40 cognitive impairment, cognitive decline and lower grey matter volume among older
41
42 adults^{11,27,28}, suggesting a positive association between housework activities and
43
44 cognitive function, plausibly through an increase in brain volume, as observed with
45
46 exercise interventions in older adults^{29,30}. However, the positive associations
47
48 between housework and cognition were not apparent in younger adults in our
49
50 population. Differences in years of education between younger and older adults likely
51
52 explain the disparity, as younger adults in this study had five more years of
53
54 education on average than older adults. Since education level is positively
55
56 associated with baseline cognitive function and slower cognitive decline³¹, it is
57
58
59
60

1
2
3 plausible that higher education levels and cognitive function in younger adults
4
5 decreases the potential for better cognitive function associated with housework
6
7
8 activities.
9

10
11
12 Our results demonstrate, for the first time, that the intensity of housework was
13
14 differentially associated with specific cognitive domains. Heavy housework was
15
16 associated with higher scores in the attention domain, while light housework was
17
18 associated with higher scores in both delayed and immediate memory domains in
19
20 older adults. Earlier studies reported that aerobic exercise interventions of varying
21
22 intensities improved specific cognitive function domains, including executive and
23
24 motor function, attention and memory, through an increase in hippocampal volume
25
26 and brain-derived neurotrophic factor expression ³²⁻³⁴. Given that housework
27
28 accounted for a significant proportion (~24–36% in women and ~19–28% in men) of
29
30 self-reported moderate-to-vigorous-intensity PA among older adults aged above 60
31
32 ¹⁴, it is plausible that the higher cognitive function associated with housework occurs
33
34 through a similar mechanism as PA or exercise ¹⁴. More studies are required to
35
36 understand the underlying mechanisms driving the age-associated differing
37
38 associations of housework intensity with specific cognitive domains.
39
40
41
42
43
44
45
46

47 Poorer cognitive performance in attention and executive functions were associated
48
49 with poorer physical function, slower gait, postural instability, and future falls among
50
51 community-dwelling older adults ³⁵⁻³⁷. We show that higher levels of heavy
52
53 housework activities were also independently associated with better physical
54
55 function (chair-stand time) and sensorimotor (PPA) performance in older but not
56
57 younger adults. Among older Swedish adults, longer chair-stand time and poorer
58
59
60

1
2
3 cognitive performance (processing speed and executive function) independently
4 increased the risk of injurious falls over 3–10 years by 10–23%³⁸. Unlike older adults,
5
6 younger adults have higher functional abilities and are unlikely to experience decline
7
8 in sensorimotor and physical functions, potentially explaining the lack of associations
9
10 between housework activities and physical and sensorimotor performances. These
11
12 results collectively suggest that the higher cognitive, physical and sensorimotor
13
14 functions related to heavy housework activities might plausibly be associated with
15
16 lower physiological fall risk among community-dwelling older adults.
17
18
19
20
21
22
23

24 We demonstrated that unlike heavy housework, light housework was not associated
25
26 with physical or sensorimotor function. The lack of associations could be due to the
27
28 already high functional ability of our study participants ²³. In support, compared with
29
30 lower intensity exercise, greater improvements in functional ability and decreased
31
32 fear of falling were observed after high intensity exercise in older adults ³⁹⁻⁴¹. These
33
34 results indicate a dose-response effect for exercise intensity on physical and
35
36 sensorimotor functions and associated falls risk in older adults. Similarly, we propose
37
38 that the positive associations of housework with physical and sensorimotor functions
39
40 are dependent on intensity, especially in community-dwelling older adults.
41
42
43
44
45
46

47 Notably in this present study, 25% and 18% more participants in the younger and
48
49 older group, respectively, met the PA guidelines derived exclusively from housework,
50
51 than that attained solely through recreational PA. This finding reflects the challenges
52
53 inherent with recreational PA participation, which is by definition, done during
54
55 discretionary hours of the day outside of occupational and domestic duties.
56
57

58 Incorporating PA into daily lifestyle through domestic duties (i.e., housework) has the
59
60

1
2
3 potential to achieve higher PA, which is positively associated with functional health
4
5 especially among older community-dwelling adults.
6
7
8
9

10 Our study recruited adults aged 21–80+ randomly from a large residential town
11
12 representative of Singapore's population, suggesting a good degree of
13
14 generalisability. We also included a comparison between older and younger adults in
15
16 the study, to elucidate the age-associated effects of housework activities on
17
18 cognitive, physical and sensorimotor functions. However, although associations can
19
20 be drawn from the study results, the cross-sectional design does not prove causality.
21
22 It is plausible that healthier older adults with higher functional ability engaged in
23
24 higher levels of housework. Nonetheless, in a 13-year follow-up study, productive
25
26 housework activities such as cooking and shopping were associated with lower
27
28 mortality risk in older adults ⁴², suggesting that housework activities are associated
29
30 with better health outcomes in older adults. Another potential limitation included the
31
32 lack of patient or public involvement in the design, planning, conduct or reporting of
33
34 the study. The study findings in community-dwelling individuals cannot be
35
36 generalised to institutionalised older adults, such as those in nursing homes. In the
37
38 present study, housework and PA measures were self-reported based on type,
39
40 intensity, frequency and duration per week. Although the LAPAQ and GPAQ used in
41
42 this study is valid and reliable ^{17,19}, future studies using more objective measures of
43
44 housework and PA should be undertaken. It is possible that socio-economic status
45
46 may mediate the effects of housework on health ⁴³, which should be further
47
48 examined in the Asian cultural context. While we adjusted for sex in all analyses,
49
50 compared with low housework groups, participants in high housework groups were
51
52 mostly women, which is consistent with earlier studies showing greater involvement
53
54
55
56
57
58
59
60

1
2
3 in household chores among women than men ⁴⁴. Future studies should investigate
4 the sex-specific effects of housework on functional health.
5
6
7
8
9

10 In conclusion, our study suggests that a combination of light and heavy housework is
11 associated with higher cognitive function, specifically in attention and memory
12 domains, among community-dwelling older adults. Furthermore, the positive
13 associations of housework levels with physical and sensorimotor functions in older
14 adults were intensity-dependent. Housework may also complement recreational
15 physical activities among current older community-dwelling adults in high-income
16 countries towards healthier ageing. Future longitudinal and intervention studies are
17 required to establish causality between housework activities and functional health.
18
19
20
21
22
23
24
25
26
27
28
29
30
31

32 **Funding**

33
34 This work was supported by Geriatric Education and Research Institute (GERI)
35 intramural funding grant number [GERI 1609].
36
37
38
39
40
41

42 **Acknowledgements**

43
44 The authors gratefully acknowledge the strong support of Prof. Pang Weng Sun in
45 making this Yishun Study possible, and the support of Daniella Ng, Queenie Tan, Dr.
46 Lilian Chye, Sylvia Ngu Siew Ching, Aizuriah Mohamed Ali, Mary Ng Pei Ern, Chua
47 Xing Ying and Shermaine Thein in this study.
48
49
50
51
52
53
54
55
56
57
58
59
60

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.

- 1
2
3 8. Lam FM, Huang MZ, Liao LR, Chung RC, Kwok TC, Pang MY. Physical
4 exercise improves strength, balance, mobility, and endurance in people with
5 cognitive impairment and dementia: a systematic review. *J Physiother* 2018; **64**(1):
6 4-15.
7
- 8
9
10
11
12 9. García-Hermoso A, Ramirez-Vélez R, Sáez de Asteasu ML, et al. Safety and
13 Effectiveness of Long-Term Exercise Interventions in Older Adults: A Systematic
14 Review and Meta-analysis of Randomized Controlled Trials. *Sports Med* 2020; **50**(6):
15 1095-106.
16
- 17
18
19
20
21 10. Stephan AJ, Strobl R, Müller M, et al. A high level of household physical
22 activity compensates for lack of leisure time physical activity with regard to deficit
23 accumulation: Results from the KORA-Age study. *Prev Med* 2016; **86**: 64-9.
24
- 25
26
27
28
29 11. Koblinsky ND, Meusel L-AC, Greenwood CE, Anderson ND. Household
30 physical activity is positively associated with gray matter volume in older adults. *BMC*
31 *Geriatrics* 2021; **21**(1): 104.
32
- 33
34
35
36
37 12. Tsuchiya K, Mitsui S, Fukuyama R, et al. An acute bout of housework
38 activities has beneficial effects on executive function. *Neuropsychiatr Dis Treat* 2018;
39 **14**: 61-72.
40
- 41
42
43
44
45 13. Beard JR, Officer A, de Carvalho IA, et al. The World report on ageing and
46 health: a policy framework for healthy ageing. *Lancet* 2016; **387**(10033): 2145-54.
47
- 48
49
50
51
52 14. Murphy MH, Donnelly P, Breslin G, Shibli S, Nevill AM. Does doing
53 housework keep you healthy? The contribution of domestic physical activity to
54 meeting current recommendations for health. *BMC Public Health* 2013; **13**: 966.
55
- 56
57
58
59 15. Department of Statistics Singapore. Population and Population Structure.
60 2020. [https://www.singstat.gov.sg/find-data/search-by-theme/population/population-
and-population-structure/latest-data](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.

- 1
2
3 24. Lord SR, Ward JA, Williams P, Anstey KJ. Physiological factors associated
4 with falls in older community-dwelling women. *J Am Geriatr Soc* 1994; **42**(10): 1110-
5
6
7
8 7.
- 9
10 25. Lord SR, Menz HB, Tiedemann A. A Physiological Profile Approach to Falls
11 Risk Assessment and Prevention. *Physical Therapy* 2003; **83**(3): 237-52.
- 12
13 26. Lakens D. Calculating and reporting effect sizes to facilitate cumulative
14 science: a practical primer for t-tests and ANOVAs. *Front Psychol* 2013; **4**: 863.
- 15
16 27. Jiang C, Xu Y. The association between mild cognitive impairment and doing
17 housework. *Aging Ment Health* 2014; **18**(2): 212-6.
- 18
19 28. Peng Z, Jiang H, Wang X, et al. The Efficacy of Cognitive Training for Elderly
20 Chinese Individuals with Mild Cognitive Impairment. *Biomed Res Int* 2019; **2019**:
21
22 4347281.
- 23
24 29. Colcombe SJ, Erickson KI, Scalf PE, et al. Aerobic Exercise Training
25 Increases Brain Volume in Aging Humans. *The Journals of Gerontology: Series A*
26 2006; **61**(11): 1166-70.
- 27
28 30. Erickson KI, Leckie RL, Weinstein AM. Physical activity, fitness, and gray
29 matter volume. *Neurobiology of Aging* 2014; **35**: S20-S8.
- 30
31 31. Clouston SAP, Smith DM, Mukherjee S, et al. Education and Cognitive
32 Decline: An Integrative Analysis of Global Longitudinal Studies of Cognitive Aging.
33
34 *The Journals of Gerontology: Series B* 2020; **75**(7): e151-e60.
- 35
36 32. Angevaren M, Aufdemkampe G, Verhaar HJ, Aleman A, Vanhees L. Physical
37 activity and enhanced fitness to improve cognitive function in older people without
38 known cognitive impairment. *Cochrane Database Syst Rev* 2008; (3): Cd005381.
- 39
40 33. Gomez-Pinilla F, Hillman C. The influence of exercise on cognitive abilities.
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
Compr Physiol 2013; **3**(1): 403-28.

- 1
2
3 34. Smith PJ, Blumenthal JA, Hoffman BM, et al. Aerobic exercise and
4 neurocognitive performance: a meta-analytic review of randomized controlled trials.
5
6 *Psychosom Med* 2010; **72**(3): 239-52.
7
8
9
10 35. Tabbarah M, Crimmins EM, Seeman TE. The Relationship Between Cognitive
11 and Physical Performance: MacArthur Studies of Successful Aging. *The Journals of*
12 *Gerontology: Series A* 2002; **57**(4): M228-M35.
13
14
15
16 36. Montero-Odasso M, Speechley M. Falls in Cognitively Impaired Older Adults:
17 Implications for Risk Assessment And Prevention. *J Am Geriatr Soc* 2018; **66**(2):
18 367-75.
19
20
21
22
23 37. Muir SW, Gopaul K, Montero Odasso MM. The role of cognitive impairment in
24 fall risk among older adults: a systematic review and meta-analysis. *Age and Ageing*
25 2012; **41**(3): 299-308.
26
27
28
29 38. Welmer A-K, Rizzuto D, Laukka EJ, Johnell K, Fratiglioni L. Cognitive and
30 Physical Function in Relation to the Risk of Injurious Falls in Older Adults: A
31 Population-Based Study. *The Journals of Gerontology: Series A* 2017; **72**(5): 669-75.
32
33
34
35 39. Sanders LMJ, Hortobágyi T, Karssemeijer EGA, Van der Zee EA, Scherder
36 EJA, van Heuvelen MJG. Effects of low- and high-intensity physical exercise on
37 physical and cognitive function in older persons with dementia: a randomized
38 controlled trial. *Alzheimers Res Ther* 2020; **12**(1): 28.
39
40
41
42
43 40. Jiménez-García JD, Hita-Contreras F, de la Torre-Cruz M, et al. Risk of Falls
44 in Healthy Older Adults: Benefits of High-Intensity Interval Training Using Lower
45 Body Suspension Exercises. *J Aging Phys Act* 2019; **27**(3): 325-33.
46
47
48
49 41. Edholm P, Nilsson A, Kadi F. Physical function in older adults: Impacts of past
50 and present physical activity behaviors. *Scand J Med Sci Sports* 2019; **29**(3): 415-
51 21.
52
53
54
55
56
57
58
59
60

- 1
2
3 42. Glass TA, de Leon CM, Marottoli RA, Berkman LF. Population based study of
4 social and productive activities as predictors of survival among elderly Americans.
5
6
7 *Bmj* 1999; **319**(7208): 478-83.
8
9
10 43. Rodriguez-Stanley J, Alonso-Ferres M, Zilioli S, Slatcher RB. Housework,
11 health, and well-being in older adults: The role of socioeconomic status. *J Fam*
12
13
14 *Psychol* 2020; **34**(5): 610-20.
15
16
17 44. Bianchi SM, Sayer LC, Milkie MA, Robinson JP. Housework: Who Did, Does
18 or Will Do It, and How Much Does It Matter? *Soc Forces* 2012; **91**(1): 55-63.
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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	<i>p</i> value	Low	High	<i>p</i> value
Younger						
<i>n</i>	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)						
<i>Recreational (MET min/week)</i>	576 (784)	774 (1302)	0.137	637 (933)	764 (1324)	0.393
<i>Transport (MET min/week)</i>	2065 (3010)	2003 (2228)	0.861	1577 (1955)	2579 (3075)	0.003
<i>Occupational (MET min/week)</i>	1686 (3619)	2408 (5658)	0.220	2052 (4252)	2199 (5699)	0.821
<i>Total (MET min/week)</i>	4327 (5151)	5185 (6903)	0.263	4266 (4971)	5543 (7511)	0.125
Housework Activity (LAPAQ)						
<i>Heavy (min/week)</i>	0 (2)	192 (292)	<0.001	47 (81)	198 (335)	<0.001
<i>Light (min/week)</i>	198 (363)	584 (593)	<0.001	95 (87)	838 (592)	<0.001
<i>Total (MET min/week)</i>	496 (908)	2228 (2079)	<0.001	425 (458)	2887 (2120)	<0.001
Older						
<i>n</i>	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)						
<i>Recreational (MET min/week)</i>	828 (1053)	890 (1047)	0.650	867 (1181)	847 (941)	0.884
<i>Transport (MET min/week)</i>	1561 (1565)	1836 (2050)	0.253	1554 (1964)	1783 (1667)	0.340
<i>Occupational (MET min/week)</i>	676 (2269)	401 (1397)	0.251	547 (2113)	557 (1783)	0.968
<i>Total (MET min/week)</i>	3065 (2731)	3127 (2531)	0.856	2968 (2968)	3187 (2366)	0.537
Housework Activity (LAPAQ)						

1							
2							
3							
4	<i>Heavy (min/week)</i>	0 (0)	131 (140)	<0.001	31 (72)	80 (134)	<0.001
5	<i>Light (min/week)</i>	446 (508)	684 (568)	<0.001	89 (93)	902 (485)	<0.001
6							
7	<i>Total (MET</i>		2236 (1584			2576 (1349	<0.001
8	<i>min/week)</i>	1116 (1270))	<0.001	347 (377))	<0.001
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							
32							
33							
34							
35							
36							
37							
38							
39							
40							
41							
42							
43							
44							
45							
46							
47							
48							
49							
50							
51							
52							
53							
54							
55							
56							
57							
58							
59							
60							

For peer review only

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.

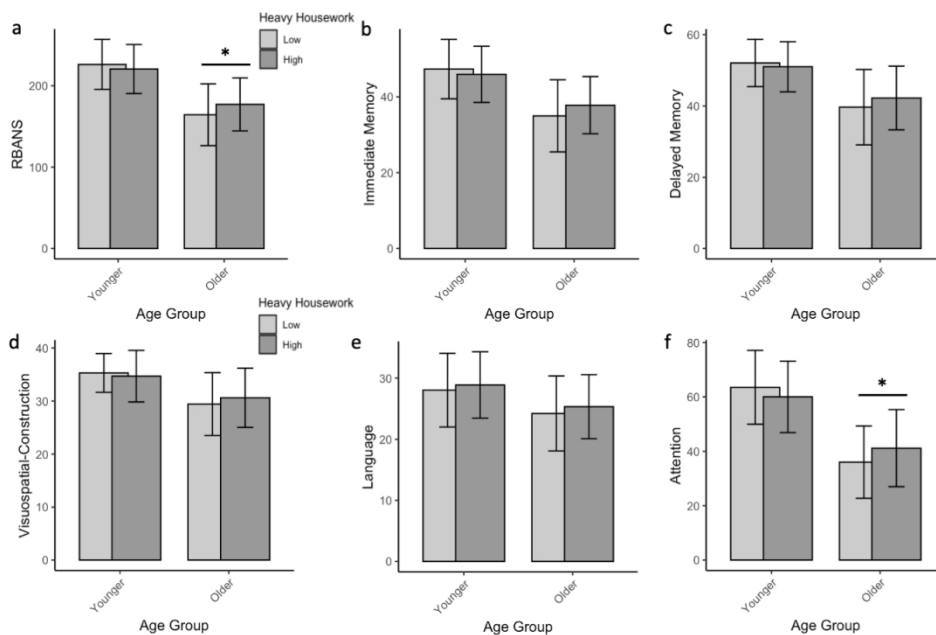


Figure 1. Mean (SD) of global cognitive function and specific domains between high and low heavy housework groups, within younger and older adults. * $p < 0.05$, adjusted for age, sex and time spent on light housework per week.

294x190mm (124 x 124 DPI)

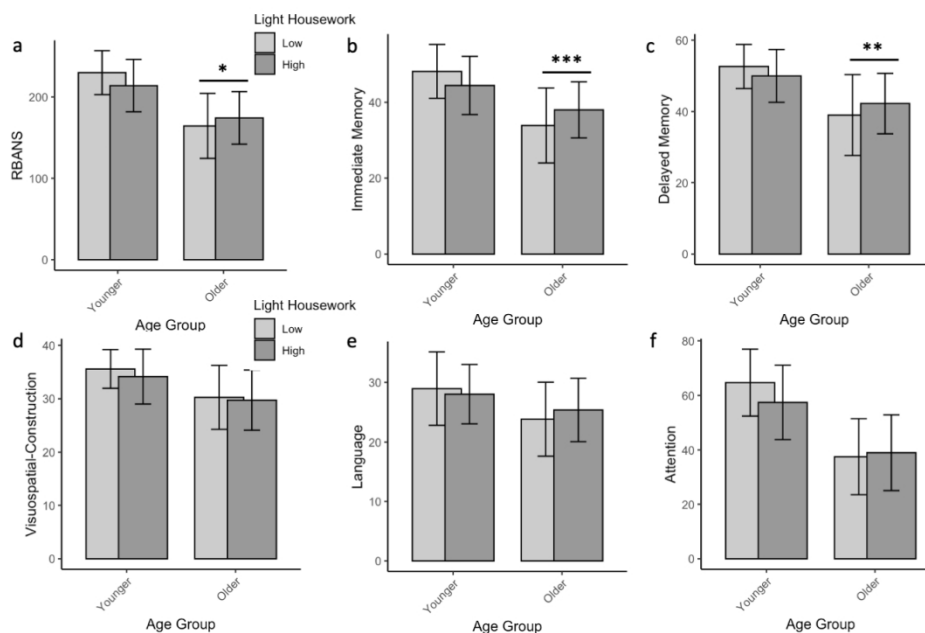


Figure 2. Mean (SD) of global cognitive function and specific domains between high and low light housework groups, within younger and older adults. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, adjusted for age, sex, height, years of education, transport-related physical activity and time spent on heavy housework per week.

294x190mm (124 x 124 DPI)

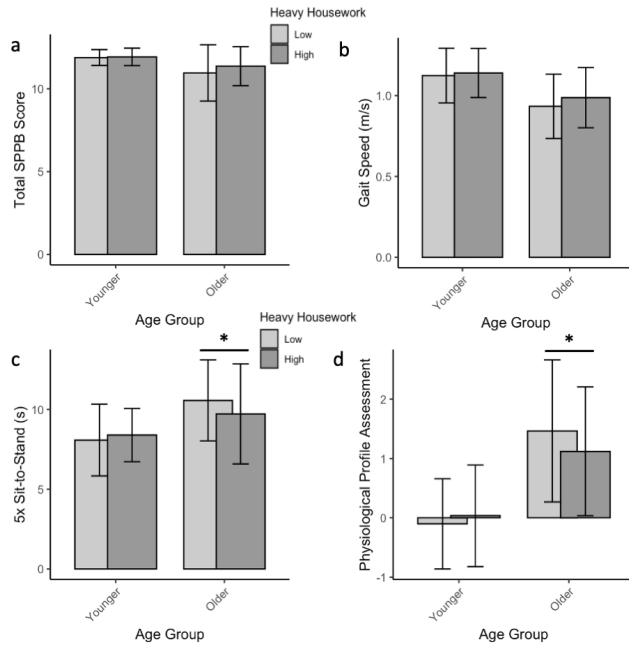


Figure 3. Mean (SD) of physical function measures including total short physical performance battery score (a), 6m habitual gait speed (b), and five-times repeated chair sit-to-stand time (c), and sensorimotor function measure including physiological profile assessment (d), between high and low heavy housework groups, within younger and older adults. *p<0.05, adjusted for age, sex and time spent on light housework per week.

294x190mm (124 x 124 DPI)

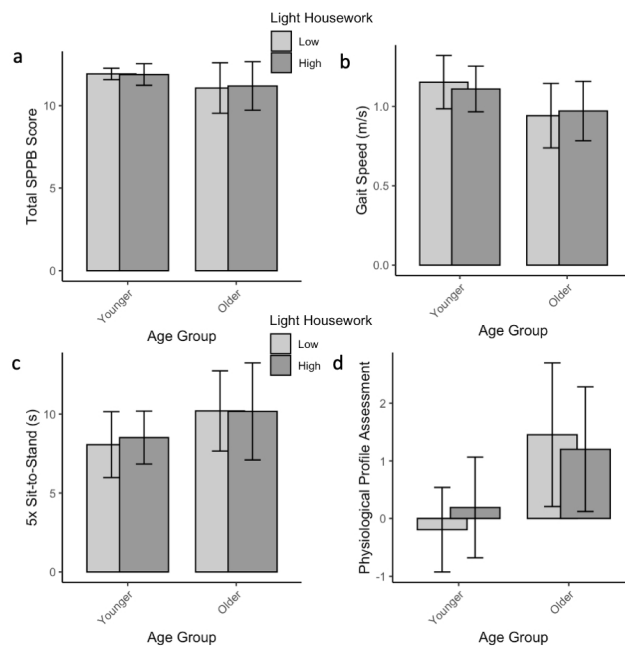


Figure 4. Mean (SD) of physical function measures including total short physical performance battery score (a), 6m habitual gait speed (b), and five-times repeated chair sit-to-stand time (c), and sensorimotor function measure including physiological profile assessment (d), between high and low light 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	
	<i>Low</i>	<i>High</i>	<i>Low</i>	<i>High</i>	<i>Low</i>	<i>High</i>	<i>Low</i>	<i>High</i>
<i>n</i>	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 sectional reporting guidelines, and cite them as:

von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche 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	
1			
2			
3	Eligibility criteria	#6a Give the eligibility criteria, and the sources and methods of selection of participants.	7
4			
5			
6		#7 Clearly define all outcomes, exposures, predictors, potential	7-10
7		confounders, and effect modifiers. Give diagnostic criteria, if applicable	
8			
9			
10	Data sources /	#8 For each variable of interest give sources of data and details of methods	7-10
11	measurement	of assessment (measurement). Describe comparability of assessment	
12		methods if there is more than one group. Give information separately	
13		for for exposed and unexposed groups if applicable.	
14			
15			
16			
17	Bias	#9 Describe any efforts to address potential sources of bias	NA
18			
19	Study size	#10 Explain how the study size was arrived at	10
20			
21	Quantitative	#11 Explain how quantitative variables were handled in the analyses. If	10
22	variables	applicable, describe which groupings were chosen, and why	
23			
24			
25	Statistical	#12a Describe all statistical methods, including those used to control for	10, 12
26	methods	confounding	
27			
28			
29	Statistical	#12b Describe any methods used to examine subgroups and interactions	10
30	methods		
31			
32			
33	Statistical	#12c Explain how missing data were addressed	NA
34	methods		
35			
36			
37	Statistical	#12d If applicable, describe analytical methods taking account of sampling	NA
38	methods	strategy	
39			
40			
41	Statistical	#12e Describe any sensitivity analyses	NA
42	methods		
43			
44	Results		
45			
46	Participants	#13a Report numbers of individuals at each stage of study—eg numbers	11
47		potentially eligible, examined for eligibility, confirmed eligible,	
48		included in the study, completing follow-up, and analysed. Give	
49		information separately for for exposed and unexposed groups if	
50		applicable.	
51			
52			
53			
54			
55	Participants	#13b Give reasons for non-participation at each stage	NA
56			
57	Participants	#13c Consider use of a flow diagram	NA
58			
59			
60			

1	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
2				
3				
4				
5				
6	Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	NA
7				
8				
9				
10	Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	12-14
11				
12				
13				
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
15				
16				
17				
18				
19	Main results	#16b	Report category boundaries when continuous variables were categorized	NA
20				
21	Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
22				
23				
24				
25	Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	NA
26				
27				
28				
29	Discussion			
30				
31	Key results	#18	Summarise key results with reference to study objectives	14
32				
33				
34	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
35				
36				
37				
38				
39	Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	14-17
40				
41				
42				
43				
44	Generalisability	#21	Discuss the generalisability (external validity) of the study results	17
45				
46				
47	Other			
48	Information			
49				
50				
51	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
52				
53				
54				
55				

The STROBE checklist is distributed under the terms of the Creative Commons Attribution License CC-BY.

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](#)

For peer review only - <http://bmjopen.bmj.com/site/about/guidelines.xhtml>