Dose response relationships between physical activity, walking and health-related quality of life in mid-age and older women

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Abstract

Background Although physical activity is associated with health-related quality of life (HRQL), the nature of the dose-response relationship remains unclear. This study examined the concurrent and prospective dose-response relationships between total physical activity (TPA) and (only) walking with HRQL in two age cohorts of women.

Methods Participants were 10,698 women born in 1946-1951 and 7,646 born in 1921-1926, who completed three mailed surveys for the Australian Longitudinal Study on Women's Health. They reported weekly TPA minutes (sum of walking, moderate, and vigorous minutes). HRQL was measured with the Medical Outcomes Study Short-Form 36 Health Status Survey (SF-36). Linear mixed models, adjusted for socio-demographic and health-related variables, were used to examine associations between TPA level (none, very low, low, intermediate, sufficient, high, and very high) and SF-36 scores. For women who reported walking as their only physical activity, associations between walking and SF-36 scores were also examined.

Results Curvilinear trends were observed between TPA and walking with SF-36 scores. Concurrently, HRQL scores increased significantly with increasing TPA and walking, in both cohorts, with increases less marked above sufficient activity levels. Prospectively, associations were attenuated although significant and meaningful improvements in physical functioning and vitality were observed across most TPA and walking categories above the low category.

Conclusion For women in their 50s-80s without clinical depression, greater amounts of TPA are associated with better current and future HRQL, particularly physical functioning and vitality. Even if walking is their only activity, women, particularly those in their 70s-80s, have better health-related quality of life.

INTRODUCTION

The health benefits of physical activity (PA) are well established. Regular participation in activities of at least moderate intensity is associated with lower mortality and morbidity, including reduced risks of obesity, anxiety and depression, cardiovascular disease, diabetes mellitus and some cancers.[1]

Evidence is growing that PA improves health-related quality of life (HRQL), a measure of individuals' own assessments of their health status. Dimensions of HRQL include physical health, mental/psychological health, social health, and global perceptions of function and well-being.[2] HRQL has been recognized as an important surveillance measure for monitoring the health of populations.[3]

Most of the evidence that PA improves HRQL comes from studies of populations with chronic conditions, including cancer,[4-7] diabetes,[8-10] and cardiovascular diseases.[11] Evidence from general populations is more limited and mostly from cross-sectional studies, which consistently show moderate to strong positive associations between PA and HRQL.[12-17] Few prospective studies of general populations have been conducted, and these have tended to find weaker associations between PA and HRQL.[13, 18, 19] However, in the Nurses' Health Study,[20] the largest and longest-running (14 years) of these studies, increases in PA were associated with clinically and statistically significant improvements in HRQL in mid-age and older US women.

Few studies have investigated the nature of the dose-response relationship between PA and HRQL (e.g., linear, curvilinear). This is important, as understanding the levels of PA required to benefit HLQL could have important public health implications.[13] For example, there could be PA thresholds below which PA offers no benefits for HRQL or above which PA offers no additional benefits.[13] Data from a national US sample[21] suggest a cross-sectional curvilinear relationship between frequency of moderate to vigorous PA and HRQL.

In contrast, studies from France and the Netherlands suggest a cross-sectional linear trend,[22, 23] and a study from Spain indicates a prospective linear trend.[24]

The aims of this study were twofold. The first was to examine concurrent and 6-year prospective associations between total PA (TPA) and physical and mental HRQL in two age-cohorts of community-dwelling healthy women. Given the popularity of walking among mid-age and older women, associations between walking and HRQL were also examined, in women who did no other PA than walking.[25] The secondary aim was to describe the nature of these dose-response relationships.

METHODS

Australian Longitudinal Study on Women's Health

The Australian Longitudinal Study on Women's Health (ALSWH) is a 20-year prospective study of changes in the health and well-being of Australian women born in 1973-1978, 1946-1951 and 1921-1926. As reported previously,[26] samples of each age cohort were randomly drawn from the national health insurance database, which includes all Australian citizens and permanent residents; women from rural and remote areas were intentionally over-sampled to ensure adequate representation. Mailed surveys were first administered in 1996 and subsequently on a rolling basis. The study was approved by the Ethics Committees of the University of Queensland and the University of Newcastle. Informed consent was received from all respondents. Further study details are available on the study's website.[27]

Study samples

The study sample for the current analyses included women born in 1946-1951 who completed surveys in 2001 (S3), 2004 (S4) and 2007 (S5), and women born in 1921-1926, who completed surveys in 2002 (S3), 2005 (S4) and 2008 (S5). These surveys were chosen because PA was measured the same way in each of them. The first survey in 1996 (S1) was completed by 14,099 women in the 1946-1951 cohort and 12,762 women in the 1921-1926 cohort. These cohorts were broadly representative of the general population in their age group, although Australian-born, employed and university-educated women were over-represented.[26] After loss to follow-up between 1996 (S1) and S3, the baseline for these analyses, data from 12,205 women in the 1946-1951 cohort and 8,998 women in the 1921-1926 cohort were available for analysis. Women lost to follow-up after 1996 were more likely to report poorer health, less education, and being born in a non-English-speaking country than those who continued in ALSWH.[28] We excluded an additional 207 women in the 1946-1951 cohort and 795 women in the 1921-1926 cohort who reported difficulty walking 100 meters, and women with possible clinical depression (1,300 women in the 1946-1951 cohort and 557 in the 1921-1926 cohort who reported at S3 that they had been diagnosed or treated for depression or were taking prescribed medication for depression), leaving data from 10,698 women in the 1946-1951 cohort and 7,646 in the 1921-1926 cohort available for analysis.

Measurements

Health-Related Quality of Life

The well-validated and widely-used Medical Outcomes Study's Health Status Survey short form (SF-36)[29] was used to measure HRQL. This self-report measure consists of 36 items: 21 measure physical HRQL, 14 measure mental HRQL, and one measures health transition. Physical and Mental HRQL Component Summary scales, with factor structures validated using the baseline ALSWH surveys,[30] served as measures of self-reported general physical and social/emotional HRQL. The Physical Component Summary (PCS) includes items from four subscales: bodily pain, physical functioning, role limitations from physical problems, and general health perception. The Mental Component Summary (MCS) includes items from four other subscales: vitality, social functioning, role limitations from emotional problems, and mental health. We also independently analyzed the physical functioning (10 physical health items), mental health (five emotional and mental health items), and vitality (two physical and two mental health items) subscales, as these subscales had statistical properties that allowed their use in the types of analyses conducted here.

PCS and MCS scores were standardized to range from 0-100, with the population average of each cohort set at 50 in accordance with standard procedures developed using ALSWH baseline data.[30] Higher scores indicate better HRQL.

Total Physical Activity and Walking

The validated Active Australia survey[31-33] was used to measure TPA and (only) walking. The survey assesses minutes in the previous week (in ≥10-minute bouts) spent walking briskly (‘for recreation or exercise or to get from place to place’), in moderate-intensity PA (‘like golf, social tennis, moderate exercise classes, recreational swimming, line dancing’), and in vigorous-intensity PA (‘that makes you breathe harder or puff and pant, like aerobics, competitive sport, vigorous cycling, running, swimming’). To account for differences in energy expenditure between the three activity types, a TPA score was computed by multiplying minutes in each activity type by an assigned metabolic equivalent (MET): (walking=3.0 METs; moderate-intensity PA=4.0 METs; vigorous-intensity PA=7.5 METs) and then summing these scores to create a in MET.min/week score.[34] Due to the non-normal distribution (zero-inflated count and overdispersion), participants were categorized based on total MET.min/week into seven categories, in order to examine dose-response relationships: 1) none (<40); 2) very low (40-<180); 3) low (180-<300); 4) intermediate (300-<600); 5) sufficient (600-<900); 6) high (900-<1100) and 7) very high (1100+). Participants in the sufficient or higher intensity categories were considered meeting national PA guidelines[35] given the lower cut-off for the sufficient category is equivalent to 150 minutes/week of moderate-intensity PA (150 minutes x 4 METS = 600 MET.min). For women whose only PA was walking, an (only) walking score (MET.min/week) was computed by multiplying walking minutes by 3.0 (METs) and categorizing responses as for TPA, to allow for comparisons between results for TPA and (only) walking.

Potential Confounding Variables

Based on a review of the literature, socio-demographic and health-related variables were included as potential confounders. Demographic variables included country of birth (proxy for ethnicity); area of residence (urban, large town, small town/rural area; derived from postal codes); educational attainment; and ability to manage on one's income (proxy for income status; categorized as 'easy/not too bad' or 'difficult/impossible'). Social variables included marital status, care giving duties (regularly providing care for children and/or for people with a long-term illness, disability, or frailty), and social connectedness (measured with the Medical Outcomes Study Social Support scale[36] in the 1946-1951 cohort and with a modified Social Networks subscale of the Duke Social Support Index[37] in the 1921-1926 cohort). Health-related variables included the number of stressful life events in the past 12 months (e.g., death of partner, moving house), number of chronic conditions (from a list of conditions, including diabetes, cancer, and heart disease, that women reported they had been told they had by a doctor in the previous 3 years[38]), smoking status and alcohol consumption. Body mass index (BMI) was calculated as kg/m^2 based on self-reported height and weight. For the 1946-1951 cohort, menopausal status (from questions about menstrual bleeding, removal of both ovaries, having had a hysterectomy; categorised as shown in the web-only data) was also assessed.

Statistical analyses

Associations between TPA and (only) walking with HRQL scores were examined using random intercept multivariable linear mixed models (the XTMIXED function) in STATA 11.2 (StataCorp, College Station, TX, 2009). Individuals served as random effects. Separate models were computed for each HRQL variable for each age cohort. All models were fully adjusted for all possible confounders found to be bivariately associated with at least one of the HRQL outcomes. Survey year served as a covariate to account for changes in the outcome as the women aged. The Hotdeck function (in which responses from individuals with identical responses on non-missing variables are randomly selected to impute missing values) was used to impute education and country of birth, which were measured only in 1996 (S1). All variables were categorical except social interaction and HRQL scores, which were continuous.

To examine cross-sectional (concurrent) relationships between TPA and each HRQL outcome, TPA and confounders measured at S3-S5 served as fixed effects in models without a time lag, with HRQL at the same survey periods serving as outcome variables. To examine prospective associations between TPA and each HRQL outcome, TPA and confounders measured at S3 and S4 served as fixed effects in prospective models with time-lag, with HRQL at S4 and S5, respectively, serving as outcome variables. Among the subgroup of women who reported no moderate or vigorous activity at S3-S5 (walking was their only physical activity), the same modeling was used, except walking replaced TPA. Bootstrap corrections were applied to skewed outcome variables.

To test for potential bias due to incomplete data, all models were re-run using the multiple imputation (MI) Iterative Chained Equation (ICE) procedure in STATA (with 20 iterations). Sensitivity analysis (where results of various combinations of subsets of imputed models are compared) indicated that parameters from imputed models were stable. Additionally, these parameters closely followed those of the unimputed models and therefore the unimputed models are reported here.

RESULTS

Select characteristics of participants are presented in table 1. Additional characteristics are described in the web supplement.

Table 1 Select characteristics of women in the analysis sample, using data collected at Survey 3, 2001 from the 1946-1951 cohort and in 2002 from the 1921-1926 cohort

	1946-1951 cohort (N=10,698)		**1921-1926 cohort (N=7,646)**	
Variables	**n**	**%***	**n**	**%***
Area of residence				
Urban	3610	(33.7)	3100	(40.5)
Large town	1294	(12.1)	868	(11.4)
Small town/rural area	4769	(44.6)	3325	(43.5)
Missing	1025	(9.6)	353	(4.6)
Education†				
Some high school or less	5188	(48.5)	3030	(39.6)
Completed high school	1824	(17.1)	1007	(13.2)
Trade/certificate/diploma	2120	(19.8)	946	(12.4)
University degree	1566	(14.6)	331	(4.3)
Income management				
Easy/not too bad	6133	(57.3)	5550	(72.6)
Impossible or difficult	3461	(32.4)	1695	(22.2)
Missing	1104	(10.3)	401	(5.2)
Marital status				
Married/de facto	8059	(75.3)	3297	(43.1)
Not married	1643	(15.4)	3973	(52.0)
Missing	996	(9.3)	376	(4.9)
Smoking status				
Never	5316	(49.7)	4532	(59.3)

Former	3062	(28.6)	2010	(26.3)
Current	1297	(12.1)	326	(4.3)
Missing	1023	(9.6)	778	(10.2)
Alcohol consumption				
Low risk drinker	5215	(48.8)	2570	(33.6)
Non-drinker	1435	(13.4)	2675	(35.0)
Rarely drinks	2213	(20.7)	1738	(22.7)
Risky/high risk drinker	621	(5.8)	189	(2.5)
Missing	1214	(11.4)	474	(6.2)
Body mass index (kg/m^2)				
Healthy weight (18.5-<25)	3955	(37.0)	3125	(40.9)
Underweight (<18.5)	128	(1.2)	247	(3.2)
Overweight (25-<30)	2955	(27.6)	2167	(28.3)
Obese (≥30)	2015	(18.8)	826	(10.8)
Missing	1645	(15.4)	1281	(16.8)
Total physical activity (MET.min/wk§)				
1. None (0 - <40)	1549	(14.5)	2313	(30.3)
2. Very low (40 - <180)	801	(7.5)	528	(6.9)
3. Low (180 - <300)	978	(9.1)	554	(7.3)
4. Intermediate (300 - <600)	1688	(15.8)	895	(11.7)
5. Sufficient (600 - <900)	1042	(9.7)	603	(7.9)
6. High (900 - <1100)	701	(6.6)	409	(5.5)
7. Very high (≥ 1100)	2504	(23.4)	1460	(19.1)
Missing	1435	(13.4)	884	(11.6)

Additional characteristics are described in the web supplement. Missing values were imputed for the sensitivity analysis.

* Percentage may not add up to 100% due to rounding.

† Measured in 1996 (S1) and imputed using Hotdeck imputation.

§ MET.min were computed as the sum of total physical activity minutes after weighting time in each activity by its assigned metabolic equivalent value (walking: 3.0; moderate: 4.0; vigorous: 7.5).[34] Participants in categories 5-7 were considered meeting physical activity guidelines in Australia,[35] given the lower cut-off for category 5 is equivalent to 150 minutes/week of moderate-intensity physical activity (150 minutes x 4 METS = 600 MET.min).

Participants' activity and HRQL scores at each survey are listed in table 2. The percentage of women who reported no activity decreased slightly over the 6 years of the study for the 1946-1951 cohort, but increased for the 1921-1926 cohort. For the 1946-1951 cohort, PCS and physical functioning scores decreased slightly while MCS, mental health and vitality scores increased slightly. In contrast, in the 1921-1926 cohort, all HRQL scores decreased over time, with the most marked decreases in the physical functioning subscale.

Table 2 For each survey year, the percentages of women who reported participation in physical activity and the women's mean (SD) scores on health-related quality of life outcomes*

	1946-1951 cohort			**1921-1926 cohort**		
	2001 S3	**2004 S4**	**2007 S5**	**2002 S3**	**2005 S4**	**2008 S5**
Physical Activity categories: percentages						
No physical activity	16.6	15.4	14.8	34.0	40.8	47.2
Only walking	43.1	42.5	40.1	38.3	30.5	29.5

Only moderate/vigorous	5.5	5.0	4.4	8.1	9.3	7.9
Walking and moderate/vigorous	34.8	37.2	40.7	19.7	19.4	15.4
SF-36 subscales: mean (SD)						
Physical components summary	48.7	47.9	47.5	50.2	48.2	46.4
	(8.9)	(9.3)	(9.6)	(8.6)	(8.9)	(8.8)
Mental components summary	49.7	50.3	51.1	53.3	52.9	52.3
	(10.9)	(11.0)	(10.6)	(7.7)	(8.4)	(8.9)
Physical functioning sub-scale	84.3	82.5	82.0	63.6	56.9	50.7
	(16.6)	(18.4)	(19.1)	(24.7)	(27.1)	(27.5)
Mental health sub-scale	76.4	77.0	77.9	81.1	80.7	79.9
	(16.1)	(16.3)	(16.0)	(13.9)	(14.6)	(15.5)
Vitality sub-scale	60.0	60.8	62.2	59.4	57.3	54.7
	(20.6)	(20.6)	(20.2)	(19.4)	(20.1)	(20.1)

SF-36 = Medical Outcomes Study's short form health survey

* Health-related quality of life was measured with SF-36 component scales and three subscales. Each component summary score was standardized to range from 0 to 100, with the population average of each cohort set at 50. Higher scores indicate better health-related quality of life.

The associations between both TPA and (only) walking with HRQL variables (Beta coefficients and 95% CIs) are shown in table 3 for the 1946-1951 cohort and table 4 for the 1921-1926 cohort. The dose-response relationships are displayed in figure 1. In concurrent models in each cohort, all coefficients except one (i.e., very low walking in the 1946-1951 cohort for MCS) were significantly higher for each activity level above the none level than for the none level. In general, coefficients increased as TPA and walking levels increased, with gains leveling beyond the sufficient (600-<900 MET.min) level for some outcomes. The strongest associations were found for physical functioning (increases of up to 10 points across the range of activity levels in the 1946-1951 cohort and up to 19 points in the 1921-1926 cohort) and vitality (up to 11 points for both cohorts).

In prospective models, the dose-response relationships were attenuated. For PCS, physical functioning and vitality, increasing levels of TPA and (only) walking were still significantly associated with increasing HRQL coefficients in both cohorts in all analyses except one (walking in the 1946-1951 cohort for PCS), with gains levelling beyond the sufficient level for some outcomes. There were no associations between increasing levels of TPA or walking and mental HRQL outcomes except for a relationship between TPA and MCS, which became significant above the sufficient activity level in the mid-age women.

Table 3 Beta coefficients and 95% CIs for SF-36 scores of women in the 1946-1951 cohort in each concurrent and prospective model of total physical activity and only walking: results from linear mixed-models analysis*

	PCS			MCS			Physical functioning			Mental Health			Vitality		
	β	**95% CI**	**p**	**β**	**95% CI**	**p**	**β**	**95% CI**	**p**	**β**	**95% CI**	**p**	**β**	**95% CI**	**p**
Concurrent models: TPA† MET.min/week															
2	2.45	1.90 to 3.00	<0.001	0.84	0.23 to 1.44	0.007	5.29	4.34 to 6.24	<0.001	1.69	0.77 to 2.61	<0.001	2.84	1.86 to 3.82	<0.001
3	2.89	2.4 to 3.38	<0.001	1.71	1.14 to 2.28	<0.001	6.35	5.48 to 7.22	<0.001	2.54	1.75 to 3.33	<0.001	5.00	4.14 to 5.86	<0.001
4	3.47	3.05 to 3.90	<0.001	1.79	1.32 to 2.26	<0.001	7.38	6.60 to 8.15	<0.001	2.70	2.01 to 3.39	<0.001	5.79	5.06 to 6.52	<0.001
5	3.68	3.22 to 4.14	<0.001	2.63	2.14 to 3.12	<0.001	8.33	7.50 to 9.15	<0.001	3.61	2.88 to 4.35	<0.001	7.69	6.9 to 8.49	<0.001
6	3.82	3.36 to 4.29	<0.001	2.35	1.80 to 2.91	<0.001	8.73	7.90 to 9.55	<0.001	3.34	2.57 to 4.11	<0.001	7.66	6.79 to 8.52	<0.001
7	4.57	4.16 to 4.99	<0.001	3.43	2.99 to 3.87	<0.001	10.25	9.48 to 11.01	<0.001	4.64	4.00 to 5.29	<0.001	10.33	9.64 to 11.02	<0.001
Prospective models: TPA§ MET.min/week‡															
2	0.86	-0.14 to 1.86	0.09	-0.03	-1.23 to 1.16	0.96	2.35	0.49 to 4.20	0.01	0.01	-1.6 to 1.62	0.99	0.79	-0.46 to 2.05	0.22
3	0.74	-0.21 to 1.70	0.13	0.82	-0.31 to 1.96	0.15	2.37	0.60 to 4.13	0.009	1.18	-0.35 to 2.7	0.13	2.18	1.05 to 3.30	<0.001
4	1.21	0.38 to 2.04	0.004	0.76	-0.15 to 1.66	0.10	3.23	1.71 to 4.75	<0.001	0.84	-0.52 to 2.2	0.23	2.52	1.55 to 3.50	<0.001
5	1.73	0.82 to 2.64	<0.001	1.06	0.06 to 2.06	0.04	4.26	2.65 to 5.87	<0.001	1.34	-0.18 to 2.86	0.08	3.54	2.46 to 4.61	<0.001
6	1.80	0.87 to 2.74	<0.001	1.10	-0.04 to 2.25	0.06	4.73	3.01 to 6.46	<0.001	1.59	-0.10 to 3.28	0.07	4.24	3.06 to 5.41	<0.001
7	1.65	0.84 to 2.47	<0.001	1.94	1.06 to 2.82	<.001	5.18	3.68 to 6.68	<0.001	2.19	0.91 to 3.48	0.001	5.39	4.47 to 6.30	<0.001
Concurrent models: (only) walking† MET.min/week¶															
2	2.55	1.82 to 3.28	<0.001	0.36	-0.44 to 1.17	0.376	6.14	4.81 to 7.48	<0.001	1.19	0.041 to 2.34	0.042	2.40	1.01 to 3.79	0.001

3	2.63	1.96 to 3.29	<0.001	1.47	0.68 to 2.27	<0.001	6.88	5.68 to 8.09	<0.001	2.53	1.40 to 3.65	<0.001	4.63	3.39 to 5.87	<0.001
4	3.34	2.74 to 3.95	<0.001	1.30	0.59 to 2.01	<0.001	7.65	6.52 to 8.78	<0.001	2.35	1.36 to 3.34	<0.001	4.89	3.79 to 5.99	<0.001
5	3.41	2.63 to 4.18	<0.001	1.84	1.02 to 2.65	<0.001	8.42	7.00 to 9.87	<0.001	2.30	1.09 to 3.51	<0.001	6.36	4.95 to 7.78	<0.001
6	3.78	3.02 to 4.54	<0.001	1.68	0.78 to 2.57	<0.001	8.67	7.27 to 10.06	<0.001	2.56	1.26 to 3.87	<0.001	6.31	4.76 to 7.84	<0.001
7	3.51	2.79 to 4.23	<0.001	1.45	0.70 to 2.20	<0.001	7.80	6.39 to 9.21	<0.001	2.18	1.01 to 3.35	<0.001	6.05	4.89 to 7.42	<0.001
Prospective models: (only) walking[§] MET.min/week[¶]															
2	0.74	-0.71 to 2.18	0.318	0.29	-1.35 to 1.94	0.727	2.59	-0.15 to 5.33	0.064	0.75	-1.54 to 3.04	0.520	0.89	-0.86 to 2.64	0.317
3	0.60	-0.77 to 1.96	0.390	0.83	-0.81 to 2.46	0.321	2.22	-0.21 to 4.66	0.073	1.24	-1.06 to 3.54	0.290	2.25	0.63 to 3.86	0.006
4	0.93	-0.33 to 2.18	0.147	0.47	-0.96 to 1.91	0.519	3.19	0.88 to 5.49	0.007	0.46	-1.54 to 2.47	0.652	1.61	0.15 to 3.07	0.031
5	1.56	-0.06 to 3.19	0.059	0.57	-1.26 to 2.40	0.542	3.67	0.74 to 6.59	0.014	0.48	-2.29 to 3.25	0.734	3.03	1.13 to 4.92	0.002
6	1.67	0.05 to 3.30	0.043	0.71	-1.44 to 2.87	0.518	5.59	2.02 to 8.78	0.001	1.56	-1.51 to 4.63	0.318	3.43	1.30 to 5.57	0.002
7	0.21	-1.38 to 1.79	0.797	0.66	-1.11 to 2.43	0.465	2.11	-0.93 to 5.14	0.173	0.27	-2.53 to 3.06	0.853	1.88	0.04 to 3.72	0.045

* 1, None (0 to <40 MET.min/week, the referent category, not shown); 2, Very low (40 to <180 MET.min/week); 3, Low (180 to <300 MET.min/week); 4, Intermediate (300 to <600 MET.min/week); 5, Sufficient (600 to <900 MET.min/week); 6, High (900 to < 1100 MET.min/week); 7, Very high (1100+ MET.min/week). All models adjusted for survey year, country of birth, area of residence, education, income management, marital status, social connectedness, care giving duties, number of life events, body mass index, smoking status, alcohol consumption, number of chronic conditions, and in the 1946-1951 cohort only, menopausal status. Estimates for the physical function and mental health subscales are bootstrapped-corrected for skewed outcomes.

[†] TPA and (only) walking were assessed at the same time as health-related quality of life (SF-36 scores).

[‡] MET.min equal the sum of total physical activity minutes after weighting time walking mins by 3.0; moderate mins by 4.0 and vigorous mins by 7.5.[34]

[§] TPA and (only) walking were assessed 3 years earlier than health-related quality of life (SF-36 scores).

[¶] In women whose only reported PA was walking, MET.min equal total walking minutes weighted by the metabolic equivalent value assigned to walking (3.0).

Table 4 Beta coefficients and 95% CIs for SF-36 scores for women in the 1921-1926 cohort in each concurrent and prospective model of total physical activity and (only) walking: results from linear mixed-models analysis*

	PCS			MCS			Physical functioning			Mental Health			Vitality		
	β	**95% CI**	**p**	**β**	**95% CI**	**p**	**β**	**95% CI**	**p**	**β**	**95% CI**	**p**	**β**	**95% CI**	**p**
Concurrent model: TPA[†] MET.min/week															
2	2.75	2.28 to 3.23	<0.001	1.30	0.78 to 1.82	<0.001	10.16	8.86 to 11.46	<0.001	2.08	1.24 to 2.91	<0.001	4.81	3.76 to 5.86	<0.001
3	3.35	2.88 to 3.82	<0.001	1.40	0.93 to 1.88	<0.001	11.62	10.33 to 12.91	<0.001	1.83	1.02 to 2.63	<0.001	5.25	4.2 to 6.3	<0.001
4	4.13	3.74 to 4.53	<0.001	1.93	1.51 to 2.35	<0.001	13.90	12.81 to 14.99	<0.001	2.64	1.90 to 3.38	<0.001	6.99	6.11 to 7.87	<0.001
5	5.01	4.55 to 5.47	<0.001	2.48	1.99 to 2.97	<0.001	16.25	14.99 to 17.51	<0.001	3.57	2.70 to 4.44	<0.001	8.48	7.45 to 9.5	<0.001
6	4.53	3.98 to 5.07	<0.001	2.17	1.57 to 2.76	<0.001	16.33	14.83 to 17.84	<0.001	3.11	2.12 to 4.09	<0.001	7.63	6.41 to 8.84	<0.001
7	5.97	5.59 to 6.35	<0.001	2.38	1.95 to 2.82	<0.001	19.14	18.09 to 20.18	<0.001	3.54	2.83 to 4.26	<0.001	10.44	9.59 to 11.3	<0.001
Prospective model: TPA[§] MET.min/week[‡]															
2	1.40	0.71 to 2.09	<0.001	0.34	-0.83 to 1.51	0.57	4.65	2.71 to 6.58	<0.001	0.21	-1.65 to 2.07	0.83	2.06	0.56 to 3.55	0.007
3	1.62	0.95 to 2.30	<0.001	0.19	-0.88 to 1.27	0.73	5.19	3.28 to 7.09	<0.001	0.42	-1.28 to 2.12	0.63	1.91	0.45 to 3.38	0.01
4	2.21	1.66 to 2.76	<0.001	0.69	-0.22 to 1.60	0.14	8.72	7.13 to 10.31	<0.001	1.23	-0.32 to 2.78	0.12	3.13	1.91 to 4.35	<0.001
5	2.79	2.15 to 3.43	<0.001	0.60	-0.52 to 1.71	0.29	10.89	9.07 to 12.71	<0.001	0.99	-0.77 to 2.74	0.27	3.68	2.28 to 5.08	<0.001
6	2.98	2.24 to 3.71	<0.001	0.21	-1.07 to 1.48	0.75	9.73	7.61 to 11.84	<0.001	0.65	-1.37 to 2.66	0.53	3.05	1.42 to 4.69	<0.001
7	3.57	3.05 to 4.08	<0.001	0.96	0.09 to 1.84	0.03	13.16	11.69 to 14.63	<0.001	1.13	-0.30 to 2.56	0.12	6.27	5.13 to 7.41	<0.001
Concurrent model: (only) walking[†] MET.min/week[¶]															
2	2.56	1.97 to 3.15	<0.001	1.14	0.46 to 1.82	0.001	10.32	8.69 to 11.95	<0.001	1.82	0.74 to 2.90	0.001	4.29	2.95 to 5.63	<0.001

3	3.54	2.93 to 4.15	<0.001	1.03	0.43 to 1.64	0.001	11.19	9.49 to 12.88	<0.001	1.22	0.17 to 2.27	0.023	5.02	3.62to 6.42	<0.001
4	4.12	3.58 to 4.67	<0.001	1.94	1.39 to 2.50	<0.001	13.93	12.40 to 15.45	<0.001	2.24	1.25 to 3.23	<0.001	7.13	5.88 to 8.39	<0.001
5	5.37	4.59 to 6.14	<0.001	2.22	1.45 to 2.99	<0.001	17.12	14.99 to 19.26	<0.001	3.31	1.90 to 4.71	<0.001	8.22	6.45 to 9.99	<0.001
6	4.19	3.23 to 5.15	<0.001	1.61	0.53 to 2.70	0.004	15.53	12.87 to 18.18	<0.001	2.27	0.45 to 4.09	0.014	6.89	4.68 to 9.10	<0.001
7	5.05	4.29 to 5.81	<0.001	1.81	0.89 to 2.73	<0.001	17.36	15.26 to 19.46	<0.001	2.59	1.09 to 4.09	<0.001	8.88	7.14 to 10.61	<0.001
Prospective model: (only) walking[§] MET.min/week[¶]															
2	1.51	0.70 to 2.31	<0.001	-0.03	-1.42 to 1.37	0.970	3.97	1.69 to 6.25	0.001	-0.28	1.94 to -2.50	0.805	2.08	0.28 to 3.89	0.024
3	1.62	0.79 to 2.46	<0.001	0.12	-1.17 to 1.41	0.851	5.48	3.11 to 7.84	<0.001	-0.15	1.96 to -2.26	0.887	1.78	-0.08 to 3.63	0.061
4	2.57	1.84 to 3.29	<0.001	0.78	-0.36 to 1.92	0.182	9.63	7.53 to 11.73	<0.001	1.15	3.13 to -0.83	0.255	3.78	2.14 to 5.43	<0.001
5	3.02	1.99 to 4.05	<0.001	0.58	-1.28 to 2.45	0.540	12.88	9.98 to 15.78	<0.001	1.24	3.96 to -1.48	0.371	4.69	2.40 to 6.98	<0.001
6	2.16	0.90 to 3.42	0.001	1.04	-1.11 to 3.20	0.342	9.99	6.37 to 13.62	<0.001	1.12	4.66 to -2.43	0.537	3.79	0.94 to 6.65	0.009
7	2.80	1.81 to 3.79	<0.001	0.40	-1.07 to 1.86	0.595	10.76	7.92 to 13.59	<0.001	-0.52	2.12 to -3.16	0.700	5.19	2.95 to 7.43	<0.001

* 1, None (0 to <40 MET.min/week, the referent category, not shown); 2, Very low (40 to <180 MET.min/week); 3, Low (180 to <300 MET.min/week); 4, Intermediate (300 to <600 MET.min/week); 5, Sufficient (600 to <900 MET.min/week); 6, High (900 to < 1100 MET.min/week); 7, Very high (1100+ MET.min/week). All models adjusted for survey year, country of birth, area of residence, education, income management, marital status, social connectedness, care giving duties, number of life events, body mass index, smoking status, alcohol consumption, number of chronic conditions, and in the 1946-1951 cohort only, menopausal status. Estimates are bootstrapped-corrected for MCS and mental health.

†TPA and (only) walking were assessed at the same time as health-related quality of life SF-36 scores.

‡ MET.min equal the sum of total physical activity minutes after weighting time walking mins by 3.0; moderate mins by 4.0 and vigorous mins by 7.5.[34]

§TPA and (only) walking were assessed 3 years earlier than health-related quality of life SF-36 scores.

¶ In women whose only reported PA was walking, MET.min equals total walking minutes weighted by the metabolic equivalent value assigned to walking 3.0.

DISCUSSION

As far as we are aware, this is the first study to describe the nature of the dose-response relationship between both TPA and (only) walking with HRQL both concurrently and prospectively. In concurrent models, HRQL increased with increasing TPA and walking, in both cohorts. The increases were observed at very low TPA and walking levels, and continued up to sufficient levels, after which increases were less marked for some outcomes, especially for walking. In prospective models, there were significant improvements in physical HRQL (PCS and physical functioning) and vitality with increasing TPA and walking levels in both cohorts, but associations with mental HRQL (MCS and mental health subscale) were attenuated. The findings indicate that most gains in HRQL for Australian women in their 50s-80s without clinical depression are associated with participation in up to 600-900 MET.minutes/week of TPA, equivalent to up to 150-225 minutes of moderate-intensity PA or to 200-300 minutes of (only) walking.

In concurrent models, for all HRQL outcomes, we observed meaningful improvements in scores (3-points or greater)[13] with TPA and (only) walking. Noteworthy were the substantial increases in physical functioning and vitality with increasing TPA and walking. Compared with doing no activity, doing low to very high levels of TPA or walking was associated with a 6- to 10-point improvement in physical functioning and a 4- to 10-point improvement in vitality in the 1946-1951 cohort and with an 11- to 19-point improvement in physical functioning and a 5- to 10-point improvement in vitality in the 1921-1926 cohort. Such strong concurrent associations between TPA and HRQL support findings from previous cross-sectional studies that have consistently shown moderate to strong associations.[12-17] Our findings add that walking, in women whose only PA is walking, is associated in a meaningful way with HRQL as well. Our findings are also consistent with cross-sectional studies showing the largest associations between PA and HRQL to be for the physical dimensions of HRQL (PCS and physical functioning)[12, 13] and for vitality.[13]

As previously shown,[13, 18, 19] associations were attenuated prospectively. Nonetheless, for both cohorts, meaningful improvements in physical functioning and vitality scores were observed across most TPA and (only) walking levels above the low activity level. The greatest improvements, 9- to 13-points in physical functioning, were observed for women in the 1921-1926 cohort who were in the intermediate and higher levels of TPA and walking. Also for this cohort, improvements of 3- to 6-points in vitality were observed for women in these same TPA and walking levels. In the 1946-1951 cohort, 3- to 5-point improvements in physical functioning and in vitality were seen for most women in these TPA levels, although improvements were less marked for women whose only PA was walking. In contrast, no meaningful improvements (all < 3 points) in mental HRQL (MCS and mental health subscale) were seen in the prospective models. These findings are consistent with those found in the Nurses' Health Study,[20] for which a 10-year increase in TPA was associated with an 8-point improvement in physical functioning, a 4-point increase in vitality, but only a 2-point increase in mental health, in a cohort of women aged 40-67 years at baseline.

Our findings partially support cross-sectional studies that have examined the nature of the dose-response relationship between TPA and HRQL, as measured with the SF-36. In a cross-sectional French study, a positive gradient in all SF-36 scores was seen across four categories of PA (inactive to vigorous) in women.[22] In a Dutch study, cross-sectional linear trends were found between quintiles of at least moderate-intensity PA and SF-36 PCS, physical functioning and vitality scores for women, although 5-year changes in PA were not prospectively associated with changes in SF-36 scores.[23] However, in a Spanish study, prospective linear trends were found between PA quartiles and six SF-36 subscales.[24] In contrast, in a large US study,[21] a U-shaped curve was observed for associations between moderate and vigorous PA and HRQL; however, differences in HRQL measure between that study and other studies make comparisons difficult.

Major strengths of our study were the use of large community-based cohorts of women and the use of data from three time points. Another strength was the categorizing of women into more categories of PA than typically done, to facilitate the examination of dose-response relationships. Furthermore, many important confounders were included in the analysis, given the large number of variables included in ALSWH. The primary limitation is the reliance on self-report data, which are subject to recall and measurement bias. However, the PA and HRQL measures have adequate reliability and validity.[30, 31, 33] The generalizability of our findings is limited by the potential effect of study attrition. The ALSWH included fairly representative national samples of women responding at baseline,[26] but as with all prospective studies, women have withdrawn over time, with more healthy women remaining in the study.[28] Therefore, our findings cannot be generalized to all Australian women in their 50s-80s.

Conclusion

Our findings indicate strong concurrent relationships between both TPA and (only) walking with indicators of physical and mental well-being, and moderate-to-strong prospective relationships with indicators of physical well-being in mid-age and older women. Stronger associations with physical well-being were noted for older women than mid-age women, with older women enjoying more physical HRQL benefits from just walking than their mid-age counterparts. Our study extends previous work by demonstrating that HRQL increases with increasing TPA and (only) walking, with increases less marked above sufficient activity levels (i.e., a curvilinear trend), for both TPA and (only) walking in two age cohorts of women, and documenting that even lower levels of TPA than currently recommended offer health benefits. These findings add to the large body of evidence indicating that mid-age and older women enjoy health benefits by staying physically active.

What is already known on this subject?

Health-related quality of life is recognized as an important measure of a population's health status. Cross-sectional studies indicate moderate to strong associations between physical activity and health-related quality of life.

What this study adds?

For women in their 50s-80s who do not exhibit signs of clinical depression, greater amounts of leisure-time physical activity are associated with better current and future health-related quality of life, particularly physical functioning and vitality. Even if walking is their only activity, women, particularly those in their 70s-80s, have better health-related quality of life. This also holds true if women do some physical activity, but do not meet physical activity guidelines for health benefits. Physical activity, including walking, should be promoted to women in their 50s and older to improve their quality of life.

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Competing interests None declared.

Ethics approval Ethics approval was provided by the Ethics Committees of the Universities of Queensland and Newcastle.

Contributors WB was involved with the initiation and development of the ALSWH surveys. KCH, JvU and WB were involved in this study's conception. KCH, JvU, and YvG developed the analysis plan, and YvG conducted the analyses. All authors participated in the interpretation of the data. KCH, JvU and YvG drafted the manuscript, and all authors were involved in critically revising the manuscript for important intellectual content. All authors read and approved the final manuscript.

Figure 1 Associations between both total physical activity and walking with five measures of health-related quality of life, separately for the 1946-1951 cohort and the 1921-1926 cohort. Each graph shows concurrent models of both TPA (solid line and filled ball: –●–) and walking (solid line and open ball:–⊖–) and prospective models of TPA (dotted line and filled ball: -●-) and walking (dotted line and open ball: - ⊖ -). The x-axis represents activity level, and the y-axis represents beta coefficients and 95% CIs for SF-36 scores with the first activity category serving as the reference category (β=0).

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