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Research Article

The Association of Coordination with Physical Activity Levels of Older Adults

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ABSTRACT

Aim: To examine the association between coordination ability and self-reported physical activity among community-dwelling older adults.

Methods: We conducted a cross-sectional study of 77 adults (81.51 ± 5.46 years) using motion capture and a gait walkway to assess rhythmic interlimb ankle, shoulder, and gait coordination. Physical activity was assessed using the Physical Activity Scale for the Elderly (PASE). We conducted multivariable linear regression modeling using backward elimination with age, gender, body mass index, Mini-Mental State Exam score, number of chronic conditions, falls, Short Physical Performance Battery (SPPB) score, and interlimb ankle, shoulder, and gait coordination as predictors, and PASE score as the outcome.

Results: Gender and SPPB score accounted for 19.4% and the three coordination measures an additional 10%, of the variance in PASE score.

Conclusion: The results showed that ankle, shoulder, and gait coordination contribute to self-reported physical activity levels among older adults, even after accounting for SPPB score.

Keywords: Aging; Coordination; Physical activity

INTRODUCTION

Participation in regular physical activity is associated with health promotion and the prevention of chronic disease among older adults [1]. However, levels of physical activity decrease with age [2], leading many older adults to be underactive [3,4]. Even small increases in physical activity can produce health benefits in older adults. Determinants of physical activity in older adults are not well understood [5] and adherence to different types of exercise are predicted by different determinants [5,6]. Male gender and younger age have been associated with greater physical activity [5,7,8]. Adherence to exercise is also predicted by factors such as fitness, non-smoking, having an active lifestyle, high self-efficacy [9], muscle strength, short reaction time [10,11], and having fewer chronic conditions [12,13]. Rhythmic interlimb coordination [14-17] and gait coordination [18] decline with aging and has shown to be independent of other measures of mobility. Interlimb coordination is the ability to rhythmically synchronize movements of two body segments while sitting or lying supine, whereas gait coordination is the ability to coordinate the right-left stepping pattern during walking. It is possible to suggest that coordination decline in older adults contributes to decreasing physical activity levels, or vice versa. For example, poor coordination may lead older adults to feel uncomfortable or expend greater effort during movement, thereby leading them to be physically inactive [19]. Evidence regarding the relationship between coordination decline and physical activity levels in older adults is lacking. Therefore, we evaluated the association of rhythmic interlimb and gait coordination with self-reported physical activity levels among

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community-dwelling older adults. We hypothesized that good coordination would be significantly associated with higher levels of physical activity. Further, we explored whether this association would be independent of other known predictors (e.g., mobility performance, health status, gender, body-mass index).

MATERIALS AND METHODS

Study design and participants

We recruited community-dwelling older adults (N=77) aged 67-99 years. Inclusion criteria were age 65 years or older, able to walk 20 feet without personal assistance, hearing sufficient to synchronize movements with auditory metronome tones, and ability to communicate, read and write in English. Exclusion criteria were a Mini-Mental State Exam (MMSE) score of less than 18 or having a neurological disorder or terminal disease. Participants gave written informed consent for methods approved by the University of Massachusetts Lowell Institutional Review Board.

Measurements

Interlimb coordination assessment: Participants were positioned supine on a physical therapy table. Orthoses with reflective markers were placed on each lower leg to confine ankle movements to dorsi-plantarflexion. A standard inter-limb synchronization protocol was used to assess ankle and shoulder coordination [20]. To assess shoulder coordination the participants were instructed to extend their arms vertically in front of them and to maintain their elbows in an extended position. Participants were instructed to rhythmically move their right and left ankles or arms at the shoulder (glenohumeral joint) simultaneously in opposite directions (anti-phase coordination) in synchronization with 0.5 Hz auditory metronome tones, which were played 10 seconds before and throughout movement trials. Data collection began 10 seconds after participants began moving their ankles or shoulders and continued until they had completed 25 movement cycles. A Qualisys (Gothenburg, Sweden) motion capture system collected kinematic data on the movement of the reflective markers at a sampling rate of 100 Hz. Data for angular position of the markers were used to estimate ankle angular position. The point estimate of relative phase between the ankles was calculated as previously described [21]. The variability of interlimb ankle and shoulder coordination were measured using the standard deviation of the first 40 point estimates of relative phase [21] of plantar and dorsiflexion. Lower values indicate less variable, and better, coordination.

Gait coordination assessment: Participants walked at their usual pace across a 22 foot long course that included a 16 foot Zeno Electronic Walkway, (Protokinetics; Havertown, PA), making 6 passes or 20 right strides across the walkway, whichever came last. The gait phase for individual strides was determined by dividing step times by stride times and multiplying by 360°. Phase Coordination Index (PCI) was calculated from gait phase values as previously described (18). Lower PCI values indicate better gait coordination. The standard deviation of ankle and shoulder coordination, and PCI, were calculated using custom written MATLAB software.

Short physical performance battery assessment: Mobility performance was assessed using the SPPB. The SPPB is a well-established, reliable, and valid measure of mobility performance [22,23] that is also applicable in clinical settings [24]. SPPB scores are positively associated with physical activity levels among older adults [25]. The SPPB includes measures of usual-paced walking speed, time to rise from a chair five times and standing balance. Scores from each component are scored between 0-4 which when summed creates a total score ranging from 0 to 12, with higher scores indicating better performance. SPPB score was calculated in the standard manner [23].

Falls assessment: Falls were defined for participants as 'unintentionally coming to a rest on the ground, floor, or other lower level, whether or not you were injured." [26] A history of falling was assessed by self-report of having fallen 0, 1, 2, or 3 or more times within the previous year. Falls have been associated with low levels of physical activity [27-29]. Number of falls was included in the statistical analysis as a potential confounder of the association between coordination and physical activity.

Physical activity levels: Participants completed the Physical Activity Scale for the Elderly (PASE) to quantify their self-reported level of physical activity. The PASE is a validated assessment that provides a summary performance of physical activities across a spectrum of physical exertion levels over the previous 7 days [30]. The amount of time spent in a range of activities was multiplied by a weighted ranking for exertion level (light, moderate, strenuous). The weighted sum of all reported physical activity categories is summed for a total PASE score. Higher PASE scores indicate higher levels of physical activity.

Demographics and comorbidities

Demographic characteristics included age, gender, and race. Additional potential confounding variables measured included Body Mass Index (BMI) determined from the measured weight in kilograms divided by height in squared meters and the Mini-Mental State Exam (MMSE) [31]. BMI [32] and cognitive function [33] have been associated with physical activity levels. Participants were asked if a physician had ever told them that they had heart disease, high blood pressure, high cholesterol, diabetes, gastric ulcer, kidney disease, liver disease, anemia, cancer, depression, osteoarthritis, spinal stenosis, rheumatoid arthritis, gout, lung disease, stroke, Parkinson's disease, multiple sclerosis, an eye disease, fibromyalgia, or Alzheimer disease.

Statistical analyses

Descriptive statistics were calculated for participant characteristics using means and standard deviations for normally distributed data. The covariance of the corresponding predictor variables was evaluated using Pearson intercorrelation analysis. Next, to evaluate the potential association of coordination with physical activity level we performed multivariable linear regression modeling using backward elimination with an elimination criterion value of $p>0.10$. Age, gender, BMI, MMSE score, number of chronic conditions, number of falls in the previous year, SPPB score, ankle coordination, shoulder coordination, and gait coordination were included in the initial regression model as predictor variables and PASE score as the outcome. Evaluation of the assumption of normality of residuals was confirmed by inspection. In the final model, we examined the change in the variance (R) accounted for by the coordination variables after adjustment for the potential confounding variables that remained in the final model. Inferential statistical analysis was conducted using IBM SPSS software (version 22) using a Type I error rate of 0.05.

RESULTS AND DISCUSSION

Descriptive results

Descriptive statistics for each variable examined are presented in Table 1. Participants had a mean (standard deviation) age of 81.51 (5.46) years and 64.9% (n=50) were female. Participants had a median of 5 chronic conditions (range: 0-15). All predictor variables had Pearson intercorrelation coefficients<0.40 and were included in the initial linear regression model (Table 1).

Table 1: Demographic and health characteristics of study participants (N=77).

Variable	Mean ± SD	Min	Max
PASE	114.15 ± 52.79	13.25	257.65
Females	105.55 ± 55.86	13.25	257.65
Males	129.50 ± 44.73	49.5	207.22
Age (years)	81.51 ± 5.46	67	99
%Female	64.9	-	-
BMI (kg/m²)	27.22 ± 6.34	16.97	51.09
#chronic conditions	4.75 ± 2.66	0	15
MMSE score	26.95 ± 2.18	22	30
Falls (%)			
0	53.2	-	-
1	26	-	-
2	14.3	-	-
≥ 3	6.5	-	-
SPPB score	9.20 ± 2.83	1	12
Ankle coordination (°)	30.35 ±13.58	10.41	96.45
Shoulder coordination (°)	17.63 ± 9.50	5.54	56.29
PCI	6.97 ± 3.48	2.6	18.62

*Mean +/-SD unless otherwise indicated.
Abbreviations: BMI: Body Mass Index; Max: Maximum; MMSE: Mini-Mental State Exam; Min: Minimum; PASE: Physical Activity Scale for the Elderly; PCI: Phase Coordination Index; ROM: Range Of Motion; SD: Standard Deviation; SPPB: Short Physical Performance Battery

Table 2 presents unadjusted Pearson correlation coefficients between predictor variables and PASE score.

Table 2: Pearson correlation coefficients of predictor variables with Physical Activity Scale for the Elderly score.

Variable	Correlation coefficient
Ankle coordination	-0.26
Shoulder coordination	-0.29
Phase coordination index	-0.27
Short physical performance battery	0.39

Table 3 presents the final multivariable linear regression model predicting PASE score. Only gender, SPPB, ankle coordination, shoulder coordination, and PCI remained in the final model. This model accounted for 29.4% of the variance in PASE score (R^2 =0.294; p<0.001). Ankle (p=0.092), shoulder (p=0.096), and gait (p=0.082) coordination were marginally significant (p=0.067) and fell within our criterion value of p<0.10 for inclusion in the final model. Gender and SPPB score accounted for 19.4% of the variance in PASE score (R^2 =0.194; p<0.001). After adjustment for gender and SPPB score, the three coordination measures (ankle, shoulder, and gait) accounted for an additional 10.0% of the variance in PASE score (R^2 =0.100; p=0.024) (Table 3).

Table 3: The final multivariable linear regression model evaluating the association between rhythmic interlimb ankle and shoulder coordination, and gait coordination with PASE score*. N=77.

Outcome: PASE score	Final model (R^2 =0.294) p<0.001		
Variables	Estimate	SE	p
Gender	-29.63	11.84	0.015
SPPB score	4.68	2.19	0.036
Ankle coordination	-0.74	0.43	0.092
Shoulder coordination	-1.05	0.63	0.096
PCI	-3.02	1.71	0.082

*Age, BMI, number of chronic conditions, MMSE score, and number of falls in the previous year were all eliminated during manual backward regression for having p>0.10.
Abbreviations: BMI: Body Mass Index; MMSE: Mini-Mental State Exam; PASE: Physical Activity Scale for the Elderly; PCI: Phase

Coordination Index; SE: standard error; SPPB: Short Physical Performance Battery

Summary of findings

Our major finding was that better in ankle, shoulder, and gait coordination were associated with higher levels of physical activity. Coordination ability (ankle, shoulder, and gait) accounted for a substantial amount of the variance (10%) in physical activity levels, in addition to that accounted for by SPPB score and gender.

Significance and implications

Our findings support the hypothesis that coordination ability is associated with physical activity levels in community-dwelling older adults. The mechanism linking poor coordination with low physical activity in older adults, and the directionality of causation between these variables, are currently unknown. Greater energy expenditure is associated with poorer lower extremity function (34). It could be that poor coordination leads to increased effort or decreased comfort during movement, which in turn may discourage older adults from being physical active. Another possibility is that lower levels of physical activity may lead to peripheral or central changes [34-36] that contribute to a decline in coordination ability.

It is known that the coordination of older adults can be improved with training [17,37-39]. Improved coordination may be one of the mechanisms by which successful interventions increase physical activity levels in older adults. Future research is needed to assess possible changes in coordination created by physical activity interventions.

Strengths and limitations

Strength of this study is that, to our knowledge, it was the first to examine the association between coordination and self-reported physical activity levels. A limitation is that the sample size may have limited the statistical power needed determine possible significant associations between falls, age, body composition, or cognitive function with physical activity levels. Also, as this is a cross-sectional study, the direction of causality cannot be confirmed from these results.

CONCLUSION

The results support our hypothesis that coordination ability is associated with self-reported physical activity levels in community-dwelling older adults. This finding indicates possible causal relationships between coordination ability and physical activity levels in older adults, though the direction of this causality is unknown. Future research is needed to examine the association of coordination with objectively measured physical activity levels.

REFERENCES

1. Van der Bij AK, Laurant MGH, Wensing M. Effectiveness of physical activity interventions for older adults: a review. Am J Prev Med. 2002;22(2): 120-33.
2. Nelson ME, Rejeski WJ, Blair SN, Duncan PW, Judge JO, King AC, et al. Physical activity and public health in older adults: Recommendation from the American College of Sports Medicine and the American Heart Association. Circulation. 2007;116(9): 1435-1445.
3. Jones DA, Ainsworth BE, Croft JB, Macera CA, Lloyd EE, Yusuf HR. Moderate leisure-time physical activity: Who is meeting the public health recommendations? A national cross-sectional study. Arch Fam Med. 1998;7(3): 285-289.
4. Brownson RC, Eyler AA, King AC, Brown DR, Shyu YL, Sallis JF. Patterns and correlates of physical activity among US women 40 years and older. Am J Public Health. 2000;90(2): 264-270.
5. Koeneman MA, Verheijden MW, Chinapaw MJM, Hopman-Rock M. Determinants of physical activity and exercise in healthy older adults: A systematic review. Int J Behav Nutr Phys Act. 2011;8: 142.
6. Van Stralen MM, De Vries H, Mudde AN, Bolman C, Lechner L. Determinants of initiation and maintenance of physical activity among older adults: A literature review. Health Psychol Review. 2009;3(2): 147-207.
7. Yasunaga A, Togo F, Watanabe E, Park H, Park S, Shephard RJ, et al. Sex, age, season, and habitual physical activity of older Japanese: The Nakanojo study. J Aging Phys Act. 2008;16(1): 3-13.
8. Burton LC, Shapiro S, German PS. Determinants of physical activity initiation and maintenance among community-dwelling older persons. Prev Med. 1999;29(5): 422-430.
9. Martin KA, Sinden AR. Who will stay and who will go? A review of older adults' adherence to randomized controlled trials of exercise. J Aging Phys Act. 2001;9(2): 91-114.
10. Brassington GS, Atienza AA, Perczek RE, DiLorenzo TM, King AC. Intervention-related cognitive versus social mediators of exercise adherence in the elderly. Am Prev Med. 2002;23(2): 80-86.
11. Williams P, Lord SR. Predictors of adherence to a structured exercise program for older women. Psychology and aging. 1995;10(4): 617-624.
12. Tu W, Stump TE, Damush TM, Clark DO. The effects of health and environment on exercise-class participation in older, urban women. J Aging Phys Act. 2004;12(4): 480-496.
13. Morey MC, Dubbert PM, Doyle ME, MacAller H, Crowley GM, Kuchibhatla M, et al. From supervised to unsupervised exercise: Factors associated with exercise adherence. J Aging Phys Act. 2003;11(3): 351-368.
14. Fujiyama H, Garry MI, Levin O, Swinnen SP, Summers JJ. Age-related differences in inhibitory processes during interlimb coordination. Brain Res. 2009;1262: 38-47.
15. Fujiyama H, Hinder MR, Garry MI, Summers JJ. Slow and steady is not as easy as it sounds: Interlimb coordination at slow speed is associated with elevated attentional demand especially in older adults. Exp Brain Res. 2013;227(2): 289-300.
16. Serrien DJ, Swinnen SP, Stelmach GE. Age-related deterioration of coordinated interlimb behavior. J Gerontol B Psychol Sci Soc Sci. 2000;55(5): 295-303.
17. Wishart LR, Lee TD, Murdoch JE, Hodges NJ. Effects of aging on automatic and effortful processes in bimanual coordination. J Gerontol B Psychol Sci Soc Sci. 2000;55(2): 85-94.
18. Plotnik M, Giladi N, Hausdorff JM. A new measure for quantifying the bilateral coordination of human gait: Effects of aging and Parkinson's disease. Exp Brain Res. 2007;181(4): 561-570.
19. Singh MA. Exercise comes of age: Rationale and recommendations for a geriatric exercise prescription. J Gerontol B Psychol Sci Soc Sci. 2002;57(5): 262-282.

20. Kelso JA. Phase transitions and critical behavior in human bimanual coordination. Am J Physiol. 1984;246(6): R1000-1004.
21. Kelso JAS. How nature handles complexity. In: Haken H (ed) Dynamic patterns: The Self-Organization of Brain and Behaviour. Cambridge: MIT Press, London, England, 1995; pp:1-26.
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): 556-561.
23. Guralnik JM, Simonsick EM, Ferrucci L, Glynn RJ, Berkman LF, Blazer DG, et al. A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. J Getrontol. 1994;49(2): 85-94.
24. Studenski S, Perera S, Wallace D, Chandler JM, Duncan PW, Rooney E, et al. Physical performance measures in the clinical setting. J Am Geriatr Soc. 2003;51(3): 314-22.
25. Laussen J, Kowaleski C, Martin K, Hickey C, Fielding RA, Reid KF. Disseminating a clinically effective physical activity program to preserve mobility in a community setting for older adults. J Frailty Aging. 2016;5(2): 82-87.
26. Lamb SE, Jorstad-Stein EC, Hauer K, Becker C. Prevention of Falls Network E, Outcomes Consensus G. Development of a common outcome data set for fall injury prevention trials: the Prevention of Falls Network Europe consensus. J Am Geriatr Soc. 2005;53(9): 1618-1622.
27. Campbell AJ, Borrie MJ, Spears GF. Risk factors for falls in a community-based prospective study of people 70 years and older. J Gerontol. 1989;44(4): M112-117.
28. Graafmans WC, Lips P, Wijlhuizen GJ, Pluijm SM, Bouter LM. Daily physical activity and the use of a walking aid in relation to falls in elderly people in a residential care setting. Z Gerontol Geriatr. 2003;36(1): 23-28.
29. Heesch KC, Byles JE, Brown WJ. Prospective association between physical activity and falls in community-dwelling older women. J Epidemiol Commun Hea. 2008;62(5): 421-426.
30. Washburn RA, Smith KW, Jette AM, Janney CA. The Physical Activity Scale for the Elderly (PASE): Development and evaluation. J Clin Epidemiol. 1993;46(2): 153-162.
31. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. J Psy Res. 1975;12(3): 189-198.
32. Petersen L, Schnohr P, Sorensen TI. Longitudinal study of the long-term relation between physical activity and obesity in adults. Int J Obes Relat Metab Disord. 2004;28(1): 105-112.
33. Eggermont LH, Milberg WP, Lipsitz LA, Scherder EJ, Leveille SG. Physical activity and executive function in aging: The MOBILIZE Boston Study. m Geriatr Soc. 2009;57(10): 1750-1756.
34. Wert DM, Brach JS, Perera S, Van Swearingen J. The association between energy cost of walking and physical function in older adults. Arch Gerontol Geriatr. 2013;57(2): 198-203.
35. Goble DJ, Coxon JP, Van Impe A, De Vos J, Wenderoth N, Swinnen SP. The neural control of bimanual movements in the elderly: Brain regions exhibiting age-related increases in activity, frequency-induced neural modulation, and task-specific compensatory recruitment. Hum Brain Mapp. 2010;31(8): 1281-1295.
36. Heuninckx S, Wenderoth N, Debaere F, Peeters R, Swinnen SP. Neural basis of aging: the penetration of cognition into action control. J Neurosci. 2005;25(29): 6787-6796.
37. Blais M, Martin E, Albaret JM, Tallet J. Preservation of perceptual integration improves temporal stability of bimanual coordination in the elderly: An evidence of age-related brain plasticity. Behav Brain Res. 2014;275: 34-42.
38. Hu X, Newell KM. Aging, visual information, and adaptation to task asymmetry in bimanual force coordination. J Appl Physiol. 2011;111(6): 1671-1680.
39. Brach JS, Francois SJ, Van Swearingen JM, Gilmore S, Perera S, Studenski SA. Translation of a motor learning walking rehabilitation program into a group-based exercise program for community-dwelling older adults. PMR. 2015;8(6): 520-528.