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The relationship between physical activity and physical performance and psycho-cognitive functioning in older adults living in residential aged care facilities

Natalia JM Bootsman,[1,2] Tina L Skinner,[1] Ravin Lal,[1] Delma Glindemann,[3] Carmela Lagasca,[3,4] GMEE (Geeske) Peeters[1,5]

[1] The University of Queensland, School of Human Movement and Nutrition Sciences, Centre for Research on Exercise, Physical Activity and Health, Brisbane, Australia

[2] VU University Amsterdam, Faculty of Behavioural and Movement Sciences, Amsterdam, the Netherlands

[3] Churches of Christ in Queensland, Kenmore, Australia

[4] The University of Queensland, School of Nursing, Midwifery and Social Work, Brisbane, Australia

[5] The University of Queensland, School of Public Health, Brisbane, Australia

Address for correspondence:

Dr Tina Skinner, The University of Queensland, School of Human Movement and Nutrition Sciences, 26B Blair Drive, St Lucia, Queensland 4072, Australia; T +61(0)7 3346 8810;
E t.skinner@uq.edu.au

Abstract

Objectives: Insight into modifiable factors related to falls risk in older adults living in residential aged care facilities (RACFs) is necessary to tailor preventive strategies for this high-risk population. Associations between physical activity (PA), physical performance and psycho-cognitive functioning have been understudied in aged care residents. This study investigated associations between PA, and both physical performance and psycho-cognitive functioning in older adults living in RACFs.

Design: Cross-sectional study.

Methods: Forty-four residents aged 85±8 years were recruited from four RACFs located in Southeast Queensland. PA was assessed as the average time spent walking in hours/day using ActivPAL3^{TM}. Physical performance tests included balance, gait speed, dual-task ability, reaction time, coordination, grip strength, and leg strength and power. Psycho-cognitive questionnaires included quality of life, balance confidence, fear of falling and cognitive functioning. Associations between PA and each outcome measure were analysed using linear or ordinal regression models.

Results: The average time spent walking was 0.5±0.4 hours/day. Higher levels of PA were significantly associated with better balance (compared with low PA, medium: B=1.6; high: B=1.3) and dual-task ability (OR=7.9 per 0.5 hour/day increase). No statistically significant associations were found between PA and the other physical and psycho-cognitive measures.

Conclusions: More physically active residents scored higher on balance and dual-task ability, which are key predictors of falls risk. This suggests that physical activity programs targeting balance and dual-task ability could help prevent falls in aged care residents.

Keywords: frail elderly; walking; psychomotor performance; psychological phenomena and processes; residential facilities

Introduction

In residential aged care facilities (RACF) on average 1.5 falls occur per bed per year (range 0.2-3.6).[1] Falls can result in serious consequences, such as fear of falling, injury and death, imposing a considerable burden on the health care system.[1] Although preventive interventions are available, their effectiveness in residents of RACFs is limited.[2] To improve the effectiveness of falls prevention programs in RACFs, investigation of the modifiable determinants of falls risk factors is required.

Physical activity (PA) has shown to be negatively associated with falls risk factors such as poor physical performance and fear of falling among community-dwelling older adults.[3,4] However, these relationships are unclear among RACF residents. RACF residents have poorer physical and/or cognitive functioning than community-dwelling older adults, resulting in increased dependency in daily activities.[5] Their reduced abilities and increased dependency results in lower levels of physical activity.[6] It is unclear whether the inverse relationship between PA and falls risk found in community-dwelling older adults also exists for those living in RACFs.

The aim of this study is to examine the associations between PA and physical and psycho-cognitive determinants of falls risk among older adults living in RACFs. This cross-sectional study focuses on residents capable of rising from a chair. This population has the highest falls risk compared to older adults confined to their wheelchairs, bed-bound, and unable to rise independently, likely due to greater exposure to situations that could result in a fall (e.a. standing, walking and changing direction).[7] As walking is the most preferred activity for older adults, PA was defined as the average time spent walking in h/day.

Methods

Data were from participants in a pilot cluster randomized controlled trial investigating the efficacy of a falls prevention program among RACF residents. For the present study, baseline measurements were used. Participants aged 65 years or over were recruited from four RACFs operated by Churches of Christ in Queensland across Southeast Queensland, Australia, providing housing for a total of 309 residents. Exclusion criteria were: being confined to a wheelchair or bed at all times, being unable to stand completely unaided for three seconds, having any medical conditions that prevented safe participation in the exercise program, and having participated in regular balance or strength exercises in the past six months. All residents were screened for eligibility and invited to participate by the RACF staff. The RACF staff only provided contact details to study investigators of those residents who were eligible and willing to participate, which resulted in a sample motivated to participate in a falls prevention program, rather than a general RACF sample. Prior to participation, all participants or legal custodians in case of cognitive impairment, provided informed consent. Fifty residents (16%) met the inclusion criteria and agreed to participate. Ethical clearance was obtained from the Medical Research Ethics Committee of The University of Queensland (2014000043). The trial is registered with the Australian New Zealand Clinical Trials Registry (ACTRN12614000348651).

The between-assessor coefficient of variation was 1.0-4.3%. Each physical test was demonstrated prior to testing. Tests and questionnaires involved interspersing and breaks to minimise fatigue. The testing order was: anthropometry, cognitive functioning, balance, reaction time, quality of life, gait speed, dual-task ability, balance confidence, leg strength, grip strength, coordination, fear of falling, sit-to-stand performance. All physical tests were performed in duplicate with the best score used for analysis. Except the balance and walk tests, all physical tests were performed seated. Assistive devices were allowed for the walk tests to get a realistic view of the older adults' normal walking speed, but not for the balance test. Each testing session took one hour on average, with all measurements completed on the same day.

Physical activity was monitored 24 h/day for five days using ActivPAL3TM inclinometers (PAL Technologies Ltd, Glasgow), placed on the anterior mid-line of the thigh of the preferred leg (or the non-affected leg in case of disease or disability), using a nitrile finger cot and a waterproof transparent film. The ActivPal was placed on the participant after all testing was completed and started measuring at midnight to minimise potential differences in movement behaviours during the first few hours of wear. Initialisation and downloading of data was performed using ActivPALTM Professional Software, version 7.1.18 Research Edition 2012 (PAL Technologies Ltd, Glasgow). The average time spent walking in h/day over the first four days was calculated. In case the activity monitor was removed earlier, the remaining full days (if ≥2 days)[8] were used to calculate the average time spent walking.

All anthropometry tests were performed according to the International Standards for Anthropometric Assessment,[9] however clothing/shoes were not removed due to practical and safety issues. Height was measured with a portable SECA 213 stadiometer (Germany), body mass with a hospital chair scale (HV-CS 150, A&D Mercury Pty. LTD, NSW, Australia) and waist circumference with a Birch tape measure (150 cm, Australia).

Balance was assessed using a modified version of the four-test balance scale.[10] Participants were scored on their ability to hold comfortable, parallel, semi-tandem and tandem stances incrementally for 10 seconds without support. Only one attempt per stance was permitted; where participants refused or failed to maintain a stance for 10 seconds, no further stance was administered. Scores were determined from the last administered stance and whether participants refused, attempted or completed their last stance (0 = refused first stance; 5 = all stances completed).Gait speed (m/s) was assessed using a 4-metre walk test at the participant's usual walking speed, of which the middle three metres were timed.

Dual-task ability was assessed by repeating the 4-metre walk test while naming as many colours as possible (walk-and-talk).[11] The time for the 4-metre walk test, less the time for the walk-and-talk test (s) (categorized and reversed) was used for analysis.

Reaction time of both feet was assessed using the MuscleLab v8.26 reaction time test (Ergotest Innovation AS, Porsgrunn).[12] Participants were required to respond as fast as possible to each of 10 computer-generated visual and audio signals with variable intervals. Responses (ms) involved tapping on a keyboard placed on the floor with one foot.

Coordination of the lower limbs was assessed using a toe-tap test.[13] One foot at a time, participants tapped their heel and toes on markers 10 times as fast as possible.

Grip strength was measured using a standard calibrated mechanical handgrip dynamometer (TTM Original Dynamometer 100 kg, Tokyo).

For leg strength, peak isometric knee extension force was measured using a standard calibrated GS-KMT load cell (Gedge Systems, Melbourne)[14] connected to a MuscleLab 4020E data acquisition system (Ergotest, Langesund) with MuscleLab software v8.26 (Ergotest Innovation AS, Porsgrunn).

If able to stand up from a chair once safely, participants performed the five repetition sit-to-stand test. Arm rest support was only used when necessary [n=21 (48%)].

All psycho-cognitive functioning questionnaires were verbally administered with the same instructions for all participants. Psycho-cognitive measurements included quality of life using the Dementia Quality of Life scale (DQoL),[15] balance confidence using the CONFbal scale,[16] fear of falling using the short version of the Falls Efficacy Scale International,[17] and cognitive functioning using the cognitive impairment subscale of the Psychogeriatric Assessment Scales (PAS).[18] PAS scores (range 0-21) were reversed so that higher scores reflect better functioning (Table 2); scores <16 are indicative of cognitive impairment.[18]

Participant characteristics including chronic conditions, medications, level of care, length of stay in RACFs and falls history were obtained from medical records.

Data were analysed using SPSS version 24.0 (IBM Corporation, Armonk, New York). The associations between PA and the outcomes were examined using linear (continuous outcomes) or ordinal (categorical outcomes) regression. For each outcome, assumptions for linear regression were checked. If the assumptions were met, PA was included as a continuous variable. Given the low level of activity in this population, the continuous variable was rescaled so that a one unit increase reflects 30 min/day. If the assumptions were not met, either the outcomes were categorised in tertiles, or ln-transformed. Potential confounders were included if they resulted in >10% change in the regression coefficient. For all models, Cohen's effect sizes (ES) were calculated. ES of <0.20, >0.50 and >0.80 indicate negligible, moderate and a large effects, respectively.

Results

Six participants were excluded due to missing PA data resulting from non-adherence to the wear protocol of the activity monitor. Therefore, the analyses included 44 participants (14% of all 309 residents; 88% of the 50 participating residents; Figure 1). For those adhering to the wear protocol, data were obtained over two (n=1), three (n=3) and four (n=40) days. The average age was 85±8 years, 68% were female, 63% received high levels of care (Table 1) and 25% had impaired cognitive functioning. The average time spent walking was 0.5±0.4 h/day (Table 2). High blood pressure was less prevalent in older adults who spent more time walking per day (p=0.033) (Table 1).

Results from the adjusted model show that compared with participants with low levels of PA, those with medium or high levels of PA had higher scores for balance (medium B=1.6, CI=0.8-2.4, p<0.001; high B=1.3, CI=0.4-2.1, p=0.003) (Table 3). The odds of being in a higher tertile for dual-task ability was 7.9 (CI=1.2-52.2) for each additional 30 min/day of PA. Large effect sizes were found for balance (ES=1.2) and dual-task ability (ES=2.5). No statistically significant associations were found between PA and gait speed, reaction time, coordination, grip strength, leg strength or sit-to-stand performance. Despite the absence of significant associations, a moderate effect size was found for leg strength (ES=0.6) and a high effect size for sit-to-stand performance (ES=1.1).

No statistically significant associations were found between PA and psycho-cognitive functioning (Table 3). However, a large effect size was found for the association between medium levels of PA and cognitive functioning (ES=1.5).

Discussion

This study investigated the association between PA and both physical performance and psycho-cognitive functioning among older adults living in RACFs. Participants who spent more time walking were less likely to have hypertension and scored better on tests of balance and dual-task ability.

The present findings from residents of RACFs are in line with those from other studies in community-dwelling older adults.[19,20] This suggests that the associations between PA and balance and dual-task ability are consistent across subgroups of older adults with varying levels of PA and physical functioning. Exercise interventions of 8-12 weeks have been found to improve balance[19,21,22] and dual-task ability[19] in community-dwelling older adults. As balance and dual-task ability are important falls risk factors,[22] exercises targeting balance and dual-task ability may be appropriate targets for falls prevention programs across older adult populations of varying physical function.

No significant associations were found between PA and the other measures of physical performance in this study. In community-dwelling populations, previous research has shown that PA was related to gait speed, reaction time and sit-to-stand performance in longitudinal studies,[21,22] and to coordination, grip strength and leg strength in cross-sectional studies.[23-25] Furthermore, no significant relationship was found between PA and quality of life, balance confidence, fear of falling or cognitive functioning. Each of these psycho-cognitive measures has been found to be related to PA in previous research in community dwelling[26,27] and RACF populations[28,29]. Homogeneity due to test floor/ceiling effects and the small sample size contributing to a lack of statistical significance (type-II-error) may explain why the present results appear to be in contrast with previous findings. Alternatively, if the current findings were confirmed in larger samples, the contrasting results may suggest that the association between PA and these physical and psycho-cognitive measures only exist in healthier community-dwelling older adults.

Demographics of the participants in this study were comparable to resident characteristics reported by the Australian Institute of Health and Welfare in terms of age (85 vs. 85 years old, respectively) and gender (68% vs. 70% female, respectively).[30] However, current participants were healthier than the average Australian aged care resident, as reflected by the lower percentage in high care (63% vs. 83%, respectively) and with cognitive impairment (25% vs. 57%, respectively),[30] and higher time/day spent walking than reported previously in 31 aged care residents (31.7±23.2 vs. 21.4±36.7 min/day, respectively).[6] Thus, the current sample was not representative of the general RACF population, and generalisation of results to the frailer RACF residents should be applied with caution. However, the current sample is likely to represent the target group of RACF-based exercise or physical activity programs aiming to prevent falls.

Notable strengths of this study include the objective measurement of PA and physical outcome measures. Also this study compared a wide range of outcome measures, allowing a detailed examination of the association between PA and physical and psycho-cognitive functioning. Previous studies measured PA in terms of movement counts per timeframe,[31,32] steps/day[20,23,26] or questionnaires,[24,25,27-29] whereas the current study used inclinometers to measure the time spent walking, which gives more reliable PA data in a frail population.[33] Reid et al.[6] also used ActivPAL, but in a smaller sample (n=31). However, the current study had greater power due to the somewhat bigger sample size and used more sophisticated statistical methods by adjusting for confounders.

A limitation of this study is that PA was assessed as the time spent walking, omitting seated activities and potentially underestimating total PA, but systematically for all participants. For all outcome measures, validated questionnaires and instruments were used where possible. However, for the measurements of leg strength and reaction time, variations on validated measurements were used. The main limitation of this study was the small sample size, resulting in insufficient power to detect statistically significant associations for some measures. Only few confounders could be included in each model, requiring a strict selection procedure of confounders that had the strongest influence on the estimates.

However, residual bias cannot be ruled out. The cross-sectional design makes it impossible to draw conclusions on the causality of the associations. Therefore, it cannot be concluded whether lower PA leads to lower functioning or vice versa or, more likely, that the relationship is bi-directional. Insight in the direction of this relationship is important as it may reveal whether PA promotion can be used to improve functioning, or whether functioning needs to be improved to enable safe participation in PA.

Future research should focus on large representative samples of RACF residents in longitudinal studies. The (potentially bi-directional) relationship between PA and physical, psychological and cognitive functioning should be investigated, as well as the associations with falls in older adults, to create a strong scientific basis for the required elements of falls prevention programs.

Conclusion

The more physically active RACF residents scored higher on balance and dual-task ability, which are key predictors of falls risk. No associations were found between PA and six of eight physical performance measures, and all four psycho-cognitive performance measures. Insight into how PA is associated with physical, psychological and cognitive functioning enhances our understanding of the complex relationship between PA and falls risk, enabling the design of more effective falls prevention programs in the population with the highest falls risk.

Practical implications

- Older adults living in RACFs who engage in more physical activity have better balance and dual task ability, which are both key predictors of falls risk.
- PA was not associated with other measures of physical performance or any measure of psycho-cognitive functioning.

- The results need to be verified in larger, longitudinal studies to draw conclusions on the causality of the associations.

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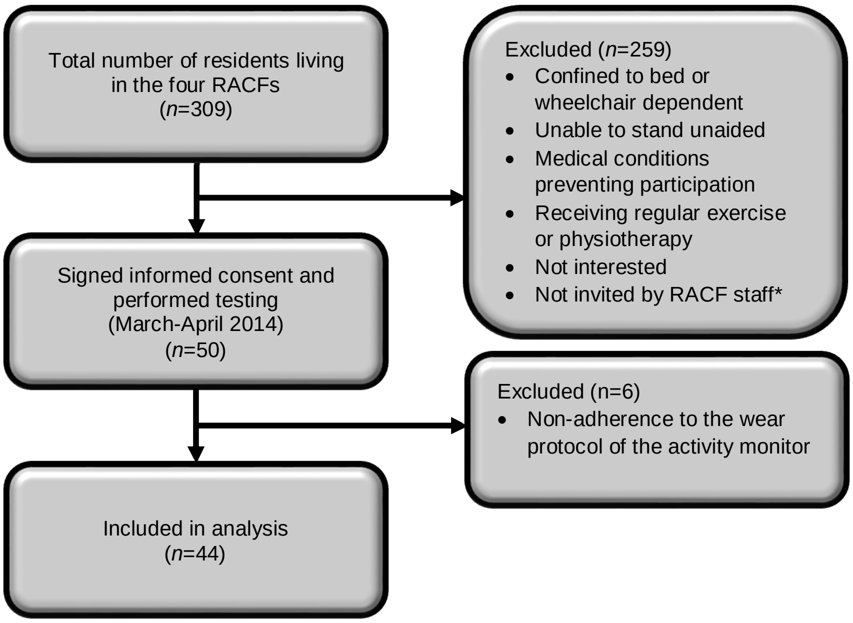
Figure 1. CONSORT flowchart.



*Recruitment performed by residential aged care facility staff based on their perception of the residents' eligibility to participate and the participants' willingness to participate.

Table 1. Participant characteristics (n=44).

Characteristics	**Physical activity**												**p-value[b]**
	Overall (N=44)			Low (N=15)			Medium (N=15)			High (N=14)			
Age (y, mean ±SD)	85	±	8	85	±	9	87	±	7	81	±	8	0.132
Sex (% female)	68			67			67			71			0.951
Education (% studied after high school)	32			20			40			36			0.466
Country of birth (% Australia)	77			73			80			79			0.901
Marital status													
% currently married	9			7			7			14			0.57
% never married	14			20			0			22			-
% divorced	14			13			13			14			-
% widowed	63			60			80			50			-
Body mass (kg, mean ±SD)	74.2	±	15.4	71.4	±	15.5	74.9	±	16.3	76.3	±	15	0.685
Waist circumference (cm, mean ±SD)	103.3	±	15	103.1	±	17.7	102.9	±	15.6	103.9	±	11.7	0.986
Body mass index (BMI,	28.9	±	5.7	28.2	±	5.8	29.1	±	6.4	29.3	±	5.1	0.866

mean ±SD)													
% underweight (<23 kg/m²)	16			27			13			7			0.666
% healthy weight (23-30 kg/m²)	43			33			47			50			-
% overweight (>30 kg/m²)	41			40			40			43			-
Length of stay in residential aged care facility (months, mean ±SD)	38	±	52	30	±	50	37	±	43	49	±	63	0.641
Level of care (% high)	63			80			57			50			0.215
Number of regular medications (mean ±SD)	10	±	3.5	10.2	±	3.7	10.5	±	3.9	9.4	±	3.1	0.691
Use of walking aid (%)	86			100			80			79			0.165
Falls in past year (%)													
% no falls	55			40			47			79			0.249
% one fall	25			33			33			7			-
% two falls or more	20			27			20			14			-

Number of chronic conditions (mean ±SD)	3.6	±	1.3	3.9	±	1.8	3.8	±	0.9	3.2	±	1.3	0.371
% Parkinson's disease	7			7			7			7			0.998
% depression /anxiety	48			60			47			36			0.423
% high blood pressure	57			67			73			29			0.033
% diabetes	14			13			20			7			0.601
% osteoporosis	14			27			7			7			0.194
% osteoarthritis	32			27			33			36			0.862
% eye disease	25			13			40			21			0.225
% incontinence	23			33			13			21			0.421
% stroke	23			20			27			23			0.911
% heart disease	73			67			80			71			0.708
% lung disease	34			33			27			43			0.654
% cancer	16			20			7			21			0.527

c

SD = standard deviation.

Physical activity is categorised as low (≤0.26), medium (0.27-0.62) and high (≥0.63 h/day).

[a] P-value was calculated using ANOVA for variables presented as mean ± SD and using Pearson Chi-Square for variables presented as percentages.

Table 2. Physical activity, physical performance and psycho-cognitive functioning.

Variables*	**N**	**Mean ± SD[a] or Median [IQR][b]**		
Time spent walking (h/d)	44	0.5	±	0.4
Time spent standing (h/d)	44	2.5	±	1.4
Time spent sitting/lying (h/d)	44	21.0	±	1.6
Balance score [0-5]	44	3.5	±	1.3
Gait speed (m/s)	43	0.5	±	0.1
Dual-task additional time (s)	43	2.7		[1.0-5.2]
Reaction time (ms)	43	353.7	±	70.7
Coordination (toe-tap time in s)	44	10.9	±	3.5
Grip strength (kg)	43	20.3	±	6.1
Leg strength (kg)	34	15.7		[11.3-22.9]
Sit-to-stand time (s)	35	20.7	±	7.2
Quality of life score [1-5]	44	3.7	±	0.7
Balance confidence score [10-30]	44	22.2	±	5.2
Fear of falling score [7-28]	44	12.9	±	5.4
Cognitive functioning score [0-21]	44	19.0		[16.3-20.0]

[*] For all variables, higher numbers indicate better outcomes, except for dual-task additional time, reaction time, coordination, sit-to-stand time and fear of falling where lower numbers indicate better outcomes.

[a] Normally distributed data are represented as mean ± standard deviation (SD).

[b] Non-normally distributed data are represented as median [interquartile range] (IQR).

Table 3. Adjusted regression models for associations between physical activity and both physical performance and psycho-cognitive functioning.

Outcomes*	PA[e]	B	OR	CI			p	ES
Balance[ae]	low	0			-		-	-
	medium	1.6		0.8	–	2.4	<0.001	1.2
	high	1.3		0.4	–	2.1	0.003	0.9
Gait speed[ae]	low	0			-		-	-
	medium	0.1		-0.03	–	0.1	0.230	0.4
	high	0.04		-0.04	–	0.1	0.369	0.3
Dual-task ability[bc]			7.9	1.2	–	52.5	0.032	2.5
Reaction time[a]		11.6		-10.5	–	33.6	0.305	0.2
Coordination[a]		-0.8		-2.4	–	0.9	0.359	-0.2
Grip strength[a]		0.04		-1.5	–	1.6	0.965	0.01
Leg strength[bde]	low		0		-		-	-
	medium		1.3	0.9	–	1.9	1.269	0.5
	high		1.4	0.9	–	2.1	1.380	0.6
Sit-to-stand performance[bce]	low		0		-		-	-
	medium		2.3	0.6	–	8.8	0.240	0.8
	high		3.3	0.8	–	14.6	0.113	1.1
Quality of life[a]		-0.04		-0.3	–	0.2	0.780	-0.1
Balance confidence[a]		-0.3		-2.1	–	1.5	0.746	-0.1
Fear of falling[a]		-1.5		-3.5	–	0.5	0.147	-0.3
Cognitive functioning[bce]	low		0		-		-	-
	medium		3.0	0.7	–	12.3	0.138	1.5
	high		1.0	0.2	–	4.1	0.969	-0.04

[a] Linear regression was used and the regression coefficients (B), confidence intervals (CI), significance values (p) and effect sizes (ES) are presented.

[b] Ordinal regression was used and the odds ratio's (OR), confidence intervals (CI), significance values (p) and effect sizes (ES) are presented.

[c] The outcome was categorised in tertiles.

[d] The outcome was ln-transformed.

[e] Physical activity was categorised in tertiles as low (≤0.26), medium (0.27-0.62) and high (≥0.63 h/day), and the results are presented for each category of physical activity with 'low' as the reference category.

* Confounders added to the model for each outcome: balance [-]; gait speed [walking aid, balance confidence, osteoarthritis]; dual-task ability [gait speed, Parkinson's Disease, number of colours mentioned in dual task]; reaction time [alcohol use, stroke, age, Parkinson's Disease]; coordination [maximum leg strength, stroke]; handgrip strength [gender, age, height, stroke]; leg strength [age]; sit-to-stand performance [age]; quality of life [facility, age, stroke, incontinence]; balance confidence [walking aid, stroke, age, falls]; fear of falling [walking aid, stroke]; cognitive functioning [age].