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Effect of a Long-Term Physical Activity Intervention on Resting Pulse Rate in Older Persons: Results from the LIFE Study

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Abstract

Background—High resting pulse rate (RPR) is often associated with adverse cardiovascular risk. Prior studies show that habitual exercise slows RPR, though most studies have focused

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Author Contributions: Bríain ó Hartaigh designed the study and wrote the initial draft of the manuscript. Laura C. Lovato and Michael E. Miller performed the statistical analyses. All of the authors contributed towards the analysis and interpretation of the data, and critical revision of the manuscript for important intellectual content. All of the authors approved the final draft of the article.

primarily on persons younger than 65 years. Our objective was to assess the utility of a long-term physical activity (PA) intervention for reducing RPR in older persons.

Design—Lifestyle Interventions and Independence for Elders Study.

Setting—Community based.

Participants—A total 1,635 persons (67.2% women) aged 70–89 years were randomized to a moderate intensity PA intervention (n=818) or health education-based “successful aging” (SA) intervention (n=817).

Measurements—RPR was recorded at baseline, 6-, 18-, and 30-months. Longitudinal changes in RPR were evaluated between intervention groups using a mixed-effects analysis of covariance model for repeatedly measured outcomes, generating least squares means with standard errors (SE) or 95% confidence intervals (95% CI).

Results—Mean duration of the study was 2.6 years (median, 2.7 years; interquartile range, 2.3–3.1 years). The average effect of the PA intervention on RPR across follow-up visits was statistically significant but clinically small (Average Intervention Difference = 0.84 beats/min; 95% CI 0.17 to 1.51; $P_{\text{average}} = 0.01$), with the most pronounced effect observed at 18-months (PA: 66.5 [0.32] beats/min, SA: 67.8 [0.32] beats/min, Difference = 1.37 (95% CI 0.48 to 2.26). The relationship became somewhat weaker and was not statistically significant at 30-months. There were no significant differences across several pre-specified subgroups.

Conclusion—A long-term moderate-intensity physical activity program was associated with a small and clinically insignificant slowing of RPR in older persons. Whether physical activity can deliver a beneficial reduction in RPR requires further examination among older adults.

Keywords

Resting pulse rate; physical activity; older persons

INTRODUCTION

A growing body of epidemiologic evidence supports the contention that cardiovascular (CV) function deteriorates with advancing age.^{1–3} To offset the burden of age-associated CV morbidities and death,⁴ there is an urgent need for public health initiatives to maintain a healthy functional CV system. It is well documented that physical activity promotes a broad spectrum of health benefits, in particular, by reducing the risk attributable to CV disease and its sequelae.^{5,6} Prior studies, however, have largely focused on populations younger than 65 years. To address this key gap in knowledge, we recently evaluated the efficacy of a moderate intensity physical activity intervention for lowering resting pulse rate (RPR) among older adults.⁷ RPR serves as an important predictor of adverse cardiovascular risk⁸ and is an indicator of physical fitness.⁹ Using data from the LIFE Pilot Study,⁷ which included 424 older persons aged between 70–89 years, we found that a 12-month moderate-intensity aerobic training program failed to lower RPR. We concluded that larger studies encompassing a longer duration of aerobic training are needed to evaluate whether exercise has the potential to slow RPR, a marker of CV risk, in older persons. The availability of data from the main LIFE Study provides us with a unique opportunity to evaluate the

effectiveness of a long-term (i.e., mean duration 2.7 years) physical activity intervention for slowing RPR in a larger (n=1,635) cohort of older persons. We hypothesized that the intervention would be associated with a reduction in RPR, providing further support for the beneficial role of physical activity in improving CV health in older persons.

MATERIALS AND METHODS

Study overview

The LIFE Study is a phase 3 multicenter randomized controlled trial, primarily designed to evaluate the efficacy of a long-term physical activity (PA) intervention compared with a health education-based successful aging (SA) intervention for lowering the incidence of major mobility disability. Details regarding the design, rationale, and implementation of the LIFE Study, along with a comprehensive description of the inclusion/exclusion criteria are published elsewhere.^{10,11} The institutional review boards at all participating sites approved the study protocol, and written informed consent was obtained from all study participants. The trial was monitored by a data and safety-monitoring board appointed by the National Institute on Aging and is registered at <http://www.clinicaltrials.gov> (registration #: NCT01072500).

Physical activity intervention

The PA intervention consisted of a combination of aerobic-walking, strength, balance, and flexibility exercises. Over the course of the intervention, PA participants attended 2 supervised center-based exercise sessions per week, and up to 3–4 home-based physical activity sessions per week. PA goals were tailored to each participant's level of physical fitness, and targets were modified in response to illness, injury, or physical symptoms.

Walking was the primary mode of exercise, as it has been previously recommended by expert bodies, does not need to be center-based, and is widely acceptable and safe among older persons.^{12,13} The PA intervention included a weekly target of achieving 150 min of walking-based exercise, as advocated by the 2008 Physical Activity Guidelines for Americans report.¹⁴ The Borg scale¹⁵ was used to regulate the intensity of exercise, which was designed to be moderate.¹³ Study participants were asked to walk at a perceived exertion of 13 (somewhat hard), and were discouraged from exercising at levels above 15 (hard) or below 11 (fairly light). Three times weekly, the PA group also completed a 10 min lower extremity-strengthening program by use of ankle weights (2 sets of 10 repetitions), at an intensity of 15–16 on the Borg scale, which was followed by a 10 min exercise designed to challenge participants' balance, as well as lower extremity stretching. The specific exercises used for strength, balance, and flexibility routines can be found on the LIFE Study public website at www.thelifestudy.org. Further details regarding the training program are available in the LIFE Study design paper.¹⁰

Successful aging intervention

Participants in the SA group were required to attend small group sessions weekly for the first 26 weeks and monthly thereafter (bi-monthly sessions were optional). The educational sessions included topics relevant to older adults, and were intended to increase awareness

relative to a variety of health topics including how to effectively negotiate the health care system, medications, foot care, preventive services and screenings recommended at different ages, how to travel safely, and nutrition. Each session concluded with a short instructor-led program (5–10 minutes) of upper extremity stretching exercises. Information related to physical activity was purposely avoided, with the exception of a physical activity brochure presented to participants during the first SA session.

Study measures

Using a structured interview method, self-reported information was obtained on participants' age, sex, race, education, smoking status, chronic conditions, and medication use. Waist circumference (cm) was measured around the slimmest region between the ribs and iliac crest, or at the navel if no natural waistline was observed. Blood pressure was obtained twice using conventional auscultation and sphygmomanometry, with participants resting for 5 minutes in the seated position. The mean of both blood pressure measures were used in current analyses. Participants' 400-m walk test was recorded.¹⁶ The frequency and duration of walking-based activities was determined using the Community Healthy Activities Model Program for Seniors (CHAMPS) self-report questionnaire – a measure that has shown good psychometric properties and sensitivity to change.¹⁷ For this manuscript, the CHAMPS questionnaire was used to assess participants' exercise-based activities performed during a typical week in the past month. Further details of the measurements obtained are described elsewhere.¹⁰ All assessment personnel were masked to randomization assignment, and remained separated from the intervention team throughout the study period. Participants were advised not to disclose the group to which they were assigned and were also asked not to discuss any aspects of the study intervention with assessment personnel.

Resting heart rate measures

The primary outcome in this study was RPR, which was recorded by certified staff in duplicate at baseline, 6 months, 18 months, and 30 months via pulse palpitation of the radial artery for 30 seconds (multiplied by 2 to convert to beats/min), after participants had rested for 5 minutes in the seated position. The mean of both RPR measures were used in current analyses. For comparison, resting heart rate (RHR) was also obtained via electrocardiography with participants resting in the supine position. Participants were advised to relax, breathe normally, and refrain from talking or moving during electrocardiography recordings.

Statistical considerations

Baseline characteristics are summarized using means $\pm$ SD, or counts with proportions. Longitudinal differences in RPR were evaluated by use of a mixed-effects analysis of covariance model for repeatedly measured outcomes. We employed an unstructured covariance matrix to account for potential over-time correlation between repeated measures. Models were adjusted for clinical site and sex (both used to stratify randomization), as well as the baseline value of the outcome measure. Least squares means were generated from these models and contrasts were used to estimate mean intervention effects with standard errors (SE) or 95% confidence intervals (95% CI) across the follow-up period. We repeated the primary analysis using RHR as determined by electrocardiography, collected at baseline,

18-months, and 30-months. An additional set of mixed-effects models were fit to explore effects within the following pre-specified baseline subgroups: self-reported use of beta-blockers, the presence of specific chronic conditions, age <80 or ≥80 years, and RPR <80 or ≥80 beats/min. For these analyses, we tested for equality of average treatment effects over time between subgroup levels using a linear contrast of the time-specific effects. Statistical analyses were performed using SAS (SAS Institute, Version 9.4), and results were considered significant at a 2-sided P value of less than 0.05.

RESULTS

Study participants

Of 1,635 persons enrolled between February 2010 and December 2013, 818 were randomized to the PA group and 817 were randomized to the SA group (Figure 1). Mean age of the study participants was 78.9 ± 5.2 years. More than two-thirds (67.2%) were women and 23.8% belonged to a racial/ethnic minority group (Table 1). Both intervention groups were similar with respect to baseline characteristics (Table 1). Participants were followed for a mean duration of 2.6 years (median, 2.7 years; interquartile range [IQR], 2.3–3.1 years), and the trial concluded in December 2013.

Adherence to intervention

Based on CHAMPS questionnaires at the 24-month follow-up visit (the minimum intended duration of intervention), the frequency of engaging in walking-related activities was higher (median [IQR], 16 times/week [10–23]) in the PA group compared with the SA group (median [IQR], 12 times/week [7–18]). The PA group also achieved a median of 210 min/week (IQR, 105–330) in walking-related activities compared with 105 min/week (IQR, 0–225) for the SA group.

Physical activity and resting pulse rate

The average intervention difference on RPR across all follow-up visits was clinically small at 0.84 beats/min (95% CI = 0.17 to 1.51; $P_{\text{average}} = 0.01$). For the majority of time-points, RPR did not differ significantly between the two groups. However, RPR was found to be modestly lower in the PA group (RPR [SE]: 66.5 [0.32] beats/min) as compared with the SA group (RPR [SE]: 67.8 [0.32] beats/min, Group Difference = 1.37 beats/min; 95% CI = 0.48 to 2.26; $P_{\text{difference}} = 0.003$) following 18 months of the PA intervention; though the relationship became somewhat weaker and non-significant at 30 months. The findings were comparable across follow-up visits after substituting RPR with RHR derived from electrocardiography.

Subgroup analyses

Differences in RPR over time by pre-specified subgroups are reported in Table 2. Participants not taking beta-blockers at baseline had a slightly lower RPR in the PA arm compared with the SA arm (0.97 beats/min; 95% CI 0.14 to 1.79); this was not observed among those on beta-blockers at baseline (−0.29 beats/min; 95% CI −1.36 to 0.79). Participants <80 years of age at baseline had a lower RPR in the PA arm than the SA arm (1.38 beats/min; 95% CI 0.51 to 2.25); this difference was not observed in participants ≥80

years (-0.30 beats/min; 95% CI -1.30 to 0.71). Although the subgroup with a baseline RPR 80 beats/min was small, some noticeable differences were observed between treatment groups, particularly at 18-months (Group Difference = 3.86 beats/min; 95% CI: 0.84 to 6.88). Despite these modest differences, none of the tests for equality of average intervention effects over time between baseline subgroup levels were statistically significant.

DISCUSSION

Using data from the largest and longest randomized controlled trial of physical activity in older persons to date,¹¹ we set out to determine whether a moderate-intensity walking-based training program lowers RPR, a surrogate of cardiorespiratory fitness and indicator of poor health. We found a statistically significant but clinically small reduction in RPR between PA and SA groups over the course of the trial, particularly at 18 months participation in the exercise intervention. Though, overall, the comparisons of RPR between intervention groups appeared mostly non-significant across the majority of time-points.

The marginal benefit of our moderate intensity walking-based physical activity program for lowering RPR appeared to weaken somewhat with time (i.e., beyond 18 months follow-up), becoming non-significant. To this end, other more strenuous modes of exercise might be necessary to preserve CV health in later life. Current research supports the contention that higher intensity aerobic training encompassing a variety of exercise modalities appear to be well tolerated with advancing age.⁴ For instance, 6 months of sustained submaximal aerobic exercise (between 50% and 85% heart rate reserve) consisting of walking, jogging, and bicycling 4 to 5 times per week reduced RHR by 9 beats/min in healthy older men.¹⁸ A vigorous endurance training intervention consisting of treadmill walking/running uphill at 90% to 95% maximum heart rate considerably lowered RPR by 10 beats/min (e.g., from 69 to 59 beats/min) in healthy sedentary seniors.¹⁹ Further, Donath and coworkers²⁰ observed a beneficial improvement in RPR among healthy older adults following completion of a stair climbing intervention. A drawback of these studies, however, was their short length of duration (e.g., range of follow-up: 2–6 months), making it difficult to determine the long-term utility of aerobic exercise for lowering RPR in older adults. Additional studies exploring different modes and varying intensities of exercise, while employing a longer duration of follow-up for the purpose of maintaining healthy CV function in later life, are warranted.

Our study is not without limitations. Maintaining adherence represents a major challenge for long-term physical activity interventions that involve older adults – on average, 63% of the total PA group attended all of the scheduled sessions. Nevertheless, the LIFE Study achieved a similar adherence rate as those reported in previous intervention studies (i.e., between 50 and 60%) that enrolled older persons.^{21,22} It is possible some of the participants may have been self-referred, thus, caution should be taken when extrapolating these findings, as our study sample may not be representative of all seniors in the general community. Only older adults who led a sedentary lifestyle and who were considered to be at risk of developing major mobility disability were eligible for enrollment. It is unknown whether older individuals with a higher level of physical function might have benefitted from the study intervention.

In a large cohort of older sedentary adults followed for 2.6 years, our structured moderate-intensity walking-based physical activity intervention led to a statistically significant but clinically small reduction in RPR when compared with a health education program. Whether physical activity favors a healthier CV function by slowing the RPR in older adults clearly requires further investigation. We hope these findings will encourage others to assess different types of exercise activities along with varying intensities for the purpose of promoting improved CV function in later life.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1. Screening funnel of participants in the study. SPPB indicates Short Physical Performance Battery.

Table 1**Baseline Characteristics by Treatment Arm**

	Overall (N=1,635)	Successful Aging (N=817)	Physical Activity (N=818)
Age, mean $\pm$ SD, years	78.9 $\pm$ 5.2	79.1 $\pm$ 5.2	78.7 $\pm$ 5.2
Women, n (%)	1,098 (67.2%)	551 (67.4%)	547 (66.9%)
Ethnicity/race, n (%)			
White	1,239 (75.8%)	635 (77.7%)	604 (73.8%)
Black	288 (17.6%)	125 (15.3%)	163 (19.9%)
Hispanic	61 (3.7%)	30 (3.7%)	31 (3.8%)
Asian	15 (0.9%)	8 (1.0%)	7 (0.9%)
Native American	2 (0.1%)	2 (0.2%)	0 (0.0%)
Hawaiian	2 (0.1%)	1 (0.1%)	1 (0.1%)
Other	23 (1.4%)	14 (1.7%)	9 (1.1%)
Refused	5 (0.3%)	2 (0.2%)	3 (0.4%)
Education, n (%)			
No formal education	13 (0.8%)	6 (0.7%)	7 (0.9%)
Elementary school	31 (1.9%)	16 (2.0%)	15 (1.8%)
High school/equivalent	484 (29.7%)	236 (29.0%)	248 (30.4%)
College	642 (39.4%)	321 (39.5%)	321 (39.3%)
Postgraduate	402 (24.7%)	208 (25.6%)	194 (23.7%)
Other	58 (3.6%)	26 (3.2%)	32 (3.9%)
Current smoker, n (%)	52 (3.2%)	25 (3.1%)	27 (3.3%)
Waist circumference, mean $\pm$ SD, cm	101.8 $\pm$ 15.5	102.0 $\pm$ 15.7	101.5 $\pm$ 15.4
SBP, mean $\pm$ SD, mm Hg	127.4 $\pm$ 18.0	127.0 $\pm$ 17.8	127.9 $\pm$ 18.1
DBP, mean $\pm$ SD, mm Hg	68.2 $\pm$ 10.2	67.7 $\pm$ 10.1	68.7 $\pm$ 10.3
RPR, mean $\pm$ SD, beats/min [†]	66.6 $\pm$ 10.3	66.4 $\pm$ 10.0	66.7 $\pm$ 10.6
RHR, mean $\pm$ SD, beats/min [‡]	64.7 $\pm$ 10.5	64.6 $\pm$ 10.1	64.8 $\pm$ 11.0
Walk time 400-m, mean $\pm$ SD, seconds	508.9 $\pm$ 114.1	512.0 $\pm$ 114.9	505.8 $\pm$ 113.2
Chronic conditions, n (%)			
Diabetes	415 (25.5%)	216 (26.6%)	199 (24.4%)
Hypertension	1151 (71.0%)	578 (71.5%)	573 (70.5%)
MI	129 (7.9%)	69 (8.5%)	60 (7.4%)
CHF	71 (4.4%)	45 (5.6%)	26 (3.2%)
Stroke	109 (6.7%)	52 (6.4%)	57 (7.0%)
Pacemaker	66 (4.1%)	33 (4.1%)	33 (4.1%)
Medication use, n (%)			
Statins	810 (50.0%)	403 (49.9%)	407 (50.1%)
Beta-blockers	611 (37.7%)	296 (36.6%)	315 (38.8%)
Calcium channel blockers	381 (23.5%)	199 (24.6%)	182 (22.4%)

Abbreviations: SBP = systolic blood pressure, DBP = diastolic blood pressure, RPR = resting pulse rate, RHR = resting heart rate, MI = myocardial infarction, CHF = chronic heart failure.

[†]Resting pulse rate was obtained via pulse palpitation of the radial artery.

[‡]Resting heart rate was recorded by electrocardiography.

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Table 2

Tests for Equality of the Average Intervention Effects Over Time According to Treatment Arms and Pre-Specified Subgroup Levels

Characteristic	Level	Time Point	Successful Aging			Physical Activity			Equality of average intervention effect across subgroups (95% CI) [†]	P value for interaction	
			N	Mean (SE)	N	Mean (SE)	N	Mean (SE)			
Beta-blocker use	No beta-blockers	Baseline [‡]	521	68.8 (0.42)	503	69.0 (0.48)			0.97 (0.14 to 1.79)	0.09	
		6 - months	509	68.4 (0.36)	470	67.5 (0.38)					
		18 - months	475	70.2 (0.40)	439	68.4 (0.41)					
		30 - months	330	69.3 (0.46)	308	68.5 (0.47)					
	Beta-blockers	Baseline [‡]	296	62.2 (0.52)	314	63.1 (0.52)			-0.29 (-1.36 to 0.79)		
		6 - months	278	62.1 (0.48)	299	62.5 (0.44)					
		18 - months	261	63.7 (0.53)	276	63.2 (0.51)					
		30 - months	181	63.3 (0.61)	188	63.9 (0.60)					
Chronic conditions	No chronic conditions	Baseline [‡]	103	66.8 (0.91)	122	68.7 (0.90)			0.23 (-1.54 to 2.01)	0.65	
		6 - months	100	66.6 (0.80)	111	66.0 (0.30)					
		18 - months	95	68.9 (0.89)	109	67.6 (0.34)					
		30 - months	64	66.9 (1.03)	81	67.1 (0.39)					
	Chronic conditions	Baseline [‡]	712	66.3 (0.38)	694	66.4 (0.41)			0.68 (-0.03 to 1.39)		
		6 - months	685	66.9 (0.76)	657	65.6 (0.31)					
		18 - months	639	67.0 (0.83)	605	66.5 (0.35)					
		30 - months	445	68.4 (0.92)	414	66.8 (0.40)					
Age	<80 years	Baseline [‡]	455	67.0 (0.48)	477	67.1 (0.48)			1.38 (0.51 to 2.25)	0.10	
		6 - months	440	66.7 (0.38)	449	65.5 (0.39)					
		18 - months	411	68.3 (0.43)	421	66.5 (0.43)					
		30 - months	289	68.1 (0.49)	299	66.7 (0.48)					
	80 years	Baseline [‡]	362	65.6 (0.50)	341	66.3 (0.58)			-0.30 (-1.30 to 0.71)		
		6 - months	247	65.5 (0.38)	321	66.1 (0.45)					

Characteristic	Level	Time Point	Successful Aging			Physical Activity			Equality of average intervention effect across subgroups (95% CI) [†]	P value for interaction
			N	Mean (SE)	N	Mean (SE)	N	Mean (SE)		
RPR	RPR <80 beats/min	18 - months	325	66.5 (0.42)	295	66.4 (0.50)	0.70 (−0.13 to 1.53)			
		30 - months	222	67.0 (0.48)	198	67.1 (0.59)				
		Baseline [‡]	730	64.1 (0.29)	721	64.1 (0.30)				
		6 - months	702	64.9 (0.35)	681	64.2 (0.35)				
		18 - months	659	66.4 (0.38)	635	65.4 (0.38)				
		30 - months	463	66.1 (0.41)	441	65.9 (0.41)				
	RPR 80 beats/min	Baseline [‡]	87	85.2 (0.49)	97	86.2 (0.60)	1.61 (−0.96 to 4.18)		0.38	
		6 - months	85	76.2 (1.00)	89	77.5 (0.97)				
		18 - months	77	79.5 (1.10)	81	75.6 (1.08)				
		30 - months	48	78.6 (1.26)	56	75.6 (1.18)				

Abbreviations: RPR = resting pulse rate; SE = standard error; CI = confidence interval.

[‡]At baseline, unadjusted, raw means and standard errors are provided. At follow-up, least squares means with standard errors are reported.

[‡]Models adjusted for baseline resting pulse rate, gender, and clinical site with the exception for RPR, which adjusted only for gender and clinical site.