Trends in prevalence of leisure time physical activity and inactivity: results from Australian National Health Surveys 1989 to 2011

Josephine Chau,[1] Tien Chey,[1] Sarah Burks-Young,[1] Lina Engelen,[1] Adrian Bauman[1]

Regular physical activity plays a major role in maintaining good physical and mental health and in the prevention of non-communicable diseases.[1] In 2011, physical inactivity was the fourth highest contributor (5.0%) to total burden of disease and injury in Australia;[2] 6.4 % of cancers, 21.2 % of cardiovascular diseases and 29.7% of endocrine diseases were attributable to physical inactivity. Globally, it is estimated that physical inactivity causes 9% of premature mortality and cost healthcare systems Int'l$53·8 billion in 2013.[3,4]

In Australia, there have been calls for a coherent national action plan for tackling the problem of inactivity with an emphasis on multi-sectoral collaboration and investment in creating physical activity opportunities and monitoring population engagement.[5,6] Population surveillance of physical activity is essential to inform public health planning and programs, as well as to determine the effects of these efforts over time.[7]

To facilitate comparisons of physical activity data over time, identical measurement methods and instruments need to be implemented using a standardised monitoring system. Historically, physical activity monitoring in Australia has focused on exercise participation and leisure time activity.[7] The Australian Bureau of Statistics (ABS) began measuring leisure time exercise and walking participation in the National Health Survey in 1989/90 and has since used consistent leisure time physical activity and questions survey methods in subsequent surveys.[8-13] This paper presents 22-year trends in leisure time physical

Abstract

Objective: To examine trends in leisure time physical activity and inactivity in Australians aged 15 years or older from 1989 to 2011.

Method: We used data from six Australian National Health Surveys conducted from 1989/90 to 2011/12 in which physical activity was assessed using comparable questions. Analyses examined trends in the prevalence of sufficient physical activity (≥150 minutes/week moderate-to-vigorous physical activity) and of inactivity (<30 minutes/week moderate-to-vigorous physical activity).

Results: The proportion of sufficiently active adults was 39.2% in 1989 and 40.7% in 2011 with an overall declining trend of 0.2% per year (*p*=0.012). The prevalence of inactivity was 38.7% in 1989 and 37.3% in 2011; the overall time trend by year was stable (OR=0.999, *p*=0.242). In women, sufficient physical activity decreased by 0.3% per year from 35.5% in 1989 (*p*=0.025); inactivity increased from 39.5% by 0.3% per year (*p*=0.004). In men, sufficient physical activity prevalence was 43.1% in 1989 with a steady trend; inactivity decreased from 37.9% by 0.5% per year (*p*<0.0001).

Conclusions: The prevalence of sufficient physical activity remains low and inactivity high. Women appear to be a key target group for intervention. Public health efforts have been ineffective over two decades for improving physical activity among Australian adults.

Implications for public health: This research supports calls for a national physical activity action plan given the multitude of benefits from sufficient physical activity. Maintenance of consistent physical activity questions in future National Health Surveys will facilitate long term tracking of physical activity levels in the Australian population.

Key words: physical activity, surveillance, prevalence

activity in Australians involving six time points spanning 1989 to 2011.

Methods

Subjects and sampling

The Australian National Health Survey (NHS) is designed to obtain representative and national benchmark information on a range of health-related issues and to monitor trends over time. The NHS began measuring exercise and physical activity in 1989/1990 and in subsequent surveys conducted in 1995, 2001, 2004/2005, 2007/2008 and 2011/2012. In this paper, we refer to surveys conducted over two years by the year in which the survey started (i.e. 1989, 2004, 2007 and 2011).

The NHS used a stratified multistage area sample design and each survey consisted of nationally representative samples of the Australian population from randomly selected private dwellings in urban and rural areas of all states and territories. Trained interviewers conducted face-to-face interviews with

one person aged 15 years or over in each household. In surveys from 2007 onwards, interviewers collected responses using a computer-assisted instrument. Exclusions included: residents of non-private dwellings; households with members of non-Australian defence forces stationed in Australia; households with diplomatic personnel of overseas governments. Survey response rates for fully and adequately responding households were 96.0% in 1989, 91.5% in 1995, 89.0% in 2001, 89.4% in 2004, 90.6% in 2007 and 84.8% in 2011 (8-13). Access to NHS data was obtained through the Australian Bureau of Statistics Confidential Unit Record Files and Remote Access Data Laboratory (permissions granted to authors 1 and 2).

Physical activity measure

Respondents were asked about their leisure time physical activity with items about frequency and duration of walking, moderate and vigorous intensity physical activity (see Supplementary Table S1 for exact wording of questions asked each survey year). Minor variations across surveys included: the 2011 survey used a 'last week' recall time frame while previous surveys used a 'last two weeks' recall period; a lower limit for walking duration of 10 minutes was used in 2011. The 'last two weeks' time frame was divided by two to allow comparisons with the 2011 survey.[14]

Other measures

Respondents provided information about their gender, age, main language spoken at home (English, other), marital status (married, de facto, divorced, widowed, never married), highest post-school education level (degree or above, trade/diploma, no post-school qualification), household income, self-rated health (excellent, very good, good, fair, poor), and smoking status (current smoker, ex-smoker, never smoker). Respondents self-reported their height and weight in all surveys prior to 2011. In the 2011 survey, the interviewers used digital scales to measure respondents' weight and a stadiometer to measure their height. Body mass index (BMI) was calculated as weight/height^2 (kg/m^2).

Analyses

Analyses used SAS software Version 9.3 (SAS Institute Inc., Cary NC, USA). We used weighting factors for each record that were provided by the ABS to reflect population demographics at the time of each survey and to account for the probability of being sampled as well as differential response rates across the population at each survey. Replicate weights were available for surveys in 2004, 2007 and 2011. We computed descriptive statistics using normalised weights with age (5-year groupings) and gender distributions standardised to that of the 2011 survey.

Being 'sufficiently active' was the primary outcome. We defined this as total physical activity ≥150 mins/week including walking, and with vigorous-intensity activity weighted by 2. A secondary outcome was being 'inactive', defined as total physical activity <30 mins/week. Descriptive statistics were tabulated by social-demographic factors and health behaviours.

We examined the probability of being sufficiently active and inactive using simple and multiple logistics regression models adjusting for social-demographics and health related behaviour factors. Significant variables for adjustment were: gender, age, marital status, education level, household income, main language spoken at home, smoking status, self-rated health, and BMI.

Analyses were carried out for each survey and trend analysis over the six surveys. Data from the six surveys were combined with an indicator variable for the year of survey and a continuous 'year' variable for linear trend analysis. Results are presented as percentage prevalences and odds ratios with 95% confidence limits.

Results

Characteristics of the population samples

Across the six surveys, greater proportions of people declined to state their household income (6.5% to 21.3%) and did not provide height and/or weight information (3.9% to 16.4%). Proportions of people categorised as married (64% to 56.5%) and current smokers (26.0% to 17.6%) decreased, and those reporting having poor health remained similar (4.0% to 4.9%). Please see Supplementary Table S2 for more details.

The proportional distribution of main language spoken at home was similar across surveys, while that for post-school qualifications varied due to changes in this demographic measure used in surveys years 1989, 1995 and 2001; the same education measure was used from 2004 onwards. Across survey years 2004, 2007 and 2011, about one-third of respondents had a trade or diploma as the highest level of post-school qualification and the proportion of those with tertiary education increased (16.7% to 23.2%).

Prevalence of sufficient physical activity and inactivity, 1989 to 2011

Across the six survey years, we observed a stable prevalence of sufficient physical activity (Table 1); 39.2% in 1989 and 40.7% in 2011. The test for trend across the surveys was not significant. The proportion of men who met physical activity recommendations was greater than in women and levels were stable over the 22-year period.

The prevalence of inactive adults was stable across the six surveys overall (35-40%) (Table 2). When stratified by gender, a significant decline in prevalence of inactivity was apparent in men and less so in women (Chi-square test for trend = 10.37, p<0.001 in men; Chi-square test for trend = 3.88, p=0.049 in women)

Factors associated with sufficient physical activity and inactivity

Patterns of correlates of being sufficiently active were similar in men and women, although men had 35% higher odds of meeting guidelines than women. The odds of being sufficiently active decreased with increasing age group relative to the 15-34 years age group, except for women aged 55-74 years old who were 15% more likely to be sufficiently active. Men and women who spoke English at home, had a degree or higher education level, in the highest income tertile, reported being in excellent or good health, or were ex-smokers or had smoking information missing were more likely to be sufficiently active than those who spoke another language at home, with less than university level education, in the lowest income tertile, had good, fair or poor self-reported health, or were current smokers, respectively. Men and women categorized as 'married', in the second household income tertile, classified as underweight, overweight or obese, or were current smokers had significantly lower odds of being sufficiently active than those categorized as 'not married, in the lowest income tertile, had normal BMI, or 'never' smokers, respectively.

Odds of being inactive increased with increasing age; men and women aged 75 years or more were respectively 2 and

Table 1: Proportion of adults achieving sufficient levels of physical activity (≥150 minutes/week moderate-to-vigorous physical activity) by socio-demographic characteristics, Australian National Health Surveys 1989/90 to 2011/12.

Year of Survey	Sufficiently active (≥150 min/week moderate-to-vigorous physical activity)[a]											
	1989		1995		2001		2004		2007		2011	
	n	%	n	%	n	%	n	%	n	%	n	%
STD Weighted N age≥15 years (%)[b]	16,621	39.2	16,778	39.7	8,645	40.7	8,234	40.0	6,116	36.6	6,729	40.7
Gender												
Female	7,611	35.5	7,694	36.0	3,964	36.9	3,858	37.1	2,820	33.3	3,028	36.2
Male	9,010	43.1	9,085	43.5	4,680	44.6	4,375	42.9	3,296	39.9	3,701	45.3
Age groups												
15-24	3,696	51.3	3,557	49.5	1,809	50.1	1,589	45.1	1,279	45.0	1,361	48.4
25-34	3,040	40.1	3,059	40.4	1,658	43.5	1,562	42.0	1,113	37.2	1,344	45.4
35-44	2,591	34.9	2,646	35.7	1,356	36.4	1,367	37.6	1,022	34.9	1,172	40.4
45-54	2,423	33.9	2,615	36.6	1,368	38.1	1,329	37.9	973	34.4	1,108	39.6
55-64	2,313	38.1	2,436	40.2	1,222	40.1	1,234	41.5	860	35.9	894	37.7
65-74	1,682	42.3	1,601	40.3	814	40.8	844	43.3	607	38.7	584	37.6
≥75	875	29.8	864	29.5	417	28.3	308	24.0	263	22.7	266	23.2
Main language spoken at home												
Missing	-	-	-	-	576	54.0	538	51.4	-	-	-	-
Other	1,151	26.5	1,030	27.9	1,090	33.8	538	28.7	422	24.6	562	31.4
English	15,469	40.7	15,748	40.8	6,978	41.1	7,158	40.5	5,694	38.0	6,167	41.8
Marital status[c]												
Married	9,776	36.1	9,596	36.8	4,757	37.7	4,412	38.2	3,158	34.6	3,643	39.0
Not married	6,845	44.9	7,183	44.3	3,888	45.0	3,821	42.2	2,959	39.0	3,086	42.9
Post school qualifications												
N/A	1,028	58.0	8,940	41.0	576	54.0	481	52.2	-	-	-	-
Degree or above	7,295	41.9	1,128	47.3	1,558	50.7	1,782	51.7	1,474	46.1	2,004	52.3
Trade/Diploma	8,298	35.8	2,626	40.4	2,975	40.5	2,726	39.6	1,738	34.5	2,264	40.4
No post school Qual	-	-	4,084	35.2	3,535	36.2	3,245	34.7	2,904	34.2	2,461	34.7
Equivalent household income quintile												
1 Low	2,443	39.2	2,794	39.1	1,537	39.5	1,388	41.5	700	30.0	596	28.9
2	3,154	37.3	2,677	36.1	1,292	38.0	979	40.2	878	30.1	772	32.1
3	2,920	38.4	2,571	38.2	1,220	39.9	925	39.0	991	32.2	1,047	37.5
4	3,137	38.7	2,772	40.3	1,115	38.9	959	39.4	1,182	39.5	1,242	42.2
5 High	3,887	42.3	3,466	45.3	1,421	47.3	1,059	38.4	1,451	49.2	1,537	54.9
Not stated	1,081	39.1	2,497	38.6	2,060	40.9	2,924	40.4	915	37.3	1,535	43.6
N/A	2,443	39.2	2,794	39.1	1,537	39.5	1,388	41.5	700	30.0	596	28.9
Self-rated health[d]												
Excellent	5,160	45.9	4,143	51.4	2,148	54.4	2,266	52.7	1,698	49.2	1,887	56.4
Very good	-	-	6,373	43.5	3,118	45.2	3,088	42.6	2,389	40.5	2,704	46.2
Good	7,458	37.4	4,239	35.0	2,296	35.6	2,003	35.0	1,493	30.9	1,647	33.2
Fair	2,229	31.8	1,675	29.7	816	28.1	674	28.3	424	23.0	396	22.9
Poor	543	26.2	349	19.0	266	25.3	203	21.7	112	16.2	96	14.6
Missing	1,230	59.2	-	-	-	-	-	-	-	-	-	-
Body Mass Index categories												
Missing	508	31.1	1,349	32.4	563	32.3	519	30.0	778	31.2	1,002	36.9
<18.5	766	39.5	493	33.5	258	37.4	197	32.4	124	28.9	65	25.3
18.5−<25.0	9,789	41.8	8,675	43.1	4,205	45.0	3681	43.3	2,498	41.1	2,386	47.1
25.0−<30.0	4,413	37.6	4,852	40.2	2,638	41.3	2,743	42.3	1,864	39.1	2,073	43.9
≥30.0	1,145	31.4	1,410	31.7	981	31.8	1,094	33.4	854	28.9	1,204	31.9
Smoking status												
N/A	1,230	59.2	1,301	58.4	576	54.0	538	51.4	-	-	-	-
Current smoker	3,848	35.0	3,105	33.7	1,709	35.5	1,472	32.7	881	27.1	857	29.5
Ex-smoker	4,045	41.1	4,732	41.8	2,244	41.4	2,514	42.4	1,861	39.3	2,153	43.8
Never smoked	7,498	38.6	7,640	39.1	4,115	41.3	3,710	40.7	3,374	38.6	3,719	42.7

a: Leisure time physical activity calculated as sum of time in walking, moderate and vigorous intensity activity (vigorous weighted by 2)

b: Age and sex standardised to 2011/12 sample

c: Married' = married or de facto; 'not married' = separated, divorced, widow, never married

d: Only four categories used in 1989/90 survey

Table 2: Proportion of Australian adults who are physically 'inactive' (<30 minutes/week moderate-to-vigorous physical activity) by socio-demographic characteristics, Australian National Health Surveys 1989/90 to 2011/12.

Year of Survey	Physical inactivity (<30 min/week moderate-to-vigorous physical activity)[a]											
	1989		1995		2001		2004		2007		2011	
	n	%	n	%	n	%	n	%	n	%	n	%
STD Weighted N age≥15 years (%)[b]	16,392	38.7	15,479	36.6	7,145	33.6	7,376	35.8	6,727	40.2	6,161	37.3
Gender												
Female	8,470	39.5	7,993	37.4	3,724	34.6	3,840	36.9	3,491	41.3	3,342	40.0
Male	7,922	37.9	7,486	35.8	3,421	32.6	3,536	34.7	3,236	39.2	2,819	34.5
Age groups												
15-24	1,844	25.6	1,824	25.4	904	25.0	1,057	30.0	933	32.8	820	29.2
25-34	2,659	35.0	2,487	32.8	1,124	29.5	1,125	30.3	1,084	36.2	977	33.0
35-44	3,059	41.2	2,790	37.6	1,321	35.4	1,313	36.1	1,165	39.8	1,057	36.5
45-54	3,176	44.4	2,803	39.2	1,216	33.9	1,305	37.2	1,186	42.0	1,062	38.0
55-64	2,552	42.0	2,393	39.5	1,072	35.2	1,100	37.0	978	40.8	924	39.0
65-74	1,554	39.1	1,636	41.2	732	36.7	738	37.9	678	43.2	645	41.6
≥75	1,549	52.8	1,547	52.8	776	52.7	739	57.5	703	60.7	675	59.0
Main language spoken at home												
Missing	-	-	-	-	260	24.3	276	26.4	-	-	-	-
Other	2,382	54.7	1,985	53.8	1,376	42.7	962	51.2	920	53.6	815	45.5
English	14,010	36.9	13,494	35.0	5,509	32.5	6,139	34.7	5,807	38.7	5,346	36.3
Marital status[c]												
Married	11,257	41.5	10,170	39.0	4,446	35.2	4,272	37.0	3,775	41.3	3,582	38.3
Not married	5,136	33.7	5,309	32.7	2,699	31.2	3,104	34.3	2,952	38.9	2,579	35.9
Post school qualifications												
N/A	351	19.8	7,761	35.6	260	24.3	232	25.2	-	-	-	-
Degree or above	5,992	34.5	568	23.8	640	20.8	741	21.5	873	27.3	954	24.9
Trade/Diploma	10,050	43.3	2,256	34.7	2,322	31.6	2,360	34.3	2,060	40.9	2,095	37.3
No post school Qual	-	-	4,894	42.2	3,923	40.2	4,043	43.3	3,795	44.7	3,112	43.9
Equivalent household income quintile												
1 Low	2,545	40.8	2,786	39.0	1,519	39.0	1,155	34.5	1,227	52.6	1,051	50.9
2	3,624	42.8	3,124	42.1	1,275	37.5	878	36.0	1,397	47.8	1,122	46.6
3	3,019	39.7	2,617	38.9	1,007	32.9	867	36.5	1,251	40.7	1,074	38.4
4	3,054	37.7	2,354	34.2	889	31.0	877	36.0	1,061	35.5	1,014	34.4
5 High	3,016	32.9	2,107	27.6	746	24.8	1,027	37.2	821	27.9	648	23.1
Not stated	1,135	41.0	2,492	38.5	1,709	34.0	2,574	35.5	971	39.5	1,253	35.6
N/A												
Self-rated health[d]												
Excellent	3,557	31.6	2,077	25.8	913	23.1	1,063	24.7	999	28.9	804	24.0
Very good	-	-	4,576	31.2	1,918	27.8	2,270	31.3	2037	34.5	1,868	31.9
Good	7,899	39.6	4,889	40.4	2,409	37.3	2,286	39.9	2,229	46.2	2,113	42.6
Fair	3,345	47.8	2,760	49.0	1,330	45.7	1,183	49.7	1,033	56.1	950	55.0
Poor	1,196	57.6	1,177	63.9	575	54.7	574	61.3	429	62.2	426	65.0
Missing	396	19.1	-	-	-	-	-	-	-	-	-	-
Body Mass Index categories												
Missing	774	47.3	1,888	45.3	736	42.3	796	46.0	1,140	45.7	1,074	39.5
<18.5	773	39.8	605	41.1	272	39.4	286	47.0	221	51.6	136	53.2
18.5−<25.0	8,297	35.5	6,588	32.7	2,826	30.2	2,791	32.8	2,193	36.1	1,617	31.9
25.0−<30.0	4,803	40.9	4,420	36.6	2,112	33.0	2,154	33.2	1,764	37.0	1,626	34.5
≥30.0	1,746	47.9	1,978	44.5	1,198	38.8	1,350	41.2	1,409	47.7	1,708	45.2
Smoking status												
N/A	396	19.1	407	18.3	260	24.3	276	26.4	-	-	-	-
Current smoker	4,873	44.3	4,094	44.5	1,953	40.6	2,007	44.5	1,692	52.0	1,472	50.7
Ex-smoker	3,629	36.9	3,922	34.6	1,735	32.0	2,014	34.0	1,757	37.1	1,712	34.8
Never smoked	7,495	38.6	7,056	36.2	3,197	32.1	3,080	33.8	3,278	37.5	2,977	34.2

a: Leisure time physical activity calculated as sum of time in walking, moderate and vigorous intensity activity (vigorous weighted by 2)

b: Age and sex standardised to 2011/12 sample

c: Married' = married or de facto; 'not married' = separated, divorced, widow, never married

d: Only four categories used in 1989/90 survey

2.7 times more likely to be inactive than those aged 15-34 years old. In both men and women, higher odds of being inactive were also observed for 'married' versus 'not married'; second household income tertile versus lowest tertile; BMI categories 'underweight', 'overweight', 'obese' versus 'normal weight'; 'current' smokers versus 'never' smokers.

Twenty-two year trends in sufficient physical activity and inactivity

Relative to survey year 1989, the odds of men being sufficiently active were stable in 1995, significantly higher in 2001 (+10%), stable in 2005, significantly lower in 2007 (-14%), and significantly higher in 2011 (+7%). For women, the likelihood of being sufficiently active compared to 1989 was steady in 1995, significantly higher in 2001 (+6%), steady in 2004, significantly lower in 2007 (-13%), and similar in 2011. Overall, there was a significant negative trend over 22 years observed for the prevalence of sufficient physical activity in women (0.3% decrease per year, p=0.025) but not in men (p=0.1442), after adjusting for covariates (Supplementary Figure 1).

Compared to survey year 1989, the prevalence of inactivity in men was steady in 1995, significantly lower in 2001 (-31%) and 2004 (-19%), steady in 2007, and significantly lower in 2011 (-16%). In women, the odds of being inactive compared to 1989 were significantly lower in 1995 (-8%) and 2001 (-24%), similar in 2004, significantly higher in 2007 (+11%) and in 2011 (+9%).

The overall trend for inactivity over 22 years after adjusting for covariates suggested a significant decline in men (0.5% decrease per year, p<0.0001) but a significant increase in women (0.3% increase per year, p=0.004) (Supplementary Figure 1).

Discussion

This study shows a decreasing trend in the prevalence of Australians engaging in sufficient levels of physical activity and stable levels of inactivity between 1989 and 2011. Overall, only two-fifths of the Australian population achieved sufficient levels of physical activity for good health over this 22-year period, while a little over one-third were inactive. We observed a significant time trend suggesting a decline in the prevalence of sufficiently active women of 0.3% per year over 22 years but not in men. Additionally,

our analyses show a significant decreasing trend in inactivity in men of 0.5% per year but an increase in inactivity of 0.3% per year in women from 1989 to 2011.

These findings add to the current literature about long-term trends in population levels of physical activity worldwide. In a review of temporal trends in physical activity, Knuth and Hallal found global levels of physical activity were low (less than 50%),[15] and most studies reviewed reported increases in leisure time physical activity (LTPA) and they concluded that "leisure-time activity levels tend to be increasing over time". Specifically, Knuth and Hallal found 17 studies showing physical activity increased over time, three studies showing declines, and five studies showing stable levels.[15] More recent trend studies add evidence indicating increasing population levels of physical activity in countries such as Denmark, Finland and Brazil.[16-18] These Australian data indicate the opposite trend in Australia; that the proportion of adults who are sufficiently active has decreased by 0.2% per year from 1989 to 2011. Earlier research has noted short term declining physical activity prevalence in Australia from 1997 to 2000 using a different measure.[19]

There are two possible explanations for the different temporal trends observed in Australia. First, the timeframe in the present study is relatively long compared to those from the studies reviewed by Knuth and Hallal.[15] Second, among studies that have used consistent physical activity measures over a longer timeframe (over 10 years), the disparate methods used to measure and define physical activity participation in different countries make comparisons between surveillance systems difficult. A recent Finnish study reported that the proportion of adults classified as having 'high' leisure time physical activity increased between 1982 and 2012 in seven FINRISK surveys.[17] FINRISK assessed physical activity using the same categorical self-report question and respondents who selected the top two response options were classified as engaging in 'high' LTPA. In another study using an unchanged set of categorical questions to measure physical activity, Petersen et al. found upward trends in highly physically active Danish adults from 1987 to 2005.[16] A study examining patterns of physical activity in Canadian adults from 1981 to 2005 using identical questions and scoring found sufficient physical activity, defined as

≥3 MET-hours/day, increased significantly over 20 years.[20] These Australian data contribute important new long-term evidence to the currently small literature base about long-term population surveillance (more than 10 years) of physical activity with consistent measures and multiple survey time points.

Another possible explanation for our findings is that physical activity was measured using consistent, comparable questions with similar survey methods in the Australian NHS while physical activity questions may have changed in other surveillance systems. Researchers have previously reported on limited comparability of data collected from different surveys within the same surveillance system due to changes in survey methods and/or changes to the physical activity measure.[21,22] For example, the physical activity component of the Health Survey for England has changed several times since the original questions in 1991 such that Stamatakis and colleagues could only examine physical activity trends for three surveys conducted from 1999 to 2004 due to limited comparability with earlier surveys.[21] Thus, changes to questions and survey methods may mask real trends in physical activity due to the inability to determine whether observed trends are due to real changes in population behaviour or due to changes in methodology. It is important for researchers to report the details of the physical activity measure used as well as acknowledge any changes in the measure and/or survey method to facilitate the accurate interpretation of their findings.

We estimated the 2011 prevalence of physical inactivity (defined as <30 min/week) to be 40% in women and 34.5% in men, higher than the mean global prevalence of inactivity of 31.1% (range: 17% to 43%) derived using the same WHO definition, but consistent with levels observed in high income countries.[23] We observed inactivity trends suggesting increases in women and decreases in men but this is difficult to compare with previous studies due to differences in definition of physical inactivity and a paucity of studies with trend data. For instance, the prevalence of inactivity in Mexico (defined as <150 min/week of MVPA) increased from 13.4% in 2006 to 19.4% in 2012 (two surveys);[24] while leisure-time inactivity in Canada (defined as energy expenditure <1.5 kcal/kg/day) decreased from 58% to 48% in men and from 63% to 50% in women.[25]

The patterns of correlates found in this study are consistent with those observed

previously: sufficient physical activity was related to being male, inversely related to age and BMI, and positively related to education level, household income, and self-reported health;[26] inactivity was related to being female, positively related to age and BMI, and inversely related to education and household income.[23] Our findings reinforce the need to focus on specific population subgroups for targeted physical activity intervention, such as women, older adults and those with lower education levels.

The strengths of this study were: the use of consistent sampling and survey methods allowing for comparable leisure time physical activity estimates over six surveys spanning two decades; and the large population representative sample of each survey providing sufficient statistical power for analyses. While the self-reported nature of the physical activity measure may have

Table 3: Factors associated with 'sufficient' levels of physical activity (≥150 minutes/week moderate-to-vigorous physical activity), Australian National Health Surveys 1989/90 to 2011/12.[a]

	All				Men				Women			
	Adjusted OR[b]	95%CI		p-value	Adjusted OR[b]	95%CI		p-value	Adjusted OR[b]	95%CI		p-value
		Lower	Upper			Lower	Upper			Lower	Upper	
Gender												
Female	1.00											
Male	1.35	1.32	1.38	<0.0001								
Age groups												
15-34	1.00				1.00				1.00			
35-54	0.81	0.79	0.84	0.0197	0.72	0.69	0.74	<0.0001	0.94	0.90	0.97	<0.0001
55-74	1.04	1.01	1.07	<0.0001	0.96	0.92	1.01	<0.0001	1.15	1.10	1.20	<0.0001
≥75	0.57	0.54	0.60	<0.0001	0.69	0.65	0.74	<0.0001	0.49	0.45	0.52	<0.0001
Main language spoken at home												
Other	1.00				1.00				1.00			
English	1.60	1.54	1.66	<0.0001	1.56	1.48	1.64	<0.0001	1.63	1.54	1.72	<0.0001
Marital status[c]												
Not married	1.00				1.00				1.00			
Married	0.76	0.75	0.78	<0.0001	0.74	0.71	0.76	<0.0001	0.78	0.76	0.81	<0.0001
Post school qualifications												
Trade/Diploma or no post school qualification	1.00				1.00				1.00			
Degree or above	1.33	1.29	1.37	<0.0001	1.35	1.30	1.40	<0.0001	1.33	1.28	1.39	<0.0001
Equivalent household income												
1st tertile (low)	1.00				1.00				1.00			
2nd tertile (middle)	0.92	0.89	0.95	<0.0001	0.90	0.86	0.94	<0.0001	0.94	0.90	0.98	<0.0001
3rd tertile (high)	1.09	1.06	1.13	<0.0001	1.11	1.06	1.16	<0.0001	1.07	1.02	1.12	<0.0001
Not stated	1.01	0.97	1.04	0.7431	0.98	0.93	1.03	0.2582	1.03	0.98	1.08	0.112
Self-rated health[d]												
Good, fair or poor	1.00				1.00				1.00			
Excellent or very good	1.63	1.60	1.67	<0.0001	1.65	1.60	1.71	<0.0001	1.60	1.55	1.65	<0.0001
Body Mass Index categories												
18.5–<25.0	1.00				1.00				1.00			
<18.5	0.71	0.66	0.75	<0.0001	0.61	0.55	0.69	<0.0001	0.75	0.70	0.81	0.227
25.0–<30.0	0.92	0.90	0.94	<0.0001	0.97	0.94	1.00	<0.0001	0.87	0.84	0.91	<0.0001
≥30.0	0.69	0.67	0.71	<0.0001	0.73	0.69	0.76	0.0022	0.66	0.63	0.70	<0.0001
Missing	0.66	0.63	0.69	<0.0001	0.66	0.61	0.70	<0.0001	0.66	0.63	0.70	<0.0001
Smoking status												
Never smoked	1.00				1.00				1.00			
Current smoker	0.74	0.72	0.76	<0.0001	0.68	0.65	0.71	<0.0001	0.81	0.78	0.85	<0.0001
Ex-smoker	1.10	1.07	1.13	0.7239	1.04	1.00	1.08	0.0004	1.15	1.11	1.20	0.039
Missing	1.83	17.0	1.96	<0.0001	2.13	1.93	2.35	<0.0001	1.63	1.49	1.79	<0.0001
Year of survey												
1989	1.00				1.00				1.00			
1995	0.98	0.95	1.01	0.7223	1.00	0.96	1.05	0.8094	0.97	0.93	1.02	0.726
2001	1.08	1.04	1.12	<0.0001	1.10	1.05	1.16	<0.0001	1.06	1.01	1.12	<0.0001
2004	0.98	0.94	1.01	0.4341	0.97	0.92	1.02	0.1355	0.99	0.93	1.04	0.655
2007	0.86	0.83	0.90	<0.0001	0.86	0.82	0.91	<0.0001	0.87	0.82	0.92	<0.0001
2011	1.03	0.99	1.08	0.0067	1.07	1.01	1.13	0.0022	0.99	0.93	1.05	0.575
Years (trend)	0.998	0.996	1.000	0.0123	0.998	0.996	1.001	0.1442	0.997	0.995	1.000	0.0250

a: Leisure time physical activity calculated as sum of time in walking, moderate and vigorous intensity activity (vigorous weighted by 2)

b: Adjusted for all other variables in the model

c: 'Married' = married or de facto; 'not married' = separated, divorced, widow, never married

d: Only four categories used in 1989/90 survey

introduced possible social desirability biases and recall error, this was likely minimal given the relatively small changes in physical activity prevalence or lack thereof over the two decades examined. Nonetheless, it is possible that interpretation of the questions, albeit consistently worded, may have changed over two decades, and obscured real trends or generated false patterns. It would be advantageous to have objectively assessed physical activity data, but this is an expensive and logistically complex undertaking at the population level and was also not possible in earlier surveys.

Another limitation was our analytic approach which divided the two-week recall time frame of earlier surveys by two to enable comparisons with the 2011 survey, which used a one-week time frame, as well as weighting vigorous minutes by two.[14] While the prevalence of sufficient activity estimated via this approach could be slightly lower than those derived by other surveillance instruments, the AHS physical

Table 4: Factors associated with physical 'inactivity' (<30 minutes/week moderate-to-vigorous physical activity), Australian National Health Surveys 1989/90 to 2011/12.[a]

	All				Men				Women			
	Adjusted OR[b]	95%CI Lower	95%CI Upper	p-value	Adjusted OR[b]	95%CI Lower	95%CI Upper	p-value	Adjusted OR[b]	95%CI Lower	95%CI Upper	p-value
Gender												
Female	1.00											
Male	0.94	0.92	0.97	<0.0001								
Age groups												
15-34	1.00				1.00				1.00			
35-54	1.36	1.32	1.39	<0.0001	1.50	1.44	1.56	<0.0001	1.22	1.17	1.27	<0.0001
55-74	1.26	1.22	1.30	<0.0001	1.34	1.28	1.40	0.0002	1.16	1.11	1.21	<0.0001
≥75	2.41	2.30	2.52	<0.0001	1.99	1.86	2.14	<0.0001	2.73	2.56	2.91	<0.0001
Main language spoken at home												
Other	1.00				1.00				1.00			
English	0.56	0.54	0.58	<0.0001	0.60	0.57	0.63	<0.0001	0.52	0.50	0.55	<0.0001
Marital status[c]												
Not married	1.00				1.00				1.00			
Married	1.22	1.19	1.25	<0.0001	1.25	1.21	1.30	<0.0001	1.22	1.18	1.26	<0.0001
Post school qualifications												
Trade/Diploma or no post school qualification	1.00				1.00				1.00			
Degree or above	0.66	0.64	0.68	<0.0001	0.63	0.61	0.66	<0.0001	0.67	0.64	0.70	<0.0001
Equivalent household income												
1st tertile (low)	1.00				1.00				1.00			
2nd tertile (middle)	1.03	1.00	1.06	<0.0001	1.66	1.59	1.72	<0.0001	1.38	1.33	1.44	<0.0001
3rd tertile (high)	0.83	0.80	0.86	<0.0001	0.97	0.93	1.00	0.0236	0.86	0.83	0.89	0.1029
Not stated	0.99	0.96	1.02	0.0054	0.46	0.40	0.51	<0.0001	0.52	0.47	0.59	<0.0001
Self-rated health[d]												
Good, fair or poor	1.00				1.00				1.00			
Excellent or very good	0.63	0.62	0.65	<0.0001	0.65	0.63	0.67	<0.0001	0.63	0.61	0.65	<0.0001
Body Mass Index categories												
18.5–<25.0	1.00				1.00				1.00			
<18.5	1.52	1.43	1.62	<0.0001	1.66	1.47	1.86	<0.0001	1.47	1.37	1.58	<0.0001
25.0–<30.0	1.06	1.03	1.08	<0.0001	1.02	0.98	1.06	<0.0001	1.09	1.05	1.13	<0.0001
≥30.0	1.37	1.32	1.42	<0.0001	1.35	1.28	1.41	0.0906	1.37	1.31	1.44	<0.0001
Missing	1.53	1.47	1.60	<0.0001	1.62	1.51	1.73	<0.0001	1.47	1.40	1.56	<0.0001
Smoking status												
Never smoked	1.00				1.00				1.00			
Current smoker	1.51	1.47	1.55	<0.0001	1.66	1.59	1.72	<0.0001	1.38	1.33	1.44	<0.0001
Ex-smoker	0.90	0.88	0.92	0.7957	0.97	0.93	1.00	0.0236	0.86	0.83	0.89	0.1029
Missing	0.49	0.45	0.53	<0.0001	0.46	0.40	0.51	<0.0001	0.52	0.47	0.59	<0.0001
Year of survey												
1989	1.00				1.00				1.00			
1995	0.89	0.86	0.92	0.0195	0.84	0.81	0.88	0.3318	0.92	0.89	0.97	0.0052
2001	0.73	0.70	0.75	<0.0001	0.69	0.65	0.73	<0.0001	0.76	0.72	0.80	<0.0001
2004	0.88	0.84	0.91	0.0050	0.81	0.76	0.85	0.0028	0.94	0.89	1.00	0.2922
2007	1.06	1.02	1.10	<0.0001	1.00	0.94	1.06	<0.0001	1.11	1.05	1.18	<0.0001
2011	0.96	0.92	1.00	0.0021	0.84	0.79	0.90	0.4844	1.09	1.02	1.15	<0.0001
Years (trend)	0.999	0.997	1.001	0.2418	0.995	0.993	0.997	<0.0001	1.003	1.001	1.006	0.0040

a: Leisure time physical activity calculated as sum of time in walking, moderate and vigorous intensity activity (vigorous weighted by 2)

b: Adjusted for all other variables in the model

c: 'Married' = married or de facto; 'not married' = separated, divorced, widow, never married

d: Only four categories used in 1989/90 survey

activity instrument demonstrates acceptable repeatability, which is an important characteristic for continued population monitoring.

Conclusion

These data indicate a lack of improvement in sufficient leisure time physical activity and inactivity levels among Australian adults over two decades, and suggest that public health efforts have had limited success in addressing this risk factor, compared to major and successful reductions in tobacco use.[27] Key target groups remained consistent across this period, with women and older adults needing particular attention. It is worrying that inactivity prevalence in women increased, when the benefits are greatest in motivating the inactive. Finally, the strengths in comparable measures should be maintained in future physical activity surveys, especially if targeted population level interventions are introduced that may reverse this stable pattern of activity. Australia has adopted the World Health Organisation's NCD Global Monitoring Framework,[28] including the target of reducing physical inactivity by 10% by 2025. The need for an Australian national physical action plan has never been clearer nor more urgent.[6]

References

1. Reiner M, Niermann C, Jekauc D, Woll A. Long-term health benefits of physical activity – a systematic review of longitudinal studies. *BMC Public Health*. 2013;13(1):1-9.
2. Australian Institute of Health and Welfare. *Australian Burden of Disease Study: Impact and Causes of Illness and Death in Australia 2011*. Canberra (AUST): AIHW; 2016.
3. Lee IM, Shiroma EJ, Lobelo F, Puska P, Blair SN, Katzmarzyk PT. Effect of physical inactivity on major non-communicable diseases worldwide: An analysis of burden of disease and life expectancy. *Lancet*. 2012;380(9838):219-29.
4. Ding D, Lawson KD, Kolbe-Alexander TL, Finkelstein EA, Katzmarzyk PT, van Mechelen W, et al. The economic burden of physical inactivity: A global analysis of major non-communicable diseases. *Lancet*. 2016;388(10051):1311-24.
5. Australian Medical Association. *Position Statement on Physical Activity* [Internet]. Kingston (AUST): AMA; 2014 (cited 2016 Sep 7). Available from: https://ama.com.au/position-statement/physical-activity-2014.
6. Salmon J. Move more, sit less! Time for a national physical activity action plan. *Med J Aust*. 2016;205(3):100.
7. Bauman A, Chau J. Monitoring population trends through physical activity surveillance – a chequered history in Australia. *Australas Epidemiol*. 2016;22(1):5-8.
8. Australian Bureau of Statistics. *1989-90 National Health Survey Users' Guide 4363.0*. Canberra (AUST): ABS; 1991.
9. Australian Bureau of Statistics. *National Health Survey Users' Guide 4363.0, 1995*. Canberra (AUST): ABS; 1995.
10. Australian Bureau of Statistics. *4363.0.55.001 – National Health Survey: Users' Guide, 2001*. Canberra (AUST): ABS; 2001.
11. Australian Bureau of Statistics. *4363.0.55.001 – National Health Survey: Users' Guide Electronic, 2004-05*. Canberra (AUST): ABS; 2005.
12. Australian Bureau of Statistics. *4363.0.55.001 – 2007-08 Australian Health Survey: Users' Guide*. Canberra (AUST): ABS; 2008.
13. Australian Bureau of Statistics. *4363.0.55.001 – Australian Health Survey: Users' Guide, 2011-13*. Canberra (AUST): ABS; 2013.
14. Brown W, Trost SG, Bauman A, Mummery K, Owen N. Test-retest reliability of four physical activity measures used in population surveys. *J Sci Med Sport*. 2004;7(2):205-15.
15. Knuth AG, Hallal PC. Temporal trends in physical activity: A systematic review. *J Phys Act Health*. 2009;6(5):548-59.
16. Petersen CB, Thygesen LC, Helge JW, Gronbaek M, Tolstrup JS. Time trends in physical activity in leisure time in the Danish population from 1987 to 2005. *Scand J Public Health*. 2010;38(2):121-8.
17. Borodulin K, Harald K, Jousilahti P, Laatikainen T, Mannisto S, Vartiainen E. Time trends in physical activity from 1982 to 2012 in Finland. *Scand J Med Sci Sports*. 2016;26(1):93-100.
18. Matsudo VK, Matsudo SM, Araujo TL, Andrade DR, Oliveira LC, Hallal PC. Time trends in physical activity in the state of Sao Paulo, Brazil: 2002-2008. *Med Sci Sports Exerc*. 2010;42(12):2231-6.
19. Bauman A, Ford I, Armstrong T. *Trends in Population Levels of Reported Physical Activity in Australia, 1997, 1999 and 2000*. Canberra (AUST): Australian Sports Commission; 2001.
20. Craig CL, Russell SJ, Cameron C, Bauman A. Twenty-year trends in physical activity among Canadian adults. *Can J Public Health*. 2004;95(1):59-63.
21. Stamatakis E, Ekelund U, Wareham NJ. Temporal trends in physical activity in England: The Health Survey for England 1991 to 2004. *Prev Med*. 2007;45(6):416-23.
22. Hallal PC, Knuth AG, Reis RS, Rombaldi AJ, Malta DC, Iser BP, et al. Time trends of physical activity in Brazil (2006-2009). *Rev Bras Epidemiol*. 2011;14 Suppl 1:53-60.
23. Hallal PC, Andersen LB, Bull FC, Guthold R, Haskell W, Ekelund U. Global physical activity levels: Surveillance progress, pitfalls, and prospects. *Lancet*. 2012;380(9838):247-57.
24. Medina C, Janssen I, Campos I, Barquera S. Physical inactivity prevalence and trends among Mexican adults: Results from the National Health and Nutrition Survey (ENSANUT) 2006 and 2012. *BMC Public Health*. 2013;13:1063.
25. Juneau CE, Potvin L. Trends in leisure-, transport-, and work-related physical activity in Canada 1994-2005. *Prev Med*. 2010;51(5):384-6.
26. Bauman AE, Reis RS, Sallis JF, Wells JC, Loos RJ, Martin BW. Correlates of physical activity: Why are some people physically active and others not? *Lancet*. 2012;380(9838):258-71.
27. Wakefield MA, Coomber K, Durkin SJ, Scollo M, Bayly M, Spittal MJ, et al. Time series analysis of the impact of tobacco control policies on smoking prevalence among Australian adults, 2001-2011. *Bull World Health Organ*. 2014;92(6):413-22.
28. World Health Organisation. *NCD Global Monitoring Framework* [Internet]. Geneva (CHE): WHO Noncommunicable Diseases and Mental Health; 2017 [cited 2017 Apr 19]. Available from: http://www.who.int/nmh/global_monitoring_framework/en/

Supporting information

Additional supporting information may be found in the online version of this article:

Supplementary Table 1: Australian Health Survey leisure time physical activity questions asked by year of survey, 1989/90 to 2011/12.

Supplementary Table 2: Socio-demographic characteristics Australian Health Survey samples by year of survey, 1989/90 to 2011/12.

Supplementary Figure 1: Trends in prevalence of physical activity and inactivity in Australia. National Health Surveys 1989/1990 to 2011/2012.