Trends in Total Physical Activity Time, Walking, and Vigorous Physical Activity Time in Queensland Adults From 2004–2018

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Background: Health benefits of physical activity (PA) accrue with small increases in PA, with the greatest benefits for those transitioning from inactivity to any level of PA. This study examined whether self-reported PA time in Queensland adults changed between 2004 and 2018. **Methods:** The Queensland government conducts regular cross-sectional telephone surveys. Between 2004 and 2018, adults aged 18–75 years answered identical questions about their weekly minutes of walking, moderate PA, and vigorous PA. Hurdle regression estimated the average annual change in weekly minutes of PA overall and by activity type, focusing on sociodemographic differences in trends. **Results:** The sample size averaged 1764 (2004–2008) and 10,188 (2009–2018), totaling 107,171 participants aged 18–75 years. Unadjusted PA increased by 10 minutes per week per year (95% confidence interval [CI], 8.8–11.1) overall, with increases for most subgroups. Adjusted PA increased by 10.5 minutes per week per year (95% CI, 9.4–11.7). Trends differed by employment—employed adults and those not in the labor force increased by 14.3 (95% CI, 12.8–15.8) and 2.2 minutes per week per year (95% CI, 0.4–4.0), respectively, with no increase for unemployed adults. The increases were due to both an increased prevalence of doing any activity and an increased average duration among active adults. **Conclusions:** Since 2004, PA time has increased for Queensland adults, with substantial variability by employment status.

Keywords: surveillance, survey research, health disparities

It is widely accepted that achieving sufficient levels of physical activity (PA) is important for good health and that insufficient PA contributes significantly to the overall burden of disease and healthcare costs. The World Health Organization Global Action Plan on PA states that “. . . regular PA is proven to help prevent and treat noncommunicable diseases such as heart disease, stroke, diabetes and breast and colon cancer. It also helps to prevent hypertension, overweight and obesity and can improve mental health, quality of life and well-being.”^{1(p6)} It was estimated in 2012 that, worldwide, physical inactivity caused 6% of the burden of disease from coronary heart disease, 7% of type 2 diabetes, 10% of breast cancer, and 10% of colon cancer.² The Australian Burden of Disease study reported that physical inactivity accounted for 2.6% of the total burden in 2011.³ Global economic analysis estimated that physical inactivity cost health care systems \$53.8 billion (INT \$) in 2013, with an additional \$13.7 billion in productivity losses due to physical-inactivity-related deaths.⁴ In Australia, the cost of physical inactivity was estimated to be \$0.5 billion (INT\$) in 2013.⁴ A 10% reduction in physical inactivity in Australia is estimated to result in a saving of A\$258 million.⁵

The World Health Organization defines sufficient adult PA as 150 minutes of moderate-intensity PA per week or 75 minutes of

vigorous-intensity PA per week or an equivalent combination of both.⁶ Trends in PA have been investigated in several international and Australian studies. A recent pooled analysis of 358 population-based surveys worldwide concluded that overall levels of insufficient PA remained stable between 2001 and 2016, with a global age-standardized prevalence of 27.5% in 2016.⁷ Insufficient PA prevalence was more than twice as high in high-income as in low-income countries and had increased in high-income countries.⁷ Australian studies have reported mixed trend results with some studies reporting small increases,^{8–12} whereas others reported that the prevalence of sufficiently active adults was decreasing¹³ or stable.¹⁴

Trends in underlying PA subcomponents, such as walking and vigorous activity, have also been examined. As the most common activity,^{15–17} walking trends have been investigated in several studies. The US Behavioral Risk Factor Surveillance System found modest increases in the prevalence of adults who did any walking for leisure-time PA between 1987 and 2000.¹⁸ It also identified walking as the most common activity among adults and among sufficiently active adults (individually or in combination with other activities). In New South Wales, between 1998 and 2006, the proportion of men and women who did any walking and who walked regularly increased,¹⁹ and the total minutes of walking increased.^{19,20} A UK study reported that work-related PA declined, while moderate and vigorous PA during sport increased between 1991 and 2004.²¹ The study also concluded that limiting the analysis to overall PA may be oversimplistic, as decreases in a single subcomponent of PA may be compensated for by increases in another subcomponent.

Evidence from systematic reviews supports a dose-response relationship between PA and premature mortality and the primary/secondary prevention of several chronic conditions.²² Relationships are generally curvilinear, with significant health benefits observed with relatively small increases in activity; and importantly, the greatest relative health benefits are observed among those transitioning from inactivity to any level of PA.²² Similar findings were reported in an analysis of pooled data from 6 large international

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cohort studies.²³ Compared with inactive adults, those who were active below recommended amounts had a 20% lower mortality risk whereas adults who met PA guidelines had a 31% lower risk.

The significant health benefits of moving from an inactive to an active state²² and the importance of walking for inactive individuals during this transition raises 2 issues. First, the trends in transitioning from inactive to active states have been comparatively less researched. Second, the focus on sufficient PA trends may overlook changes in the PA subcomponent durations.

This paper aimed to address these issues by (1) using hurdle models, which simultaneously model binomial outcomes (active/inactive) and continuous outcomes (minutes of PA) and (2) investigating the trends and factors associated with overall PA, as well as its primary subcomponents (total walking, walking place to place, and vigorous PA). Multivariable trend analysis focuses on identifying instances where trends differed by population subgroups.

Methods

The current study is based on responses from repeated, independent cross-sectional preventive health surveys conducted by the Queensland Government Department of Health using computer-assisted telephone interviews (CATI) in 2002, 2004, 2006, and annually since 2008. From 2002 to 2014, the sampling frame was random-digit dialing of residential landline numbers; from 2015 onwards, it has been a near-complete Queensland list-based frame of both landline and mobile numbers. Adults aged 18 years and older from residential households who speak English sufficiently well for telephone interviewing are eligible. Less populous areas are oversampled, and survey weights adjust for survey sampling design and apply population benchmarks from the most recent estimated resident population.²⁴ The detailed methodology is available on the Queensland Health website.^{25,26} The surveys received Human Research Ethics Committee (approval number HREC/15/QWMS/6) ethics approval.

Outcome Variables

Since 2004, survey participants aged 18–75 years have been asked the core Active Australia (AA) questions²⁷ ([Supplementary Material](#) [available online]), and 2 additional questions specifying how much of “total walking time” was spent walking “from place to place.” The questions have been used without change since 2004.

Minutes of activity in the past week were calculated for (1) total walking time, (2) moderate PA, (3) vigorous PA, (4) total PA (sum of measures 1–3), and (5) place-to-place walking. Only the participants who provided valid responses for measures 1 to 3 were included in the calculations. As recommended in the AA manual, a maximum of 840 minutes per week per activity type was applied, and moderate PA was included in the total PA but not analyzed separately.²⁷ Inactivity was defined as zero minutes of activity in the past week.

Covariates

The following sociodemographic characteristics were available: sex (men and women), age group (18–29, 30–44, 45–64, and 65–75 y), employment status (employed, unemployed, and not in the work force), highest educational attainment (still studying/no postschool qualification, bachelor degree or higher, trade certificate, and diploma/nontrade certificate), marital status (married/de facto relationship, separated/divorced/widowed, and never married), socioeconomic indexes for areas: index of relative socioeconomic

disadvantage (prior to 2008) and index of relative socioeconomic advantage and disadvantage (2008 onward) (quintile 1, most disadvantaged to quintile 5, most advantaged),²⁸ and accessibility/remoteness index of Australia (major cities, inner regional, outer regional, and remote/very remote).²⁹ Socioeconomic indexes for areas and accessibility/remoteness index of Australia are calculated after each 5-yearly census, with each survey year including the most current available index. The following behavioral risk factors were available: body mass index based on self-reported height and weight and categorized according to World Health Organization criteria (<18.5 kg/m², underweight; 18.5 to <25 kg/m², healthy weight; 25 to <30 kg/m², overweight; and ≥30 kg/m², obese)³⁰ and smoking status (daily smokers and adults who are not daily smokers).

Statistical Methods

All analyses were conducted in Stata 15.³¹ The mean minutes of PA in the past week and 95% confidence intervals (CIs) were calculated for the total population and for each sociodemographic and behavioral risk factor subgroup, including the participants who reported zero minutes of PA.

Distributions of PA time in the general population are typically strongly right skewed, with a large proportion of zero values; for example, one Australian study reported 15% zero values.⁹ Outcomes with such distributions can be considered to have 2 components—a discrete arm (zero vs nonzero) and a continuous arm (positive values). Hurdle regression is a 2-part modeling technique that combines a binary model for the probability of observing a zero-versus-nonzero outcome and an appropriate regression model for the positive values. Separate independent covariates can be modeled in each arm.^{32,33} Hurdle regression allows for an overall estimation of the marginal effects of covariates. Coefficients from each arm are used to establish the direction and statistical significance of an effect but are not directly interpretable.

Population-weighted hurdle regression was used to model the trends in PA time, using probit regression to model zero-versus-nonzero outcomes and log-linear regression to model outcomes with positive values, which were approximately normally distributed after natural log transformation. Complete-case analysis was used. The average marginal effects of the survey year on PA time were estimated using the Stata “margins” command.³³ Poisson regression was used to quantify change in the proportion of inactive adults.

Unadjusted Analysis. Unadjusted trends in PA time are presented as the average annual change in weekly minutes of activity, 95% CIs, and Wald *P* values for the total population, and then they are stratified by sociodemographic characteristics and behavioral risk factors, as outlined in the covariates section. The trends were positive if the activity time was increasing and negative if it was decreasing. Evidence of the difference in trends between subgroups (such as men vs women) was examined using Wald tests.

Adjusted Analysis. Multivariable models were then built for each outcome using the process below. Interactions with the survey year were tested to identify subgroups that were changing at different rates.

All variables used in the unadjusted analyses were included. The interaction terms between each variable and survey year and between the sex and age group were sequentially added to both arms of the model and were retained if *P* < .05 (Wald) and McFadden pseudo *R*² (a logical analog of the percentage of the response variable variation which is explained by the model) increased by at least 1%. Interactions with the survey year were then tested in each

arm separately and removed from that arm unless $P < .05$ and the pseudo R^2 difference was at least .5%. These criteria were selected to avoid overparameterizing the model. The results are presented as the average annual change in the weekly minutes of activity for the total population and by selected subgroups.

Significant changes in PA over time were further examined to determine whether they were due to changes in the proportion who were inactive (significant coefficient in the probit model), the amount of PA among active adults (significant coefficient in the log-linear model), or both.

Sensitivity Analysis. The activity times were lower in 2004 and 2006 than in subsequent years; therefore, adjusted models were used to examine whether significant trends remained when these years were excluded.

Results

Descriptive

Since 2004, the survey size has varied, with, on average, 1764 participants from 2004 to 2008 and 10,188 participants from 2009 to 2018, for a total of 107,171 participants aged 18–75 years across the study period. The average survey response rate was 67% (range 44%–81%). The activity time was missing for 5431 (5.1%) observations. The characteristics of the population, number of participants with available and missing data, mean minutes of activity in 2004 and 2018 for the total population, and by sociodemographic characteristics and behavioral risk factors, are available in the Supplementary Materials ([Supplementary Tables 1–5](#) [available online]) but are not discussed in the text to maintain a focus on trend analyses.

Unadjusted Analysis

On average, the unadjusted total PA increased by 10 minutes per week per year (95% CI, 8.8–11.1) for the total population (Table 1). All subgroups other than unemployed adults experienced a statistically significant increase in total PA (Table 1). Increases for the total population and most subgroups were also seen for total walking (Table 1), vigorous PA (Table 2), and place-to-place walking (Table 2).

In 2004, 19.4% of the population (95% CI, 17.6–21.2) reported no PA; this decreased by 4.2% (95% CI, 3.5%–4.9%) per year to 9.5% (95% CI, 8.7%–10.4%) in 2018. There was evidence, however, for nonlinearity of the association ($P < .001$), with a larger decrease between 2004 and 2008 (12.7%/y; 95% CI, 8.6%–16.6%) than between 2008 and 2018 (2.4%/y; 95% CI, 1.5%–3.4%).

Adjusted Analysis

An interaction term between survey year and employment, indicating a substantial difference in trends by employment, was included in all models except vigorous PA. The adjusted trend results for each outcome are presented for the total population and by employment, where appropriate (Table 3). Education level and marital status by year interactions are included in the relevant models but are not shown in the tables because the contribution to overall model fit was minor relative to employment status.

Adjusted total PA time increased on average by 10.5 minutes per week per year (95% CI, 9.4–11.7). Trends differed by employment, with total PA time increasing by 14.3 minutes per week per year (95% CI, 12.8–15.8) for employed adults, 2.2 minutes per

week per year (95% CI, 0.4–4.0) for adults who were not in the work force, and no evidence of change for unemployed adults (3.6 min/wk/y; 95% CI, –3.0 to 10.2). A low prevalence of unemployed adults leading to low precision of the estimate contributed to the latter finding. Total and place-to-place walking time increased on average by 7.2 and 5.3 minutes per week per year, respectively. Trends varied only by employment, and the pattern of variation by employment was similar to that observed for total PA. A small but significant increase was evident for vigorous PA; however, there were no differences among subgroups.

Least squares regression of the average adjusted predictions of (1) total PA time, (2) total walking time, (3) vigorous PA time, and (4) place-to-place walking time (in minutes per week) on the survey year are presented for the total population and by employment (Figure 1).

For each outcome, there was both a significant increase in the proportion of people doing any activity ($P < .001$ for the survey year coefficient in the probit models) and a significant increase in the average amount of activity done by active adults ($P < .001$ for the survey year coefficient in log-linear models).

Sensitivity Analysis

Total Population. When the data from 2004 to 2006 were excluded, the adjusted trends for increased activity time remained significant for the total population for all activity types but increased at a slower rate—the total PA increased by 7.4 minutes per week per year (95% CI, 5.9–9.0), whereas total walking, vigorous PA, and place-to-place walking times increased by 5.8 (95% CI, 4.9–6.8), 1.6 (95% CI, 0.9–2.3), and 3.9 minutes per week per year (95% CI, 3.2–4.6), respectively.

By Employment. As observed from the total population, excluding the data from 2004 to 2006 reduced the rate of increase in total PA, walking, and walking place-to-place for employed adults. For total PA, the interaction term between the survey year and employment remained in the log-linear arm but not the probit arm of the model, potentially indicating that differences by employment in the proportion transitioning from inactive to active states occurred prior to 2008. For place-to-place walking, it remained in the probit arm but not in the log-linear arm. For total PA, increases of 9.2 minutes per week per year were observed in both employed (95% CI, 7.2–11.2) and unemployed adults (95% CI, 1.6–16.8), whereas the increase for those who are not in the workforce was not substantially changed.

Discussion

Between 2004 and 2018, the amount of total PA for adults increased on average by 10.5 minutes per week per year in Queensland. Increases were observed for total walking, place-to-place walking, and vigorous PA (on average 7.2, 5.3, and 2.4 min/wk/y, respectively). In most cases, increases were observed for all population subgroups. However, there were differences by employment, with employed adults experiencing greater gains in overall PA time and walking (total and place-to-place) than adults not in the labor force, whereas no gains were evident for unemployed adults. Increases in PA time came from a combination of reduced prevalence of inactivity and increased activity among those already active.

Several limitations of this study are acknowledged. Self-reported PA levels are only modestly correlated with objective measures such as accelerometers, and self-report can either underestimate or overestimate directly measured PA.³⁴ However, the capacity to use objective data collection in large population

Table 1 Unadjusted Trends in Self-Reported Total Physical Activity and Total Walking From 2004–2018 for Adult Participants (18–75 y) of the Queensland Preventive Health Survey, for Persons and Stratified by Sociodemographic Characteristics and Behavioral Risk Factors

	Total physical activity				Total walking			
	Min/wk		P value ^a	P value ^b	Min/wk		P value ^a	P value ^b
	Annual change	95% CI			Annual change	95% CI		
Persons	10.0	8.8 to 11.1	<.001		6.8	6.2 to 7.5	<.001	
Sex								
Men	11.7	9.7 to 13.6	<.001	.005	9.0	8.0 to 10.1	<.001	<.001
Women	8.3	6.9 to 9.6	<.001		4.8	4.0 to 5.6	<.001	
Age group, y								
18–29	13.3	9.7 to 16.9	<.001	<.001	9.1	7.2 to 11.0	<.001	<.001
30–44	11.4	9.5 to 13.2	<.001		6.8	5.8 to 7.9	<.001	
45–64	9.9	8.2 to 11.5	<.001		6.7	5.7 to 7.6	<.001	
65–75	3.7	1.4 to 5.9	.001		3.5	2.1 to 4.8	<.001	
Socioeconomic status ^c				.26				.05
Most disadvantaged	10.9	8.5 to 13.3	<.001		8.1	6.7 to 9.6	<.001	
Quintile 2	11.2	8.9 to 13.5	<.001		7.9	6.5 to 9.3	<.001	
Quintile 3	10.5	7.9 to 13.1	<.001		6.6	5.1 to 8.0	<.001	
Quintile 4	7.6	5.0 to 10.2	<.001		5.4	3.9 to 6.8	<.001	
Most advantaged	9.2	6.5 to 12.0	<.001		6.4	4.8 to 7.9	<.001	
Remoteness ^d				.57				.94
Major cities	9.8	8.3 to 11.4	<.001		6.7	5.8 to 7.6	<.001	
Inner regional	8.9	6.7 to 11.1	<.001		6.6	5.3 to 7.9	<.001	
Outer regional	11.2	8.5 to 13.9	<.001		7.2	5.6 to 8.8	<.001	
Remote/very remote	8.4	3.2 to 13.6	.002		7.1	4.4 to 9.7	<.001	
Employment status				<.001				<.001
Employed	14.4	12.8 to 15.9	<.001		9.2	8.3 to 10.0	<.001	
Unemployed	5.4	–1.2 to 12.0	.11		4.1	0.6 to 7.6	.02	
Not in work force	2.2	0.5 to 3.9	.01		2.5	1.4 to 3.5	<.001	
Education level				<.001				<.001
No postschool qualification	9.7	7.7 to 11.7	<.001		7.4	6.2 to 8.6	<.001	
Bachelor's degree or higher	7.4	5.2 to 9.5	<.001		4.4	3.2 to 5.6	<.001	
Trade certificate	15.4	12.3 to 18.6	<.001		10.5	8.7 to 12.3	<.001	
Diploma/nontrade certificate	8.5	6.2 to 10.9	<.001		6.5	5.2 to 7.9	<.001	
Marital status				.02				.001
Married/de facto	10.5	9.2–11.7	<.001		6.4	5.7 to 7.2	<.001	
Separated/divorced/widowed	6.3	3.7–8.9	<.001		4.5	2.9 to 6.1	<.001	
Never married	10.3	6.7–14.0	<.001		9.4	7.5 to 11.3	<.001	
Smoking status				.04				.002
Daily smoker	13.0	9.7 to 16.4	<.001		10.0	7.8 to 12.1	<.001	

(continued)

Table 1 (continued)

	Total physical activity				Total walking			
	Min/wk		P value ^a	P value ^b	Min/wk		P value ^a	P value ^b
	Annual change	95% CI			Annual change	95% CI		
Not a daily smoker	9.3	8.1 to 10.6	<.001		6.4	5.7 to 7.1	<.001	
BMI category ^c				.02				.02
Underweight	10.6	3.4 to 17.8	.004		5.9	1.6 to 10.2	.007	
Healthy weight	11.3	9.3 to 13.3	<.001		7.6	6.4 to 8.7	<.001	
Overweight	11.6	9.6 to 13.5	<.001		7.8	6.6 to 8.9	<.001	
Obese	7.5	5.6 to 9.5	<.001		5.3	4.1 to 6.5	<.001	

Abbreviations: BMI, body mass index; CI, confidence interval. Note: Analysis method: estimated average marginal effects using hurdle regression with a probit model for zero-versus-nonzero values and a log-linear model for positive values. Each model includes survey year, the covariate (eg, sex) and an interaction term between survey year and the covariate.

^aWald test for a change over time (trend) for each subgroup (eg, men). ^bWald test for a difference in the trend between subgroups (eg, men vs women). ^cSocioeconomic indexes for areas: index of relative socioeconomic disadvantage (prior to 2008) or index of relative socioeconomic advantage and disadvantage (2008 onward). ^dAccessibility/remoteness index of Australia. ^eCategorized according to World Health Organization criteria: <18.5 kg/m² = underweight, 18.5 to <25 kg/m² = healthy weight, 25 to <30 kg/m² = overweight, and ≥30 kg/m² = obese.

Table 2 Unadjusted Trends in Self-Reported Vigorous PA and Place-to-Place Walking From 2004–2018 for Adult Participants (18–75 y) of the Queensland Preventive Health Survey, for Persons and Stratified by Sociodemographic Characteristics and Behavioral Risk Factors

	Vigorous physical activity				Place-to-place walking			
	Min/wk		P value ^a	P value ^b	Min/wk		P value ^a	P value ^b
	Annual change	95% CI			Annual change	95% CI		
Persons	2.4	1.9–3.0	<.001		4.6	4.2–5.1	<.001	
Sex				.75				<.001
Men	2.5	1.6–3.4	<.001		6.3	5.5–7.1	<.001	
Women	2.3	1.7–2.9	<.001		3.2	2.6–3.7	<.001	
Age group, y				.35				<.001
18–29	2.8	1.1–4.5	.001		5.3	3.8–6.7	<.001	
30–44	2.7	1.9–3.6	<.001		5.2	4.4–6.0	<.001	
45–64	2.7	2.1–3.4	<.001		4.9	4.2–5.5	<.001	
65–75	1.9	1.2–2.7	<.001		2.4	1.6–3.2	<.001	
Socioeconomic status ^c				.39				.003
Most disadvantaged	3.0	2.0–4.1	<.001		5.8	4.7–6.8	<.001	
Quintile 2	2.4	1.4–3.4	<.001		5.9	4.9–7.0	<.001	
Quintile 3	2.9	1.6–4.2	<.001		4.1	3.0–5.2	<.001	
Quintile 4	2.1	0.8–3.3	.001		3.4	2.4–4.4	<.001	
Most advantaged	1.4	0.1–2.8	.04		4.3	3.2–5.5	<.001	.65
Remoteness ^d				.09				
Major cities	2.4	1.6–3.2	<.001		4.5	3.8–5.1	<.001	
Inner regional	1.7	0.8–2.7	<.001		4.8	3.9–5.8	<.001	
Outer regional	3.3	2.1–4.5	<.001		4.6	3.5–5.7	<.001	
Remote/very remote	0.4	–2.2 to 3.0	.76		5.9	3.6–8.3	<.001	
Employment status				<.001				<.001
Employed	3.3	2.6–4.0	<.001		6.1	5.4–6.7	<.001	
Unemployed	0.6	–2.9 to 4.2	.72		1.9	–0.5 to 4.4	.12	
Not in work force	0.7	–0.1 to 1.6	.10		2.2	1.4–2.9	<.001	
Education level				.12				<.001
No postschool qualification	1.4	0.4–2.3	.006		4.7	3.8–5.7	<.001	
Bachelor's degree or higher	1.8	0.8–2.9	.001		3.3	2.5–4.1	<.001	
Trade certificate	3.2	1.8–4.6	<.001		9.0	7.5–10.5	<.001	
Diploma/nontrade certificate	2.7	1.6–3.7	<.001		4.6	3.6–5.5	.001	.14
Marital status				.001				
Married/de facto	3.2	2.7–3.7	<.001		4.6	4.0–5.1	<.001	
Separated/divorced/widowed	1.4	0.3–2.6	.01		3.6	2.5–4.7	<.001	
Never married	0.4	–1.4 to 2.2	.66		5.4	4.0–6.9	<.001	
Smoking status				.40				.10
Daily smoker	2.9	1.4–4.4	<.001		6.2	4.4–7.9	<.001	

(continued)

Table 2 (continued)

	Vigorous physical activity				Place-to-place walking			
	Min/wk		P value ^a	P value ^b	Min/wk		P value ^a	P value ^b
	Annual change	95% CI			Annual change	95% CI		
Not a daily smoker	2.2	1.6–2.8	<.001		4.7	4.2–5.2	<.001	
BMI category ^e				.57				.004
Underweight	2.9	–0.3 to 6.1	.08		2.7	–0.5 to 6.0	.10	
Healthy weight	2.4	1.5–3.4	<.001		4.5	3.7–5.4	<.001	
Overweight	3.1	2.2–4.0	<.001		5.9	5.1–6.7	<.001	
Obese	2.2	1.3–3.1	<.001		3.9	3.1–4.8	<.001	

Abbreviations: BMI, body mass index; CI, confidence interval. Note: Analysis method: estimated average marginal effects using hurdle regression with a probit model for zero-versus-nonzero values and a log-linear model for positive values. Each model includes survey year, the covariate (eg, sex) and an interaction term between survey year and the covariate.

^aWald test for a change over time (trend) for each subgroup (eg, men). ^bWald test for a difference in the trend between subgroups (eg, men vs women). ^cSocioeconomic indexes for areas: index of relative socioeconomic disadvantage (prior to 2008) or index of relative socioeconomic advantage and disadvantage (2008 onward). ^dAccessibility/remoteness index of Australia. ^eCategorized according to World Health Organization criteria: <18.5 kg/m² = underweight, 18.5 to <25 kg/m² = healthy weight, 25 to <30 kg/m² = overweight, and ≥30 kg/m² = obese.

Table 3 Adjusted Trends in Self-Reported Total PA, Total Walking, Vigorous PA and Place-To-Place Walking From 2004–2018 for Adult Participants (18–75 y) of the Queensland Preventive Health Survey, for Persons and Stratified by Employment Status (Except for Vigorous PA)

	Total PA			Total walking			Vigorous PA			Place-to-place walking		
	Min/wk			Min/wk			Min/wk			Min/wk		
	Annual change	95% CI	P value ^a	Annual change	95% CI	P value ^a	Annual change	95% CI	P value ^a	Annual change	95% CI	P value ^a
Persons	10.5	9.4–11.7	<.001	7.2	6.5–7.9	<.001	2.4	1.8–2.9	<.001	5.3	4.8–5.8	<.001
Employment status												
Employed	14.3	12.8–15.8	<.001	9.6	8.7–10.5	<.001				6.6	6.0–7.3	<.001
Unemployed	3.6	–3.0 to 10.2	.29	2.5	–1.4 to 6.3	.21				1.8	–0.6 to 4.1	.14
Not in work force	2.2	0.4–4.0	.02	2.4	1.3–3.5	<.001				2.6	1.8–3.4	<.001

Abbreviations: ARIA+, accessibility/remoteness index of Australia; CI, confidence interval; PA, physical activity; SEIFA, Socioeconomic indexes for areas. Note: Analysis method: estimated average marginal effects using hurdle regression with a probit model for zero-versus-nonzero values and log-linear model for positive values. Adjusted for sex, age group, sex × age group (total PA), smoking status, body mass index category, SEIFA quintiles, ARIA+, employment, employment × year (all except vigorous PA), education level, education level × year (total and place-to-place walking), marital status, marital status × year (total walking). Persons level estimates are applicable to all examined subgroups except where explicitly indicated otherwise in the table.

^aWald test for a change over time (trend) for each subgroup (eg, employed).

Figure 1 — Least squares regression of the average adjusted predictions of (1) total PA time, (2) total walking time, (3) vigorous PA time, and (4) place-to-place walking time (in minutes per week) on survey year for the total population and by employment status. Predictions obtained using multivariable hurdle regression with a probit model for zero-versus-nonzero values and log-linear model for positive values. Adjusted for sex, age group, sex $\times$ age group (total PA), smoking status, body mass index category, SEIFA quintiles, ARIA+, employment, employment $\times$ year (all except vigorous PA), education level, education level $\times$ year (total and place-to-place walking), marital status, and marital status $\times$ year (total walking). ARIA+ indicates accessibility/remoteness index of Australia; PA, physical activity; SEIFA, socioeconomic indexes for areas.

studies is limited.³⁵ In the context of the current trend analyses, self-reported data would bias the findings if the magnitude of underestimating or overestimating PA changed over time or changed disproportionately across subgroups. This is considered unlikely due to consistent data collection methodology. Despite this consistency, the results for the activity times for all outcomes were lower for 2004 and 2006 compared with later years. The sensitivity analysis showed a reduced rate of change of weekly PA duration when these years were excluded; therefore, their inclusion may overestimate the increase in average weekly PA time between 2008 and 2018.

A key strength of this study was the use of hurdle regression,³² an analytical approach that combines increases in PA duration and increases in the proportion of active adults in a single metric. Methods that can be used to model PA data, which are often right skewed with a large number of observations of zero activity time, include hurdle regression and zero-inflated regression (usually Poisson or negative binomial).^{36,37} Zero-inflated models are especially useful for rare events where some observations of zero (events) will be structural,

meaning that it was impossible for the event to occur, and some observations of zero are due to sampling variation, where an event was possible but did not occur in the sample. In zero-inflated regression, observations of zero are modeled as coming from both of these sources (sampling distribution and excess zeros). Conversely, hurdle regression assumes that all observations of zero are structural, so observations with zero activity time are modeled separately from observations with any activity time. Hurdle regression assumptions are appropriate when modeling PA, as it is reasonable to consider that people reporting zero PA in the past week are inactive. Hurdle regression also provides more interpretable results in this context since changes in the “prevalence of persons doing any PA” and changes in the “average duration of PA for active persons” can be considered separately as well as together.

Other strengths of this study are the large sample size, especially from 2008 onwards, and the consistency of the surveillance system methodology and PA questions. Because self-reported PA is sensitive to differences in question format,³⁸ it is important that established surveillance systems maintain existing PA data collection protocols

and comparability with historical trends to identify any gains in PA. The inclusion of mobile phones from 2015 has been shown to have no impact on the population-level PA trends³⁹ despite differences in behavioral risk factor profiles between households that are mobile only and those with both mobiles and landlines.

The current study found that the largest gains in PA involved walking. The US Surgeon General has identified walking as a common and easily adopted form of activity,⁴⁰ and it is the most common PA in Australia, with 41% of adults aged 18–64 years and 62% of adults aged 65 years and older participating in recreational walking in 2016–2017.⁴¹ Walking was the only form of PA for 19% of older Australians in 2014–2015.⁴¹ In the United States, it was the most commonly reported leisure-time PA undertaken in the past month (47% reported).¹⁵ There are numerous national and international initiatives to increase walking, including a recently launched statewide Queensland Walking Strategy.⁴² The current study informs such initiatives by highlighting the importance of supporting walking among inactive or less active subgroups.

That increases were higher among employed adults is not surprising. Although associations between unemployment and poor physical health are well established,^{43,44} it is unclear whether unemployment is a cause or consequence of poor health.^{45,46} Addressing slower gains in PA among those not in the workforce is challenging but may be partially addressed through broad population strategies to promote walking.

The findings of this study confirm the results of earlier studies reporting increased PA.^{8,9,19} Increases were observed among most population subgroups. It is likely that public health strategies have contributed to these gains, especially for low-intensity activities and among inactive adults. These results also demonstrate that focusing on the prevalence of sufficient PA may overlook more modest gains. From a public health perspective, given the evidence that the largest health benefits are observed among the least active adults, such increases are particularly important.

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