Physical Activity, Body Mass Index and Health in Australian Women

Selected findings of the Australian Longitudinal Study on Women's Health

Report prepared for the

Population Health Division
of the
Australian Commonwealth Department of Health and Ageing

June 2003

Wendy Brown, Kylie Ball, Stewart Trost and Annette Dobson

with assistance from

Jessica Ford and Ester Cerin

The University of Newcastle
AUSTRALIA

The University Of Queensland

Table of Contents

List of Tables

List of Figures

Acknowledgments

The Australian Longitudinal Study on Women's Health is funded by the Commonwealth Department of Health and Ageing and managed by researchers at the Universities of Newcastle and Queensland. This report was written by Wendy Brown, Kylie Ball, Stewart Trost and Annette Dobson from original research conducted by the authors in association with Gita Mishra, Christina Lee, Lauren Williams, Anne Russell, Anne Young and Justin Kenardy, with additional statistical analyses performed by Ester Cerin and Jess Ford, using databases and other information prepared by the entire research team.

Take Home Messages

1 The ALSWH provides the first opportunity in Australia to track changes in patterns of physical activity and BMI, in adult women from diverse socioeconomic, geographic and cultural backgrounds.

2 There is potential for the data from this study to shed light on the complex interactions between socio-demographic characteristics and PA and BMI as behavioural risk factors for a multitude of chronic health problems and conditions that affect women at different stages of their lives.

3 The addition of food intake data in the third wave of surveys will provide an opportunity to further explore the underlying determinants of overweight and obesity in women.

4 The data will be valuable in terms of informing policy and practice in health promotion and preventive health care. Specifically the study will be able to:

- Provide population data to evaluate competing proposals about the amount of PA which is associated with optimal health (150 or 420 minutes per week).
- Provide population data on time spent sitting, which will provide further insight into the causes of increasing levels of overweight and obesity.
- Provide population data which will help to inform the relative importance of PA and BMI on health outcomes. (ie Is it better to be fat and active than thin and inactive?).
- Assist with the development of State and Federal initiatives to promote increased levels of physical activity, using determinants of PA and BMI from this study.
- Assist with evaluation of State and Federal initiatives to promote increased levels of physical activity.

Overview

Physical activity (PA) and the maintenance of healthy body weight have significant effects on the prevention and management of chronic disease. A recently published joint WHO/FAO report found that there is *convincing* evidence relating (1) regular physical activity to the prevention of obesity, type 2 diabetes, cardiovascular disease, some cancers and osteoporosis, (2) overweight and obesity to the development of type 2 diabetes and some cancers, and (3) low body weight to the development of osteoporosis. Physical activity and weight loss (in those already overweight) are also implicated in the management of many of these chronic diseases.

The Australian Longitudinal Study on Women's Health (ALSWH) offers the first opportunity in Australia to explore the relationships between PA and weight and the development and progression of chronic disease in three cohorts of Australian women. The study also provides the opportunity to track changes in PA and BMI through natural life-stages, and to document the individual and social factors which are associated with changes in these variables across the adult life-span.

This report presents data from three cohorts of women who have been participating in the ALSWH since 1996. The report is based on discussions between members of the ALSWH research team and staff from the Division of Population Health in the Department of Health and Ageing (DoHA), which aimed to identify a number of policy-relevant issues that the ALSWH is able to explore.

The issues addressed in this report include:

- The descriptive epidemiology of PA and BMI and the complementary role of these data to those from other national surveys.
- Issues relating to the measurement of PA, specifically as they relate to inclusion of work-related activity and to the establishment of 'thresholds' for PA guidelines.
- Relationships between PA and BMI with well-being and symptoms at different life stages.
- Relationships between occupation and employment status with PA and BMI
- Changes in PA and BMI over time and the social context of these changes
- Relationships between PA and BMI, and between PA, BMI and health in the three age cohorts.
- Relationships between sitting time, PA and BMI

The data presented in this report are based on a synthesis of existing ALSWH publications, as well as extensive additional analyses. The report begins with a brief description of ALSWH, and then provides information relevant to each of the issues outlined above.

What is the Australian Longitudinal Study on Women's Health?

The Australian Longitudinal Study on Women's Health (ALSWH)—widely known as Women's Health Australia—is a longitudinal population-based survey, which is examining the health of more than 40,000 Australian women. It provides an evidence base to the Commonwealth Department of Health and Ageing for the development and evaluation of policy and practice in many areas of service delivery that affect women. Overviews of the survey, its rationale and methods, can be located on the Study's website http://www.newcastle.edu.au/centre/wha and overview publications include a book targeted at the non-expert level (Lee 2001) and several academic reports (Brown et al. 1996, 1998).

The study was designed to explore factors that influence health among women who are broadly representative of the entire Australian population.

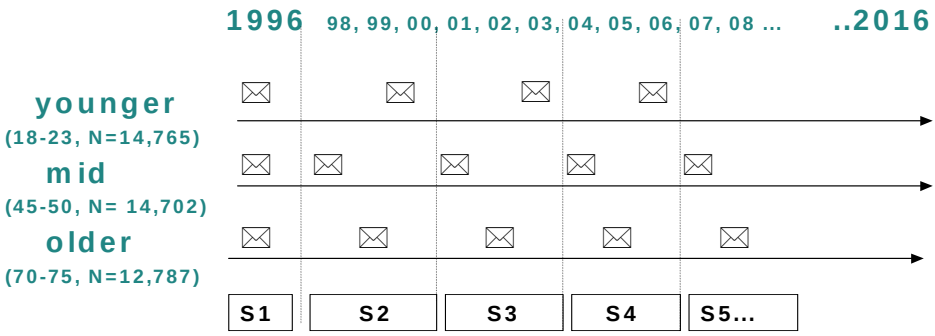
The study assesses:

- Physical and emotional health (including well-being, major diagnoses, symptoms)
- Use of health services (GP, medical specialist and other professions, access, satisfaction)
- Health behaviours and risk factors (diet, exercise, smoking, alcohol, other drugs)
- Time use (including paid and unpaid work, family roles, and leisure), sociodemographic factors (location, education, employment, family composition)
- Life stages and key events (such as childbirth, divorce, widowhood).

Women in three age groups (aged 18–23 years, 45–50 years and 70–75 years in 1996) were randomly selected from the Medicare database, but with women from rural and remote areas sampled at twice the rate of women in urban areas. This means that the numbers of rural women are sufficiently large for statistical comparisons. The study is designed to continue for 20 years, with each age cohort being surveyed once every three years. The time-line for the surveys conducted since the initial survey of all three cohorts in 1996, and for the surveys which are planned for the next five years, is shown in Figure 1.

The age groups were selected in order to follow women through life stages which are likely to be critical to their health and well-being. When the study began, women in the younger cohort were in the early stages of transition from adolescence to adulthood, so they could be tracked as they move into the work force, enter adult relationships, and become mothers. At survey 1, the majority of these young women were living with their families of origin (51%) or in shared housing (24%). Almost half (48%) were students; 79% were single; and 92% had no children. By survey 2, 48% were living with a partner (23% were married and 20% in long-term de facto relationships) although only 17% were mothers. Two-thirds (67%) had post-secondary educational qualifications and 59% were in full-time paid employment.

Figure 1: Timeline for the main ALSWH surveys



Women in the mid-age cohort were selected in order to explore the health effects of the social and personal changes of middle age. At survey 1, the majority (75%) were married; 37% had full-time employment and 31% had part-time paid work. While 91% were mothers, only 58% had children under 16 living with them. Middle age is a time of relative demographic stability, so the picture was relatively similar at the time of survey 3 in 2001, with 78% married, 37% in full-time work and 23% in part-time work, although the proportion with children living at home had fallen to 37%.

In order to recruit older women who are generally still actively involved members of the community, women in the older cohort were in their early 70s at the start of the study. Data from these women are providing information about predictors of continuing well-being and independence in older adult life. At survey 1, the majority of older women (58%) were married, but the proportion of widows increased from 36% to 41% of the sample by survey 2. More than 80% of the older women are pensioners, including 35% who have superannuation or other private income.

Wherever possible, the surveys incorporate widely used scales and items that have known validity and reliability. For example, the main measure of health used in the study is the Medical Outcomes Study Short-Form 36 (SF-36) Health Survey which is an international standard generic measure of health-related quality of life. This instrument provides an eight scale health profile (SF-36 Subscales) and two summary scores representing physical and mental health (PCS: physical component summary score; MCS: mental components summary score). The sub-scales measure: physical functioning (PF), bodily pain (BP), role limitations due to physical health problems (RP); general health perceptions (GH), vitality, energy or fatigue (V), general mental health, covering psychological distress or well-being (MH), role limitations due to emotional problems (RE), and social functioning (SF).

While a majority of the older women prefer to complete the surveys by post, some older women have chosen to remain in the study by completing a shortened version of the survey by telephone interview. For example, in 1999, 9,501 older women completed the full-length version of survey 2 and 920 completed a shortened version by telephone. Women who answered the short survey were similar in most respects to those who answered the long survey, except that they tended to be older and were less likely to have formal qualifications.

In addition to the main surveys, selected participants are invited to participate in sub-studies which address specific issues or target specific groups. For example, a sub-sample of the younger women have participated in a sub-study of eating disorders, and a

sub-sample of mid-age women who were experiencing menopause have participated in a study of menopause-related weight change.

Participants are also invited to consent to linkage of their survey responses with unit records from the Medicare database. Under present legislation, individual signed consent is required for access to individual data, and approximately half the women have provided this consent. This enables us to access information about type of service, characteristics of the provider, and out-of-pocket costs for every Medicare-eligible service. Aggregated unidentified data are also available for those who have not consented to access to individual records.

The project has been able to retain a very high proportion of the original participants. Among the younger women, 72% responded to survey 2 in 2000, a retention rate which compares well with other surveys of this highly mobile age group. Retention rates have been much higher among the mid-age women; 92% and 85% of this group respectively responded to survey 2 in 1998 and survey 3 in 2001. Of the older women, 91% responded to survey 2 in 1999 and 83% to survey 3 in 2002.

The maintenance of these cohorts will provide a valuable opportunity to explore associations over time between aspects of women's lives and their physical and emotional health. In this way, the study will be able to provide information that will assist the Commonwealth Department of Health and Ageing—as well as other Commonwealth and State Departments—to plan for the future and to develop policies which are most appropriate to Australian women of all ages.

This is one of a series of reports which has been prepared on the basis of meetings between the research team, and staff of selected Sections and Divisions of the Commonwealth Department of Health and Ageing. Initial discussions, held in October and November 2002, addressed policy needs and their match with existing data. On this basis, specific topics were selected for the preparation of brief syntheses of existing research, supplemented by some new analysis of existing data. Drafts were presented to the Departmental staff in February–April 2003, and the final reports prepared on the basis of feedback from this process. Further analyses can be conducted on request.

Further information is available from Jan McMahon, email Janet.McMahon@health.gov.au or visit the website http://www.newcastle.edu.au/centre/wha.

Part One: Physical Activity

1 Physical Activity Measurement in the ALSWH surveys

Survey 1 1996

In survey 1 PA was measured using questions from the 1980-89 NHF risk factor prevalence studies (National Heart Foundation, 1980; National Heart Foundation, 1983; National Heart Foundation, 1989). The items rely on self report of *frequency* of participation in 'vigorous' ('exercise which makes you breathe harder or puff and pant, such as netball, squash, jogging, aerobics, vigorous swimming etc') and 'less vigorous' ('exercise which does not make you breathe harder or puff and pant, like walking, gardening, swimming and lawn bowls') exercise in a 'normal' week, with duration of twenty minutes or more. Responses to these two questions were used to derive a 'baseline physical activity score' by weighting frequency of vigorous exercise by 5 and of less vigorous exercise by 3 and summing the two products. The resulting physical activity (PA) scores were categorised as none (<5), low (5–<15), moderate (15–<25), or high (≥ 25), where a score of 15 is equivalent to the current national PA guidelines of 5 bouts of moderate activity per week, or 3 bouts of vigorous activity, or any combination of the two (Brown, Mishra, Lee, & Bauman, 2000).

A third question, which asked about frequency of work-related activity in a normal week, was included in the baseline surveys for the younger and mid-age women only:

> "in the course of your WORK (paid or unpaid) how many times in a normal week would your work involve exertion for more than 20 minutes without stopping, that is, exertion which makes you breathe harder and puff or pant?"

Subsequent surveys

The PA measure used in survey 1 was selected in 1995 because it was regarded as the best available measure at that time, and because the ALSWH data could then be compared with other large Australian data sets. However, in the period between survey 1 and survey 2, there was wide consensus that PA measures needed to be improved, specifically to include a measure of *duration* of activity. Hence, for survey 2 and subsequent surveys, the decision was made to change the PA items to the then newly developed items which were being used in the evaluation of the *Active Australia* campaign (now widely know as the 'Active Australia' items). These include three questions about the duration of time spent in brisk walking (for recreation or exercise or to get to and from places), moderate intensity leisure activity (eg social tennis, moderate exercise classes, recreational swimming, dancing); and vigorous leisure activity (that makes you breather harder or puff and pant, like aerobics, competitive sport, vigorous cycling, running, swimming) during the last week (Armstrong, Bauman & Davies, 2000).

A PA score was derived from these questions using the 'MET.mins' method (Brown & Bauman, 2000), by multiplying the time spent in each type of activity (walking, moderate and vigorous) by a generic 'MET' value for that type of activity, then summing the resultant MET.mins for the three categories. [The generic MET values were derived from the published MET values (Ainsworth et al, 2000) for actual activities reported in response to these items in the 1996 NSW Physical Activity Survey; walking, 3.5; moderate 4, vigorous 7.5; (Bauman, Chey, Brown, Booth 1998). (The 'MET' is a unit of energy expenditure, where one MET is equivalent to resting energy expenditure, which equates with about 3.5 mL oxygen consumption per kg of body weight)].

MET.mins scores were categorised as none (<50), low (50–<600), moderate (600–<1200), or high (≥ 1200), with a score of 600 equivalent to the current national PA guidelines of five 30 minute bouts of moderate activity per week (150 minutes x 4 METs). (For reference, in the national surveys, categorisation as 'active' and 'inactive' was based on total minutes of activity reported in response to the three questions, with time spent in vigorous activity weighted by two to reflect its greater intensity. A threshold of ≥ 150 weighted minutes (equivalent to 600 MET.mins/week of moderate intensity activity) was used to categorise respondents as 'active'.

A question about time spent in vigorous household or garden chores (that make you breathe harder or puff and pant) was also included in surveys 2 and 3, but responses were not included in the derivation of the PA scores.

2 Descriptive Epidemiology of Physical Activity

The proportions of women in each PA category for surveys 1 and 2 are shown in Table 1. As different questions were used at survey 1 and survey 2 it is not possible to compare prevalence estimates from these two measures (Brown, Bauman, Chey, Trost and Mummery, 2002).

For the follow-up surveys, the ALSWH questions were very similar to those used in the 1999 and 2000 national surveys. The methods for scoring and classification were however slightly different (MET.mins instead of weighted minutes). Notwithstanding, among the mid-age women, the proportions categorised as 'active' were quite similar in both surveys, while among the younger women the national survey provided a higher estimate of 'activity.' This might be explained by the inclusion of more rural women in the ALSWH cohorts, or by some bias in the smaller national samples towards inclusion of women with an interest in PA, which would have been unlikely for the ALSWH cohorts, as PA was not a major focus of these surveys. This may also be true for the older women, for whom there was also a higher prevalence estimate for 'activity' in the national sample. However, the age range of the oldest group in the national sample may also be a confounding factor; 60-75 years, compared with 73-78 for survey 2 of the older ALSWH cohort.

Younger Women

Data from survey 1 indicate that young women (age 18–23) who were married or living in a de facto relationship, engaged in full-time home duties and/or living with children were more likely to be inactive. Women who were born in Europe or Asia were also over-represented in the 'inactive' categories (Brown, Mishra, Lee & Bauman, 2000).

At survey 2, (age 22–27) there was a clear and direct relationship between indicators of socioeconomic status (SES) such as education, occupation and income and the proportion of women classified as active, using the definition of ≥600 MET.minutes per week in walking to and from places and in leisure time PA (Brown and Trost, 2001).

Mid-Age Women

Among the mid-age women, survey 1 data indicate that those born in Europe, Asia or other non-English speaking countries, those in full-time work or who were not in paid work, those in trade, clerical or sales work, and those living with children were more likely to be inactive (Brown, Mishra, Lee & Bauman, 2000).

At survey 2, there were clear relationships between activity and indicators of SES such as education and occupation in the mid-age women (age 52–57). There was no clear association between activity status and income, but those in the lowest income category were more likely to be active, possibly reflecting the fact that women who did not have access to a car walked more as a means of getting to and from places. [For example, among mid-age women without access to a car, the odds ratio for walking 60 minutes a week or more was 2.2 (95% CI:1.89–2.59), compared with those who had access to a car whenever they needed it; Brown and Trost, 2001]. Women with partners in the highest occupation and income categories were also more likely to be 'active'.

Older Women

Among the older women, survey 1 data show that those who were married tended to be less active than their widowed or single counterparts. At survey 2 there were clear associations between 'activity' and education, own and partner's former occupations and ability to manage on income, such that those in more advantaged socioeconomic groups were more likely to be active.

Table 1: Distribution of PA categories and activity classifications—surveys 1 and 2, with comparable data from the national PA survey.

	PA categories				Activity Classification	
	None %	Low %	Moderate %	High %	Inactive %	Active %
SURVEY 1 1996						
YOUNGER WOMEN N = 14,502	14.9	28.6	25.6	30.2	43.5	55.8
MID-AGE WOMEN N = 13,609	27.7	30.5	25.3	16.4	58.2	41.7
OLDER WOMEN N = 11,421	27.0	29.7	30.4	12.9	56.7	43.3
SURVEY 2						
YOUNGER WOMEN 2000 N = 9,432	10.5	34.4	23.3	31.7	44.9	55.0
MID-AGE WOMEN 1998 N = 12,338	18.2	30.7	22.1	28.9	49.0	51.0
OLDER WOMEN 1999 N = 8,914	32.8	29.5	16.4	21.3	62.3	37.7
'ACTIVE AUSTRALIA' Survey*						
Age 18-29						
1997					27.9	72.1
1999					36.3	63.7
2000					34.4	65.6
N = 1087						
Age 45-59						
1997					43.4	55.6
1999					49.7	50.3
2000					51.7	48.3
N = 1034						
Age 60-75						
1997					49.1	50.9
1999					52.5	47.5
2000					44.9	55.1
N = 731						

*data kindly provided by Professor Adrian Bauman (personal communication)

3 Work-Related Physical Activity

The issue of whether work-related PA should be included in measures of physical activity has been the subject of recent debate. There is an argument that women (and men) who are 'on their feet all day' must be more active than their counterparts who have desk jobs. While this is true, there are few occupations today in which the intensity of activity could be classified as 'moderate (>3 METs).

Responses to the 'occupation' questions in survey 1 (which asked women to report their 'main' occupation) and to the 'work-related' physical activity question (see page 9) were used to explore the young and mid-age women's perceptions of the amount of time they spend in work-related activity (see Figure 2). The figure shows the median frequency of 'exertion for more than 20 minutes without stopping' by reported occupational category. Among the young women, it is clear that women in the 'professional' (eg teacher) and 'clerk' (eg telephonist, secretary) categories report least occupational exertion, and those in the 'trade' (eg gardener, hairdresser), sales, machine operator/driver and manual worker (eg cleaner) categories report the most. Note that the mean frequency of 'exertion' was low, and that these data are heavily skewed, because of the high proportion (56.7%) of women reporting no work-related 'exertion.'

For the mid-age women, there was a similar picture, with women in the professional (eg teacher, doctor) and administrative (eg secretary, telephonist) categories reporting the lowest frequency of 'exertion' and those in the manual worker (eg cleaner, kitchen-hand) category reporting the highest. There were no obvious differences between the remaining seven occupational categories for mid age women (see Figure 2).

In view of the finding that young and mid-age women in the 'professional' and 'clerk' categories reported lower frequency of work-related PA, relationships between occupational category and *leisure-time* PA are of interest. Do the women who have low levels of work-related activity 'compensate' by being more active in their leisure time? Among the younger cohort, women in the professional and para-professional (eg technician, policewoman) and manual worker categories had higher 'leisure-time' PA scores at baseline than those in the 'clerk' and 'sales' categories. There were however few clear differences in PA scores across occupational category in the mid-age women. Note that leisure time PA scores for every occupational category were lower in the mid-age than in the young women. (See Figure 3).

The relationships between PA and *employment status* is shown in Figure 4. Among the younger women, it is clear that those in full-time home duties (usually those with small children) report the lowest levels of PA, and students report the highest (see Figure 4). However, amongst the mid-age group, the PA scores for women in full-time and part-time paid work were less variable than those in the other employment categories. Women who were 'unable to work' reported very low levels of activity.

The implication of these findings lies in targeting physical activity promotion efforts to women who report the lowest levels of work-related and/or leisure time PA, most notably young women in the 'administrative' occupation category, and mid-age women in the 'professional' and 'clerk' categories.

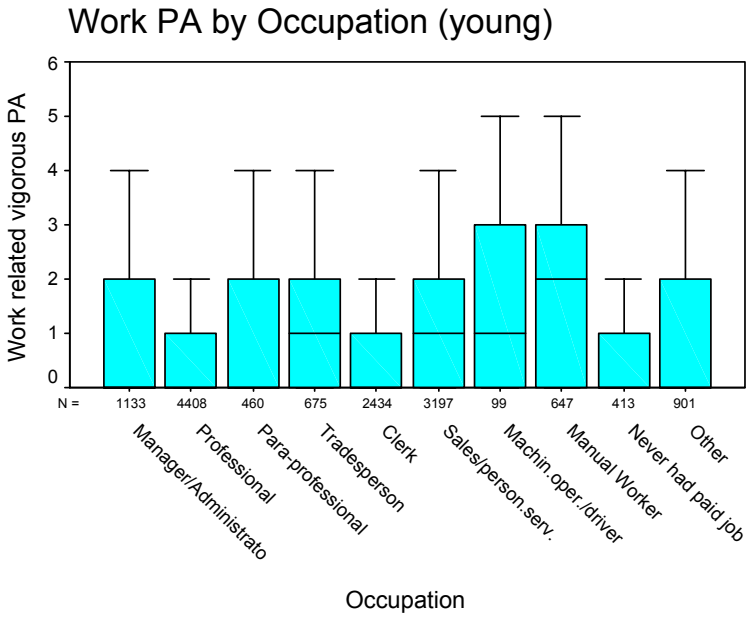
Implications of including time in work-related physical activity in estimates of 'activity prevalence'

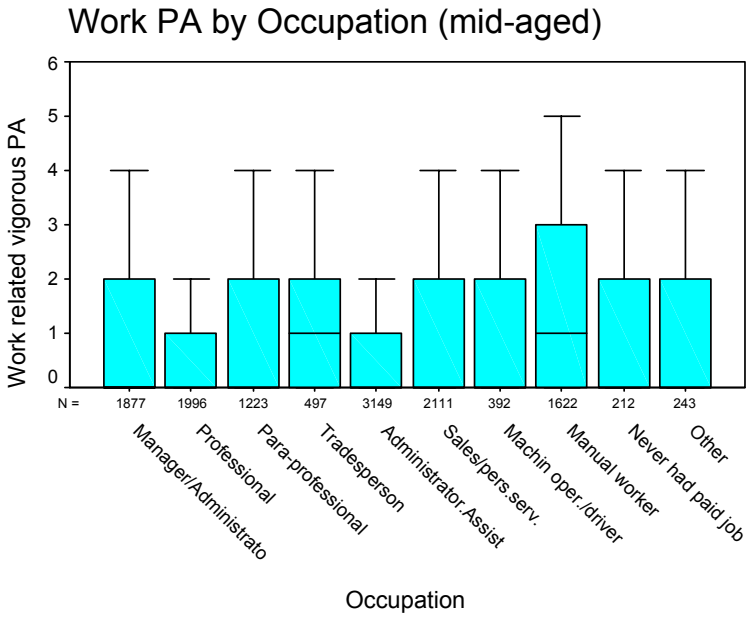
In survey 2 the mid-age women were asked to estimate the total time spent altogether in work (paid or unpaid) doing vigorous activity (such as labouring, farm work, heavy gardening, heavy work around the yard, heavy housework etc)

Responses to this question were heavily skewed, with a median time in work-related activity of 30 mins (inter-quartile range 0-240). If we estimate this type of vigorous work to have an average MET value of 5 (Ainsworth et al, 2000), then the proportion of women in this cohort reaching the 600 MET.mins 'threshold' for PA would increase from 51% (based only on responses to the walking, moderate and vigorous leisure time activity questions) to 62% if time spent in all types of work-related activity is included.

The Active Australia item about time spent in vigorous household or garden chores was included in the second surveys of the younger and older women and the third survey of mid-age women. When responses to this item were included in the algorithm to estimate the proportion of women reaching the 600 MET.mins threshold, the proportion of women categorised as 'active' increased among young women from 55% to 76% (N=9,432), among mid-age women from 49% to 63% (N=12,338) and among older women from 37 to 63% (N=8,914).

Figure 2: Median number of sessions/week that work (paid or unpaid) involves exertion for more than 20 minutes without stopping, by occupation category in the younger (N=14,367, top panel) and mid-age (N=13,322, below) cohorts. (Survey 1 data).





Key for 'work related vigorous PA'

KEY	0	1	2	3	4	5
Category	Never	Once a week	Two or three times a week	Four, five or six times a week	Once every day	More than once every day

Figure 3: *Mean (SE) survey 1 PA scores by occupation category in the younger (N= 14,370, top panel) and mid-age (N= 13,313, bottom panel) cohorts. (Note that the PA scores are based primarily on leisure-time physical activity).*

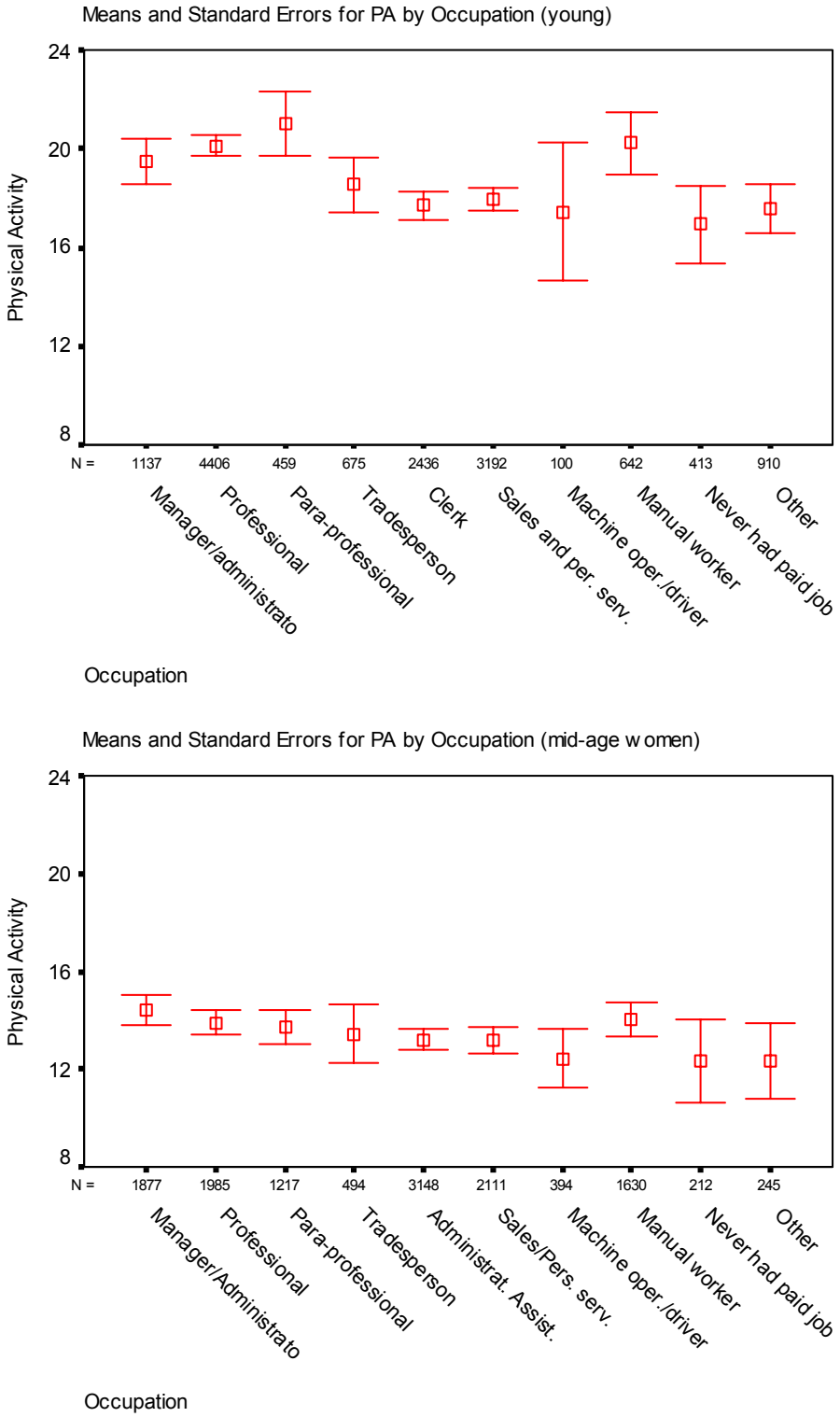
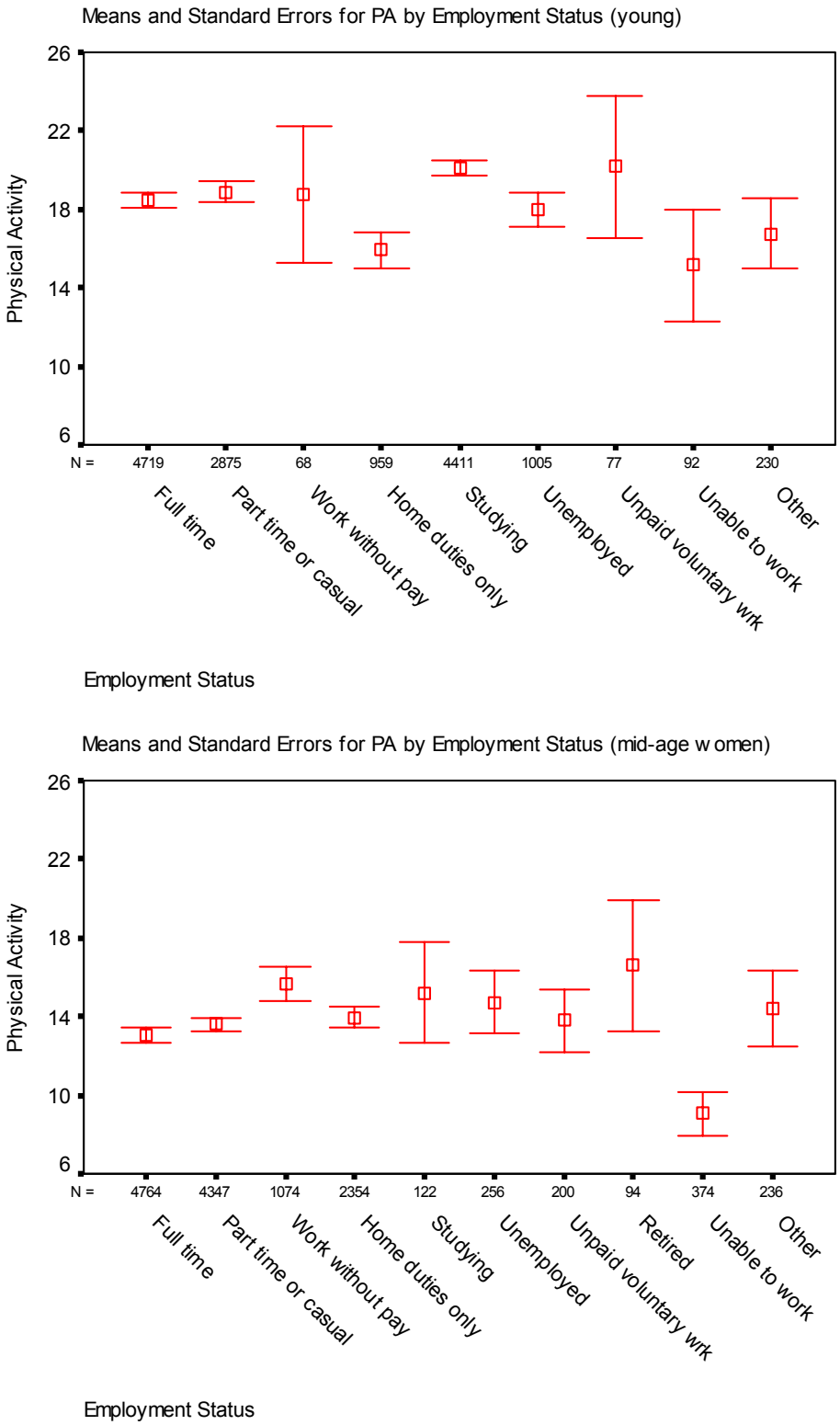


Figure 4: *Mean (SE) PA scores by employment status for younger (N=14,436, top panel) and mid-age (N= 13,821, bottom panel) women. (Survey 1). (Note that the PA scores are based primarily on leisure-time physical activity).*



4 Physical Activity, Symptoms, Conditions, GP Use and Well-Being

In due course, the data from these three cohorts will be useful for clarification of dose-response issues relating to the role of physical activity in the prevention and management of many chronic health problems. To date, cross-sectional survey 1 data have been used to explore relationships between PA and physical and mental well-being, symptoms and conditions, with adjustment for confounding factors such as smoking and SES. The direction of these relationships has not yet been clarified using longitudinal analyses.

Physical activity and symptoms and conditions

There were cross sectional relationships between survey 1 PA scores and symptoms and conditions, as summarised in Table 2. After adjusting for multiple potential confounding variables, (eg smoking, alcohol, dieting, BMI, stress, education, contraception, HRT etc) the odds ratios for many of these relationships indicated a 20–30% lower odds for reporting symptoms and conditions when moving from the 'none' to 'low' category of PA. (See Table in Appendix for actual odds ratios).

Table 2: Relationships between PA and symptoms and conditions in each cohort. (Survey 1).

	YOUNGER	MID-AGE	OLDER
Symptoms			
Tiredness	***	***	***
Constipation	***	***	***
Back pain	***	**	***
Sleeping difficulties	ns	***	***
PMS	**	-	-
Heavy periods	**	-	-
Severe period pain	*	-	-
Stiff and painful joints	-	***	***
Conditions			
Hypertension	-	ns	***
Osteoporosis	-	-	***

Symbols indicate significant relationship between (increasing) PA scores and decreased odds of reporting symptoms. *** p<0.0001; ** p<0.001;* p<0.01; ns = no significant association; '-' = question not asked.

Physical activity and use of GP services

Exploration of the relationship between PA scores in survey 2 and high use of GP services (defined as ≥ 7 annual visits in the younger cohort, ≥ 5 visits in the mid-age cohort, and ≥ 9 visits in the older cohort) indicated significant associations in all three cohorts; women in the 'none' category for PA were more likely to report high GP use than women in any of the other PA categories in all three cohorts ($p<0.0001$ for all comparisons). (See Figure 5).

Physical activity and well-being

Trend curves for the relationship between survey 1 PA scores and three sub-scale scores (vitality, mental health and general health) of the SF-36 (measure of health-related quality of life or well-being, Ware and Sherbourne, 1992) were reported in 2000 (Brown et al 2000). The shape of the vitality and general health curves showed a greater increase in SF-36 scores across the 0-15 range of PA scores, with smaller subsequent increases in well-being with increasing PA. Mental health scores increased most markedly with PA scores of 0-10, and remained fairly constant across increasing PA after that point, especially in the older women. Note that the 'threshold' for 'sufficient activity' is equivalent to a score of 15 on this scale.

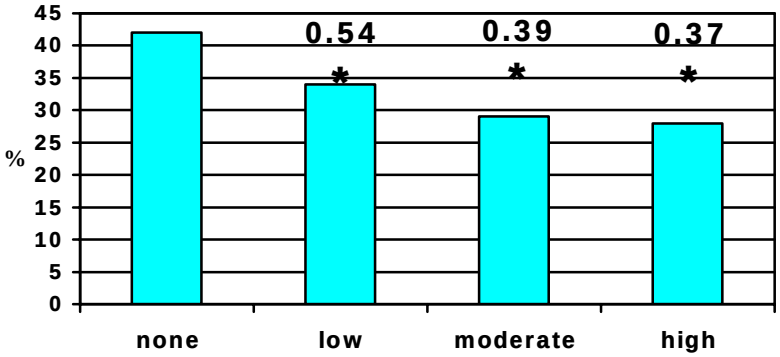
The data did not suggest a specific 'cut-point' 'in PA score above which there are specific health benefits, but rather a gradual increase in health-related quality of life (well-being) with increasing PA, with the most marked increases observed in the PA score range of 0-15 or 0-20. This suggests that getting the most sedentary women to be a little more active (for example, moving from a score of 0 to a score of 10) will be associated with greater improvements in well-being than getting those who are already 'active' (score >15) to be more active.

Trend curves for the SF-36 physical and mental component summary scores (PCS and MCS) and weekly minutes of PA[1] reported in survey 2 are shown in Figure 6a. These graphs clearly indicate a similar relationship between PA and well-being to those shown for the survey 1 data, with the greatest increases in well-being associated again with increases in weekly minutes of PA at the lower end of the PA range. (See Figure 6a).

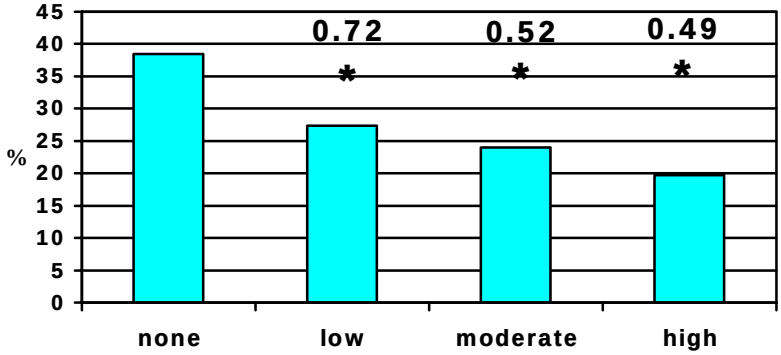
[1] (for weighted minutes, time in vigorous activity is weighted by two to account for its greater intensity)

Figure 5: Percentage of women in each PA category reporting 'high' use of GP services in the younger (top), mid-age (centre) and older (bottom) cohorts. (Survey 2 data). (Numbers indicate odds ratios for high GP use by women in each PA category, compared with women in the 'none' category. Asterisks indicate significant difference between categories, when compared with 'none').

YOUNGER



MID-AGE



OLDER

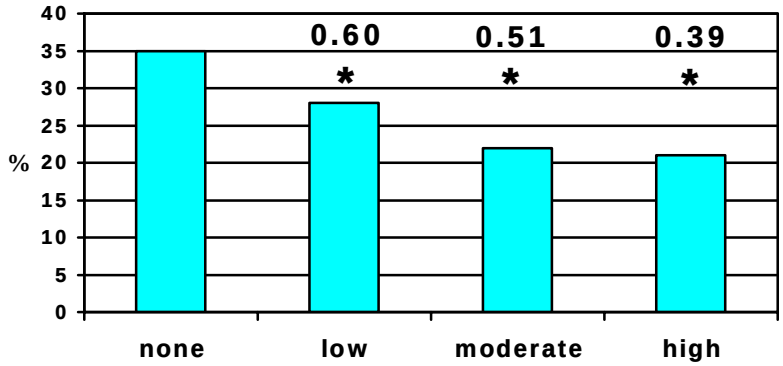
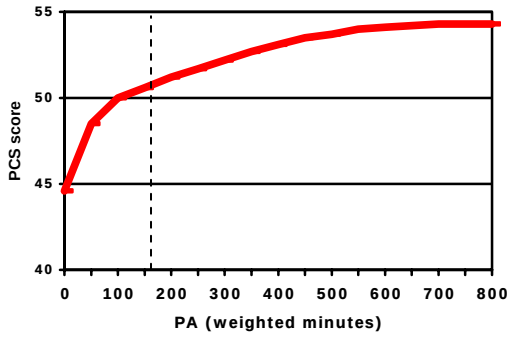
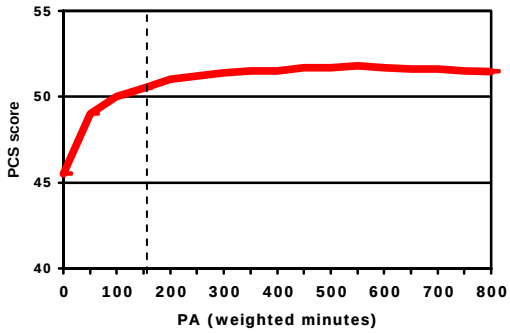


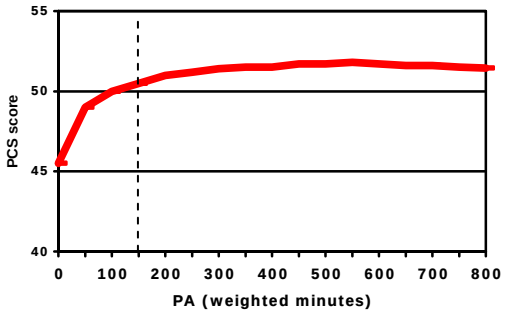
Figure 6a: Relationships between Physical Components Summary (PCS) and Mental Components Summary (MCS) scores of the SF36 with weighted minutes of PA in the younger (top panel), mid-age (centre) and older (bottom) cohorts. (Survey 2 data). (Dashed lines indicate position of the 150 minute 'threshold' for 'sufficient activity').

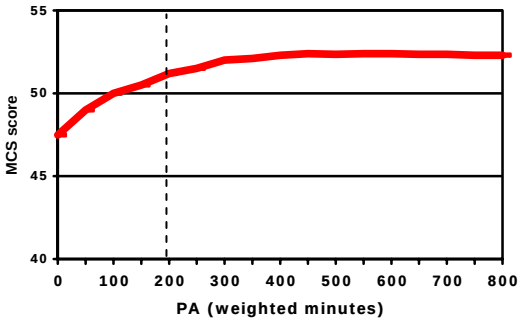
Younger cohort



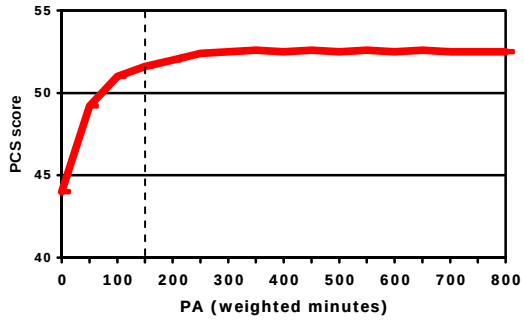


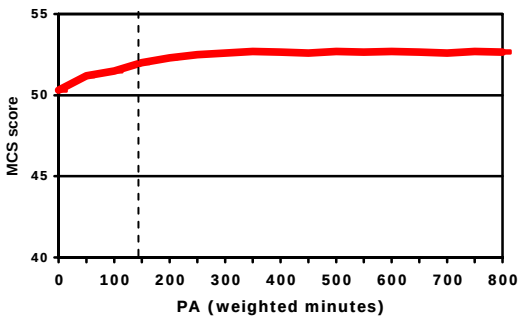
Mid-age cohort





Older cohort





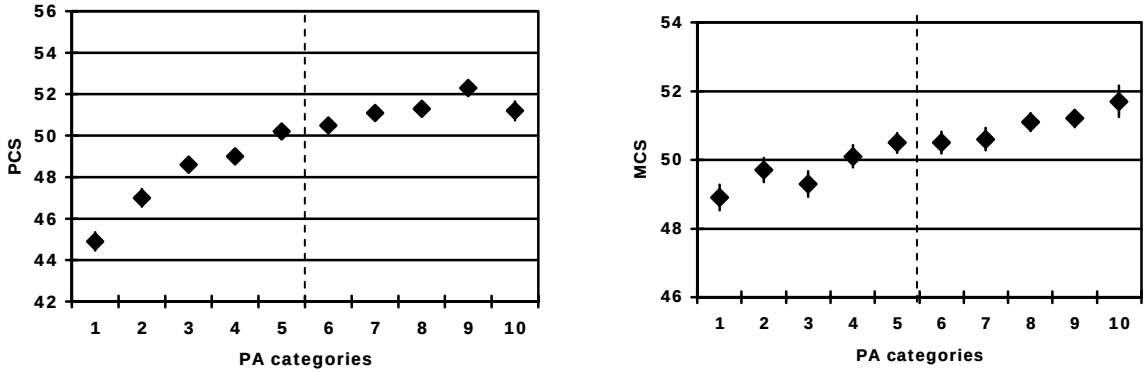
How much activity for health benefit?

These graphs can be used to provide data which may be useful in the current debate about the amount of PA which is necessary for good health. For example, in the young and mid-age cohorts, mean physical components summary scores (PCS) for those reporting 150 minutes of moderate intensity activity per week are approximately 12% higher respectively than for women who are sedentary (no activity). For those who report 300 minutes of activity per week, the PCS scores are only further improved by about 2%. Among the young women, PCS scores appear to increase further with increasing PA, while among the mid-age women there is little further increase in PCS with increasing PA.

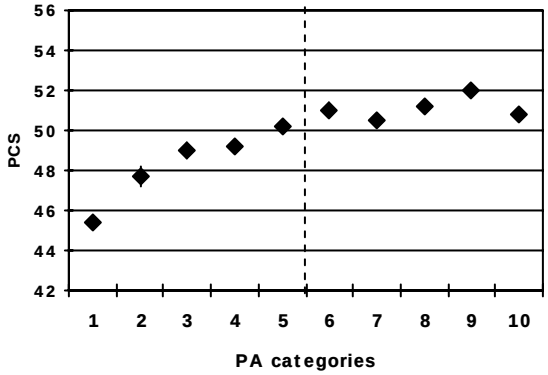
Another way of illustrating the relationship between PA and health-related quality of life is shown in Figure 6b. In this figure, mean PCS and MCS (mental components summary) scores from survey 2 are shown by ten categories of PA score. From the PCS graphs it is clear that the largest differences in physical well-being are seen in all three cohorts between category one (no PA) and two (1-120 minutes/week). While acknowledging the limitations of these cross-sectional data, they do support the notion that there would be population health benefits if all the women currently classified as 'inactive' (45% of the young women, 49% of the mid-age women and 62% of the older women) could be encouraged to do some physical activity. In contrast, there is a weaker relationship between PA and MCS scores (note the different scale in the right hand panel of Figure 6b), but optimal MCS scores appear to be associated with the eight and ninth categories of PA, which equate with about one hour of PA per day. Note that in these graphs, the current recommendation of 150 minutes PA a week is between the fifth and sixth category on the x axes of the graphs, and is indicated by the dashed lines.

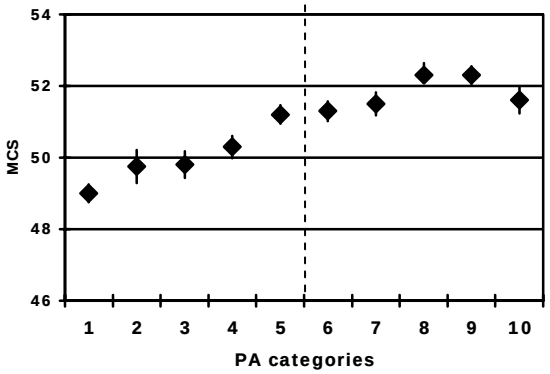
Figure 6b: Mean (SE) PCS and MCS scores by PA categories in younger (N=9,412, top), mid-age (N=12,114, middle) and older (N=9,549, bottom) women. (Survey 2 data).

Younger women

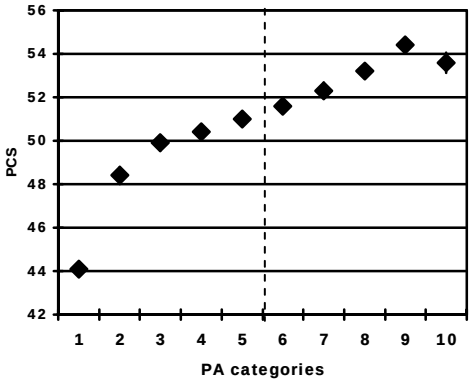


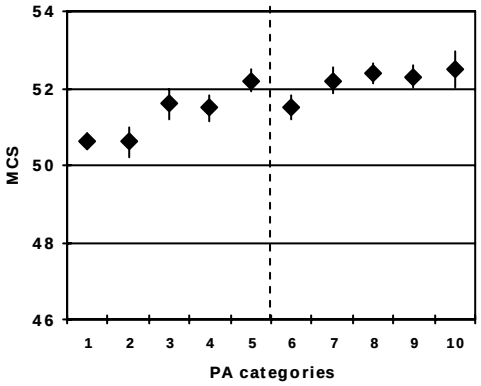
Mid-age women





Older women





KEY

Category	1	2	3	4	5	6	7	8	9	10
Younger N	884	734	800	814	1107	980	864	1301	1440	508
Mid-age N	2006	468	759	1053	1364	1147	974	1325	1360	770
Older N	2907	616	640	746	829	757	572	829	827	341
MET.mins	0	1-120	121-240	241-360	361–600	601-840	841–1080	1081-1680	1681–3360	>3360
Minutes	0	1-30	31-60	61-90	91-150	151-210	211-270	271-420	421-840	>840

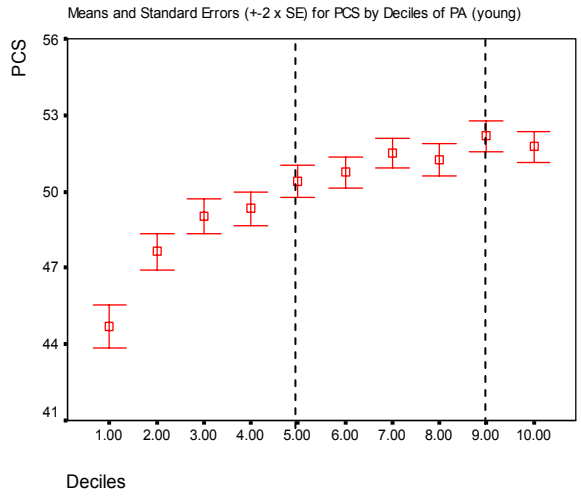
One hour of physical activity per day?

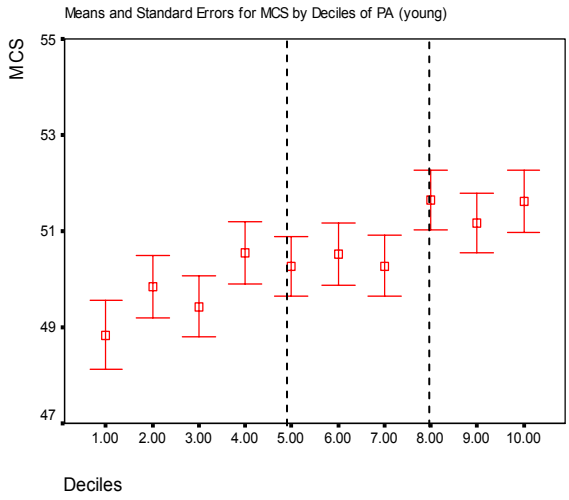
A recent US Institute of Medicine report has suggested that the current guidelines for 'sufficient activity for health benefit' (which suggest 30 minutes of moderate (leisure time) activity on most days, which is taken in Australia to equate with 150 minutes of activity per week) set the 'benefit' threshold too low (Food and Nutrition Board, Institute of Medicine, 2002). This report recommends that in order to prevent most chronic health problems, the threshold should be raised to 60 minutes per day, or 420 minutes per week of activity. Although the data shown here are cross-sectional, they do have implications for this debate.

In Figure 7 the PA data are shown for approximate 'deciles' of PA. There are limitations with this approach, because the data are divided into categories with approximately equal numbers of women in each category. The result is that there is some overlap of scores between categories, which cannot be avoided because of the way the PA scores are distributed. It is however possible to see from this Figure that the proposed new threshold of 420 minutes per week (1680 MET.mins) lies in the eighth 'decile' of PA for young women, and in the ninth 'decile' for the mid-age and older women. In order to achieve this 'new' PA target, mid-age women who are currently in the lowest one third of the sample for PA (first three 'deciles') would have to increase their activity time by almost 400 minutes per week (from an average of 22.5 minutes) to achieve this target. As our data show, many women have difficulty achieving current guidelines of 150 minutes of activity per week, so it is likely that most women would see this higher target as quite unrealistic.

Figure 7: Mean (SE) PCS and MCS scores by deciles of PA score in younger (N=9,412, top), mid-age (N=12,114, middle) and older (N=9,549, bottom) women. (Survey 2 data). [Dashed vertical lines show approximate position of 'thresholds' of 600 (150 mins) and 1680 MET.mins (420 minutes/week or 60 mins/day)].

Younger women

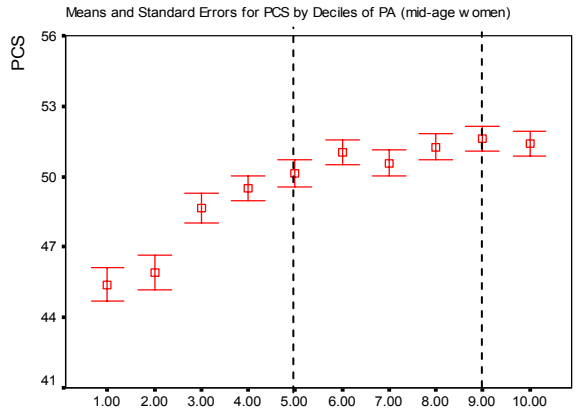


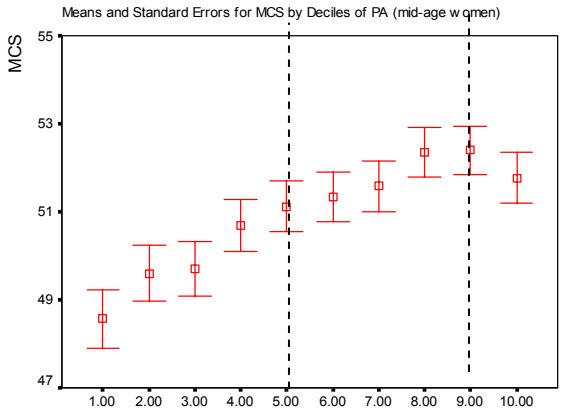


KEY

Decile	1	2	3	4	5	6	7	8	9	10
N	900	915	917	925	928	915	922	920	920	908
MET.mins	0–33	40–180	180–330	330–491	491–705	705–930	930–1260	1260–1740	1740–2520	2520–17485

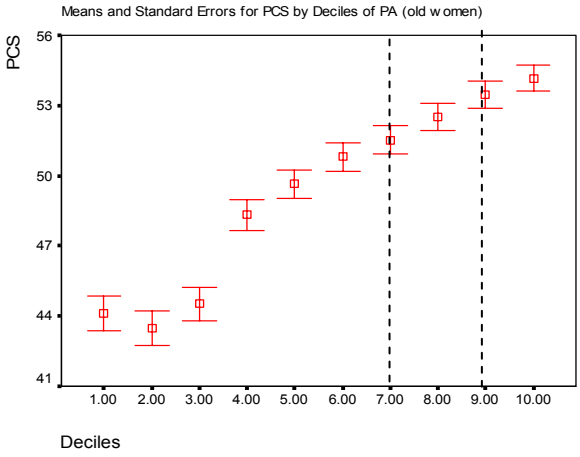
Mid-age women

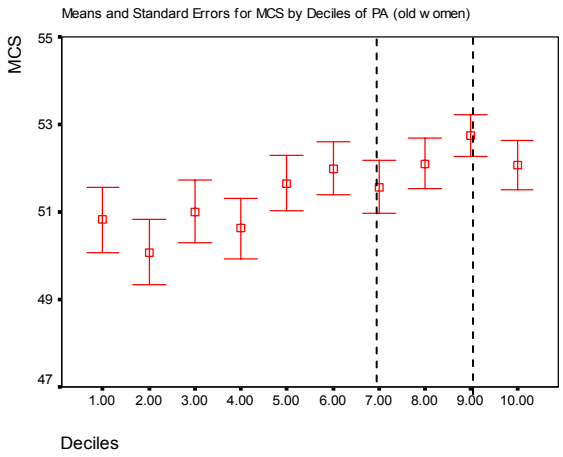




Decile	1	2	3	4	5	6	7	8	9	10
N	1110	1102	1104	1107	1106	1090	1098	1100	1113	1098
MET.mins	0-0	0-90	90-270	270-440	440-600	600-840	840-1140	1140-1620	1620-2670	2670-18,000

Older women





KEY

Decile	1	2	3	4	5	6	7	8	9	10
N	798	814	813	808	832	827	829	824	836	829
MET.mins	0-0	0-0	0-0	0-180	180-360	360-540	540-810	810-1260	1260-1980	1980-32,625

5 Changes in Physical Activity with Age

Younger Women

Repeated cross-sectional data from this cohort suggest no change in the distribution of PA categories between survey 1 (56% 'active') and survey 2 (55% 'active'). However, longitudinal analysis indicates that, for almost 40% of the sample, physical activity category changed between survey 1 and survey 2, with approximately 20% of the women changing from being 'active' to 'inactive' and another 20% changing from being 'inactive' to 'active'. After adjustment for age, other socio-demographic variables, BMI and physical activity at survey 1 (but not for regression to the mean), the odds ratios for being inactive at survey 2 were higher for women who reported getting married, (OR = 1.46, 95% CI:1.27–1.68) having a first (OR = 2.27, 95% CI: 1.90–2.59) or subsequent child (OR =2.06, 95% CI: 1.70–2.51) or beginning paid work (OR = 1.15, 95% CI: 1.03–1.20) than for women who did not report these events. In contrast, odds ratios for inactivity at survey 2 were lower among those who reported returning to study (OR = 0.77, 95% CI: 0.63-0.94) or changed work conditions (unspecified) (OR = 0.82, 95% CI: 0.74–0.90) (Brown & Trost, 2003).

Young women who married, had a baby or started paid work between survey one and survey two were therefore most likely to have changed from being 'active' at survey one to 'inactive' at survey two.

Mid-Age Women

Between surveys 2 and 3, the proportion of mid-age women meeting guidelines for health enhancing physical activity (150 minutes or 600 MET.mins per week) declined from 53% to 47%. Longitudinal analysis indicated that, for almost 36% of the cohort, physical activity status changed between survey 2 and 3, with approximately 21% of women changing from 'active' to 'inactive' and a further 15% changing from 'inactive' to 'active.' After adjustments for income, language spoken at home, BMI and physical activity status at survey 2 (but not for regression to the mean), the odds ratio for being 'active' at survey 3 was 1.5 (95% CI 1.2–1.9) among women who entered retirement, compared with those who did not retire. Conversely, the odds ratios for being active at survey 3 were lower for women who reported a significant change in work conditions (hours, conditions, responsibilities), compared with those who did not (OR = 0.86; 95% C.I. 0.76–0.96). Experiencing menopause, divorce, death of a spouse or partner, spouse or partner retiring from work, and children 18 years and under leaving home were not associated with physical activity status at survey 3. Of note, women who were ‘active’ at survey 2 were more than 3 times more likely than their inactive counterparts to be 'active' at survey 3 (OR = 3.2 95% CI 2.9 – 3.6).

Mid-age women who remained in the paid work-force, especially those who reported changes in work responsibilities, were therefore most likely to have changed from being 'active' at survey one to 'inactive' at survey two.

Older Women

Among women in the older cohort, those who reported in survey 2 that, in the last three years, they had been diagnosed with arthritis, osteoporosis, diabetes, heart disease, stroke, asthma, bronchitis or emphysema, or depression, as well as those who reported having had hip or knee surgery in this time period, were more likely to have decreased their PA levels (or to have become completely sedentary) since survey 1. Those who

reported that they had been widowed since the time of the last survey were more likely to report adoption of increased levels of PA.

Older women who were able to maintain or increase their physical activity between surveys 1 and 2 had better mental health scores (sub-scales of SF-36) at survey 2 than at survey 1 (Lee and Russell, 2003).

Part Two: Body Weight and Obesity

1 Measures

In the ALSWH surveys self-reported height and weight are used in each survey to calculate Body Mass Index (BMI) using the formula: weight in kg/(height in m)^2.

For the mid-age cohort, categories of BMI are based on the National Health and Medical Research Council's classification in which 'underweight' is defined as BMI <20, 'healthy weight' as BMI ≥20–≤25, 'overweight' as BMI >25–≤30, 'obese' as BMI >30–≤40 and morbidly obese as BMI >40.

Because of the greater proportion of women in the younger cohort with BMI <20, an adaptation of the WHO BMI categories is used: 'very underweight' is defined as BMI <18.5, 'underweight' as BMI 18.5–<20, 'healthy weight' as BMI 20–<25, 'overweight' as BMI 25–<30, and 'obese' as BMI ≥30. (In the WHO categories 'underweight' is defined as <18.5 and 'healthy' as 18.5–24.9. The overweight and obese categories are the same as those used here, but the WHO further subdivides the obese category into three categories of obesity).

Because of the complex inter-relationship between BMI and illness, in this report the focus is on results for the younger and mid-age cohorts, with only selected data from the older cohort.

2 Descriptive Epidemiology of Body Mass Index

Mid-Age Women

At survey 1, 7% of the mid-age women were classified as underweight, 46% as healthy weight, 28% as overweight, 18% as obese (including 2% with BMI >40). This distribution is different from that reported in the 1995 National Nutrition Survey (NNS, based on measured height and weight, see Table 3). The difference is consistent with previous estimates of self reported BMI which show that women tend to over-estimate their height and under-estimate their weight (compared with measured values), resulting in lower estimates of BMI and lower estimates of overweight and obesity in self-report data. It is therefore likely that our estimates of the health risks of overweight and obesity are underestimated.

The mean (SD) for reported height in the mid-age cohort at survey 1 was 164 (6.95) cm, compared with 161.1 in NNS. Mean reported weight at survey 1 was 68.2 (14.49) kg, compared with 71.2 in the NNS, and mean BMI was calculated to be 25.7 (5.28) kg/m^2, compared with 27.4 in the NHS. (National Nutrition Survey, 1995).

At survey 1, women from rural and remote areas, those with lower levels of education and those who had a hysterectomy were more likely to have BMI ≥25 (Brown, Dobson & Mishra, 1998).

At survey 2 there were clear inverse associations between education, occupation, partner's occupation and partner's income, and BMI (Brown and Trost, 2001).

Table 3: Distribution of BMI categories in the three cohorts at survey 1 and 2, with corresponding data from the 1995 National Health Survey

	BMI categories				
	<18.5 %	**18.5–<20 %**	**20–<25 %**	**25–<30 %**	**≥30 %**
YOUNGER WOMEN					
Survey 1 1996 N = 12,686 Age 18–23	10.4	16.4	51.5	15.3	6.4
Survey 2 2000 N = 8,209 Age 22–27	7.3	12.6	49.3	19.8	11.0
National Nutrition Survey 1995 N = 833 Age 19–24	5.4	15.0	49.6	17.4	8.6
MID-AGE WOMEN					
Survey 1 1996 N = 13,197 Age 45–50	1.9	5.3	46.3	28.2	18.4
Survey 2 1998 N = 10603 Age 52–57	1.6	4.4	42.9	30.7	20.4
National Nutrition Survey 1995 N = 1852 Age 45–64	1.0	2.3	34.3	35.5	25.1
OLDER WOMEN					
Survey 1 1996 N = 11,421 Age 70–75	3.2	5.3	44.6	32.9	13.9
Survey 2 1999 N = 9331 Age 73–78	4.2	6.0	43.0	32.4	14.4
National Nutrition Survey 1995 N = 1221 Age 65 and over	1.6	3.0	30.9	35.6	22.9

Younger Women

At survey 1, a much higher proportion of women in this cohort was classified as underweight, compared with the mid-age cohort. In this cohort the distribution of BMI categories was closer to that reported in the NHS survey.

Mean reported height for the young women at survey 1 was 166.3 (SD 7.7) cm, compared with 163.9 in the NNS. Mean reported weight was 62.6 (12.7) kg compared with 63.4 in

the NNS, and mean BMI was calculated to be 22.7 (4.7) kg/m^2, compared with 23.5 in the NNS. (National Nutrition Survey, 1995).

At survey 1, young women from rural or remote areas, those with lower levels of education and occupation, and those who had at least one child were over-represented in the BMI ≥30 category. In contrast, there was greater representation of smokers in the BMI <18.5 category. At survey 2 there were also clear inverse associations between education, occupation and income, and BMI (Brown and Trost, 2001).

3 Relationships between BMI, Symptoms, Conditions and GP Use

Cross sectional data from survey 1 confirm the results of previous studies which document clear associations between increasing BMI and increasing likelihood of many symptoms and conditions in both the mid-age and young women. Of particular interest in mid-age women are the strong associations between leanness and decreased likelihood of hypertension, diabetes and cholescystectomy (gall bladder removal) (see Table 4). Odds ratios for reporting these problems were greater than two among mid-age women with BMI in the 'overweight' range, and greater than four among women in the obese category (BMI ≥30). Even among young women, odds ratios for hypertension, asthma, headaches, back pain, sleeping difficulties, irregular periods and high use of GP services were significantly higher among those with BMI>30. They were however significantly lower for reporting low iron (see Table 4). In contrast, among young women with low BMI (<18.5) odds ratios for reporting irregular periods and low iron were significantly higher than for women in the 'healthy' weight category (Brown, Mishra, Kenardy & Dobson, 2000).

Using both continuous and categorical data to explore the relationships between BMI and SF-36 summary and sub-scales demonstrated that in mid-age women, low BMI is associated with fewest physical health problems, and the NHMRC recommended 'healthy weight range' (BMI 20-≥25) is associated with optimum mental health, lower prevalence of tiredness and lowest use of health services. Among the young women, mean scores for the SF-36 subscales for physical functioning, general health and vitality were highest for women with BMI in the range 18.5–25.

Acknowledging the limitations of the cross-sectional nature of these data, the results indicate that the deleterious effects of overweight can be seen at a relatively young age, and that BMI <25 is associated with fewer indicators of morbidity in both younger and mid-age women. However, BMI <18.5 is also associated with some health problems, and it is likely that these will be exacerbated, and others will develop over time, if 'underweight' is maintained. From a public health perspective, the data provide strong support for the recommended healthy BMI range of 20–25 for Australian women.

Table 4: Associations between BMI category and health indicators for younger and mid-age women. (Survey 1 data).

	Younger women N= 12686	Mid-age women N=13197
Conditions		
Hypertension	++	++
Diabetes		++
Low iron	-	
Asthma	+	
Symptoms		
Headache	+	
Back pain	+	+
Tiredness		+
Irregular periods	+-	
Sleeping difficulties	+-	
Surgery		
Cholescystectomy		++
Hysterectomy		+
Health Care Use		
GP consultations	+	+
Specialist consultations		+

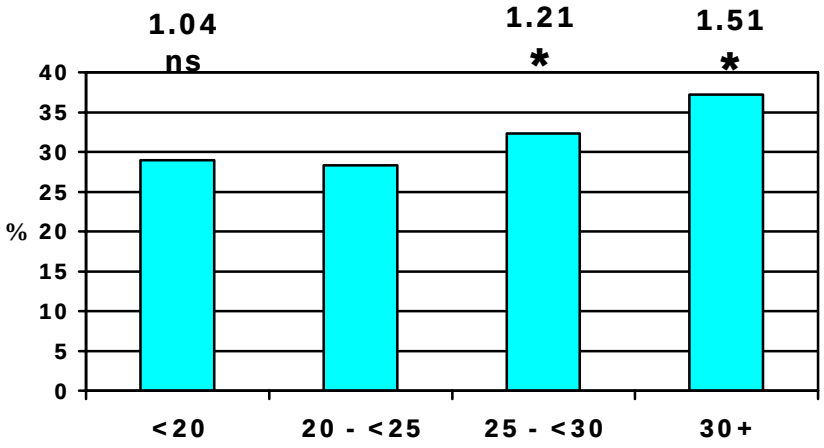
++	more than twice as likely if BMI>25, and more than three times as likely if BMI>30
+	significantly more likely if BMI>30
-	significantly more likely if BMI<18.5
+-	significantly more likely if BMI is either <18.5 or >30.

Use of GP services

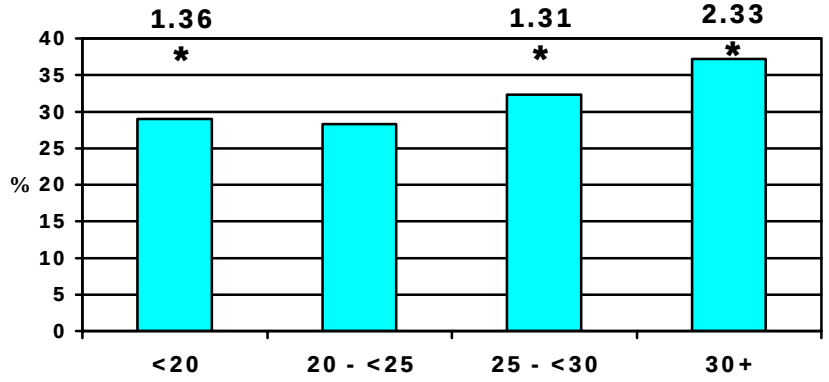
Exploration of the relationship between BMI scores in survey 2 and high use of the family GP (defined as ≥7 annual visits in the younger cohort; ≥ 5 visits in the mid-age cohort, and ≥ 9 visits in the older cohort) indicated significant associations in all three cohorts, with women who were in the overweight or obese categories significantly more likely to be high users of GP services than those in the 'healthy' category ($p<0.0001$ for all contrasts except overweight v acceptable weight in young women, $p=0.004$). Mid-age women in the underweight category were also more likely to be high users than those in the healthy weight range ($p=0.002$). (Differences between 'underweight and 'acceptable weight' were not statistically significant in the younger and older cohorts).

Figure 8: Percentage of women in each BMI category reporting 'high' use of GP services in the younger (top), mid-age (centre) and older (bottom) cohorts. (Survey 2 data). (Numbers indicate odds ratios for high use of GPs among women in each BMI category, compared with those in the 'healthy' BMI category, and asterisks indicate statistically significant differences, compared with the 20-<25 category).

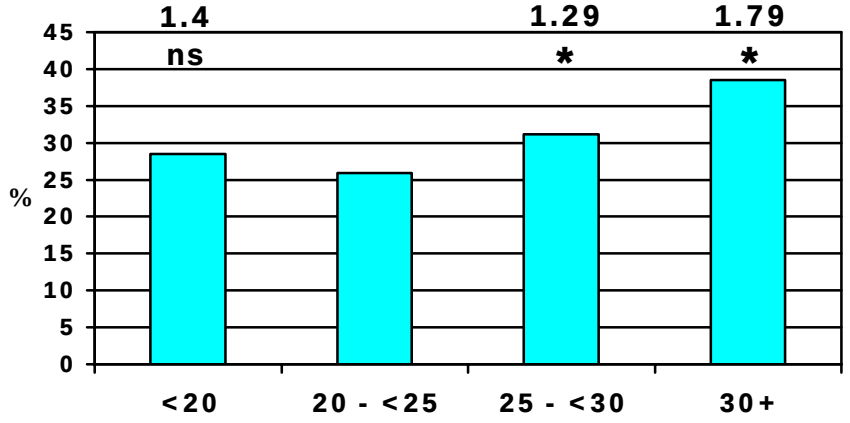
YOUNGER



MID-AGE



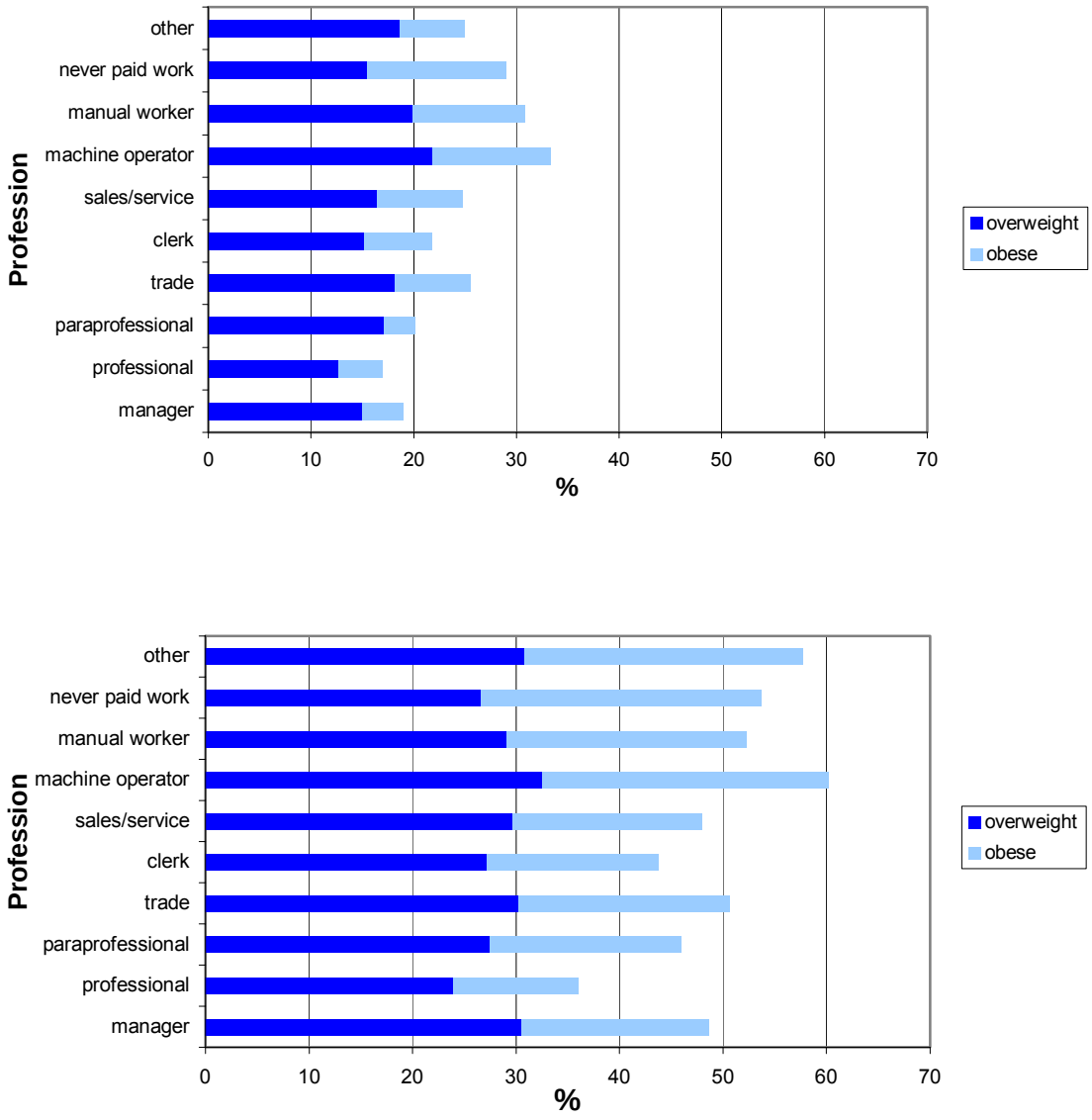
OLDER



4 BMI and work

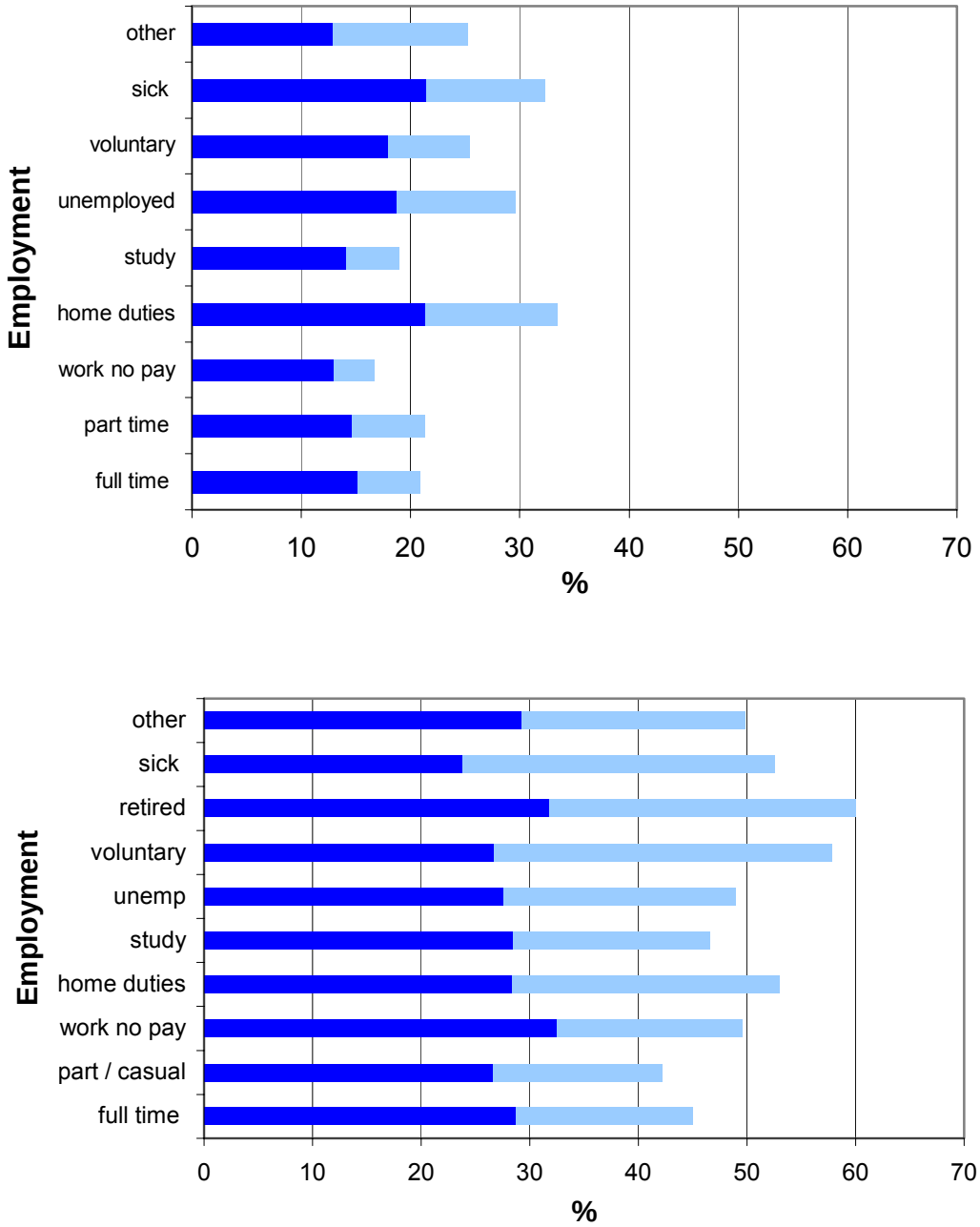
The proportions of younger and mid-age women categorised as overweight or obese are shown for each occupation category in Figure 9. Among the younger and mid-age women there was a clear tendency for those in 'blue-collar' occupations to be classified as overweight or obese, with more than half the mid-age women in the 'trade' 'machine operator' and 'manual worker' categories having BMI >25. In both cohorts, rates of overweight and obesity were lowest in the 'professional' occupation category.

Figure 9: Percentage of younger (top) and mid-age (bottom) women in the overweight and obese BMI categories by occupation. (Survey 1 data).



The proportion of women with BMI >30 is also shown by employment status in Figure 10. Among the younger women, those in home duties and those who were unemployed, sick, or doing voluntary work, were more likely to have BMI >30. Among the mid-age women, prevalence of obesity was highest among the volunteers and those who had retired.

Figure 10: Percentage of younger (top) and mid-age (bottom) women in the overweight and obese BMI categories by employment status. (Survey 1 data). (Dark bars = overweight; light bars = obese).



5 Changes in BMI with Age

Younger Women

Comparison of the distribution of BMI categories among more than 7,000 young women for whom we have both height and weight data in survey 1 and survey 2 indicates that the proportion of very underweight women decreased by 10%, and the proportion of overweight and obese women increased by 11% between survey 1 and survey 2 (see Table 5).

Table 5: Proportions of younger women in each BMI category at survey 1 and survey 2.

BMI category	Survey 1 1996 N = 7281 %	Survey 2 2000 N = 7281 %
Very underweight	17.3	7.0
Underweight	14.9	12.4
Healthy weight	47.7	49.6
Overweight	14.2	20.0
Obese	5.9	11.0

During the four-year period between survey 1 and survey 2, BMI was maintained within 5% of survey 1 values in fewer than half (44%) of the young women. There was an increase in BMI of more than 5% of survey 1 values in 41% of these young women, while there was a decrease of more than 5% in BMI in 15% of the women. Those most likely to have maintained the same BMI category group were either still studying or in managerial or professional occupations, had never married and were not mothers. They were more likely to have been in the healthy weight range at survey 1, to report low sitting time, to be non-smokers or ex-smokers, to report no restrictive dieting practices and to never or rarely eat take-away food. After controlling for socio-demographic factors, 'BMI maintainers' remained more likely to have been in the healthy weight range at survey 1, to report less time sitting, and to consume take-away food less frequently than those who gained weight during this period. (Ball, Brown & Crawford, 2002).

In the younger cohort, there was a mean weight change in the overall sample of +2.5kg (SD=6.81, median = 2) between survey 1 and survey 2. Those who gained more than 5% of baseline BMI between survey 1 and survey 2, on average, gained 8.5kg (SD=5.3; median = 7kg). These women were more likely to be married and to have become a new mother between the surveys.

Those who lost more than 5% of 'baseline BMI' between survey 1 and survey 2 were more likely to have been in the overweight/obese BMI category at the time of survey 1, to be ex-smokers or current smokers and to report frequent dieting, or other disordered eating. Women in this group were also more likely to have two or more children and no (paid) work.

Publication of the ALSWH data on weight change in young women (Ball, Brown & Crawford, 2002) provides the first longitudinal data on adult weight change in Australia. Prior to this, serial cross-sectional data have suggested that the prevalence of overweight and obesity has increased in Australia over recent decades. However, we have had no knowledge of weight change patterns in individuals over time; or of which individuals or

groups are gaining weight and becoming obese. The data therefore provide important insights into Australia's current obesity epidemic. The findings of widespread weight gain in this younger cohort, especially among those who were already overweight at survey 1, are concerning, and support the view that the prevention of weight gain and obesity among young adult women is an urgent public health priority. If the rate of weight increase observed in this four-year period is maintained until 2016 (by which time the average age of these young women will be 40), it is estimated that the average weight will be 75 kg and the average BMI will be 27.2. Intervention strategies are needed *now* to prevent continued weight gain in young women, with women of lower socio-economic status, new mothers, and those already overweight as priority target groups.

Mid-age Women

At survey 2 more than half the mid-age women were classified as overweight or obese (BMI>25) (compared with 46% of the same women at survey 1). The proportion classified as overweight increased from 28% at survey 1 to 31% at survey 2. Corresponding data for obesity were 18% at survey 1 and 21% at survey 2.

Longitudinal analysis by PhD student Lauren Williams has confirmed that mid-age is a time of weight gain for Australian women. After excluding women who had a hysterectomy (surgical menopause) the mean (± SD) weight gain in the two year period between survey 1 and survey 2 was 1.0 (4.7) kg (n=9,200), which corresponds with a change in mean BMI from 25.5 (5.0) at survey 1 to 25.9 (5.1) by survey 2, two years later. As for the young women, we can hypothesise that, if the rate of weight gain persists, then by the time this cohort reach the age of 65, their average weight will be 68.2kg and their average BMI will be 29.1.

One third of the cohort gained 2.25 kg or more in the two-year interval, an amount shown to be clinically significant in contributing to metabolic syndrome in overweight women. Sixteen percent of weight gainers increased weight by 4.5 kg or more, while 15% decreased weight by 2.25 kg or more. Only half the cohort maintained their weight within the range of ± 2.25 kg (~5lb).

This PhD study is also exploring the influence of the menopause transition on weight change. Cross-sectional results at survey 1 showed that women in the late stages of peri-menopause (amenorrhoea for 3 months but less than 12 months) had significantly higher BMI than women at other stages of menopause. Analysis of the relationship between menopause transition status and weight gain showed that women who progressed through both stages of menopause (pre-menopause to post-menopause) in the two year period experienced the highest mean weight gain (1.5 kg), followed by those going through stage two (peri-menopause to post-menopause; 1.1 kg) after controlling for age, height, weight, geographic location, smoking and physical activity at baseline. Women who remained pre-menopausal or those who progressed from pre-menopause to peri-menopause had the lowest mean weight gain (0.9 kg). These findings have implications for prevention of weight gain during the menopause transition. Qualitative data relating to women's perceptions of weight gain and its causes at this life-stage, will be available once Ms Williams' thesis is completed.

Among the mid-age women, there is also an inverse relationship between indicators of socio-economic status [such as employment (paid work, hours of work, shift work, night work), education (age left school, highest qualifications, occupation) and family unit (married, living alone, partners occupation and income)] and the development of obesity related conditions (eg heart disease, back pain, tiredness, stiff joints) between survey 1 and survey 2, such that the more disadvantaged women were more likely to report increased BMI and to develop these problems (Ball, Mishra and Dobson, in press).

Part Three: Relationships Between PA and BMI

1 Physical Activity and BMI

Relationships between BMI and deciles of physical activity at survey 2 are shown in Figure 11.

Among the younger women, there was little variation in BMI with PA. This is likely to be explained by confounding factors such as smoking, which is more prevalent among low active, low BMI women. Among the mid-age and older women, mean BMI for those in the highest categories of PA is two BMI categories less than that of those in the lowest categories.

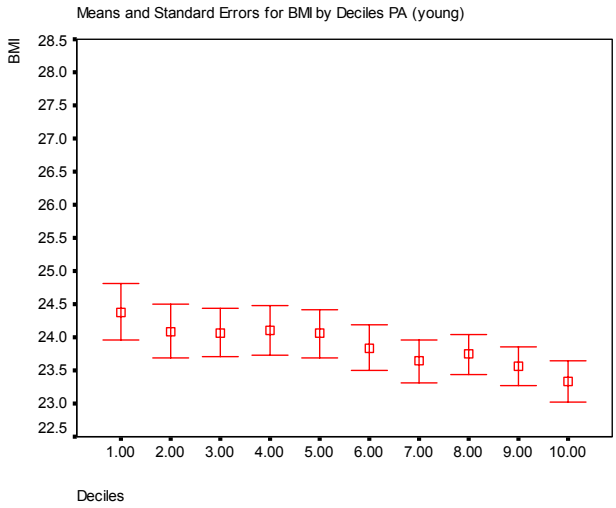
These data can be used to model the weight differences which are associated with increasing levels of physical activity. For example, in the mid-age women, those who report no physical activity have a mean BMI which is two points higher than those in the eighth decile, who report between 1140 and 1620 MET.mins per week (285–405 minutes/week) of activity. Assuming a mean height of 164 cm, there is a weight difference of 5.4 kg between these two groups. While acknowledging the limitations of the cross-sectional nature of these data, they do lend support to the view that adoption of five to seven hours of moderate physical activity per week (about one hour per day) might be associated with a decrease in mean weight of about 5kg.

2 Diet and BMI

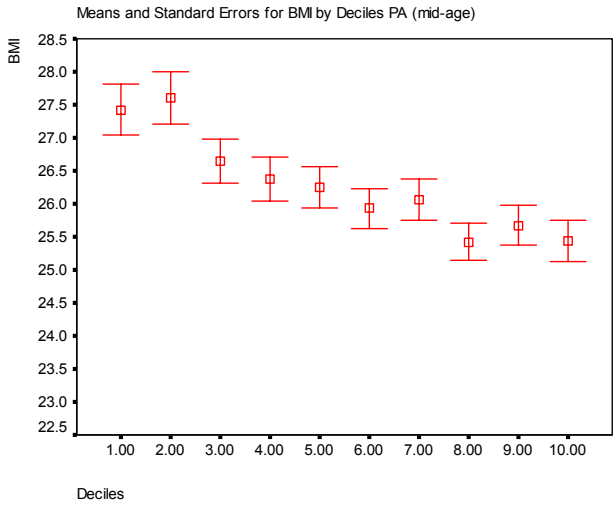
Surveys 1 and 2 for the younger and mid-age women included limited questions assessing eating behaviours. In the younger cohort, takeaway food consumption was an important predictor of weight gain, with women who reported eating takeaway food 'rarely or never', being at lower risk of weight gain than young women who reported consuming takeaway food more frequently (Ball et al., 2000). Survey three for the mid-age and younger women incorporates a comprehensive food frequency questionnaire, so that the relationships between BMI and overall dietary patterns, as well as consumption of specific foods, can be investigated for women in different socioeconomic and occupational sub-groups, in due course.

Figure 11: Mean BMI by deciles of PA scores. (Survey 2 data). Key to deciles is explained in Figure 7.

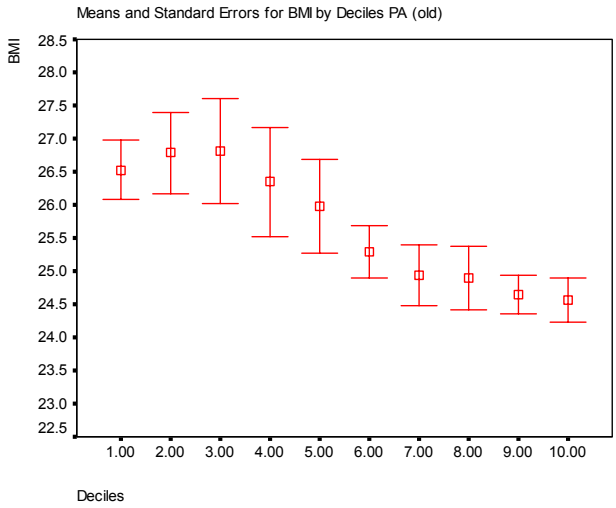
Young



Mid-age



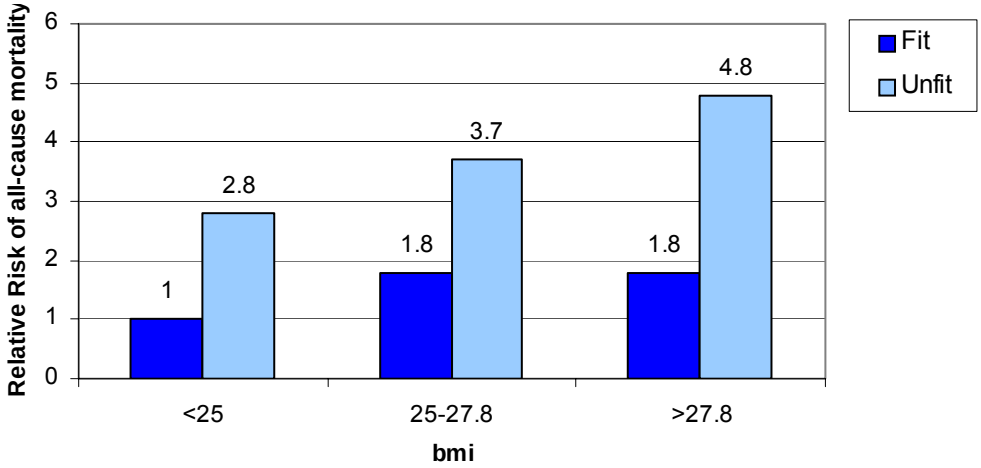
Older



3 Physical Activity, BMI and Health

Data from the Cooper Institute in Dallas indicate that fit men have lower all-cause mortality and CVD mortality than unfit men, and that men who are fit but overweight have lower risk of CVD than unfit men with 'healthy' body weight. The graph below shows relative risk of all-cause mortality in 21,856 men (aged 30-83, followed for an average 8.1 years) in different BMI and 'fitness' groups, compared with 'fit' men with BMI <25 (Lee, Jackson and Blair, 1998). (See Figure 12).

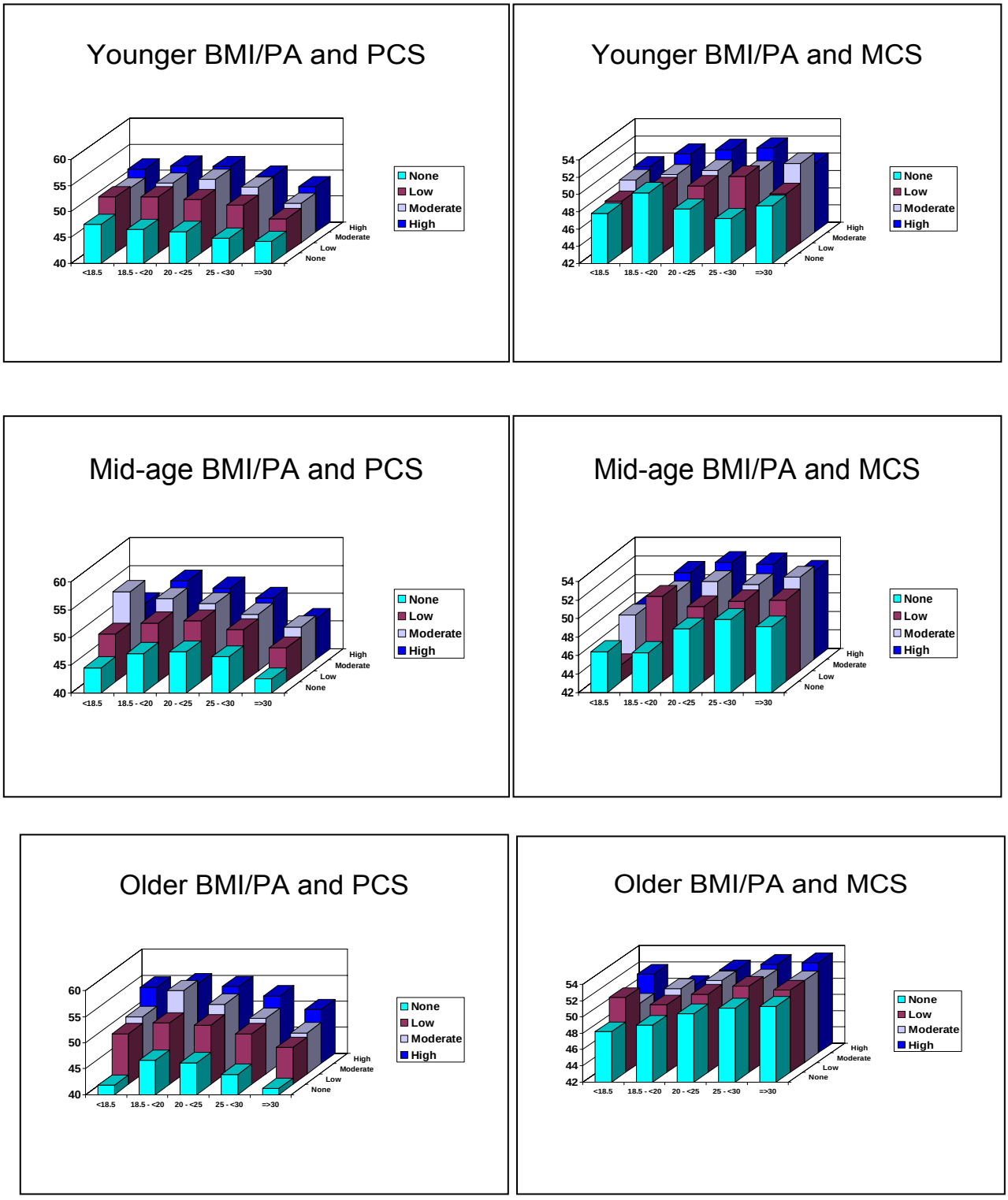
Figure 12: Relative risk of all-cause mortality for men in three BMI categories who are 'fit' and 'unfit' (compared with 'unfit' men with BMI<25; Lee et al, 1998).



The ALSWH does not include data on fitness, but the graphs in Figure 13 illustrate how BMI and PA are related to physical and mental health, as measured by the SF-36.

The data confirm that, women the overweight category who report low, moderate or high PA have significantly higher PCS scores than women in the reference group (healthy weight range with no activity). This is true also for some groups of women in the BMI>30 category (see Figure 13). The same patterns are evident among women who are underweight; those who are inactive have the lowest PCS scores. While the same trends are evident for mental health scores, there is less variability across the PA/BMI categories for MCS. Nonetheless, women with BMI >25 who are active, have higher MCS scores than sedentary, healthy weight women (see Figure 13).

Figure 13: Relationships between BMI (x axis) and PCS/MCS (y axis), for women in the four PA categories (z axis). (Survey 2 data). (Data included in Appendix)



4 Physical Activity, Sitting Time and BMI

Younger Women

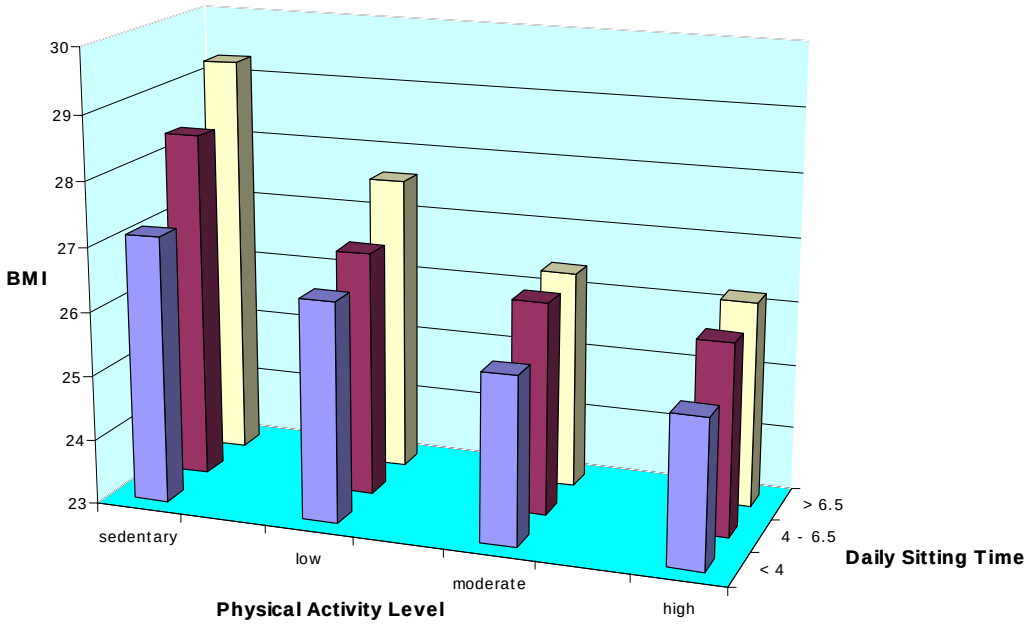
PA was not associated with weight gain among younger women between survey 1 and survey 2. While this finding might be partly attributable to the use of a less sensitive PA measure at survey 1, sitting time was associated with weight gain. The use of a measure of time spent sitting and investigations of its association with BMI in a large population sample is relatively novel. The ALSWH findings, showing a clear increased risk of weight gain with increased sitting time in the younger cohort, support limited existing evidence that sedentary behaviour may be related to BMI, independent of PA (eg see Salmon et al, 2000). Ongoing research is exploring issues of how sitting at work/in leisure interacts with work and leisure-time PA and how this interaction predicts BMI in young women.

Mid-age women

The associations between physical activity, sitting time and BMI were investigated in the middle aged cohort using data collected at survey 3. Weekly physical activity was classified as 'sedentary' (0 – <37.5 MET.mins), 'low' (37.5 - <600 MET.mins), 'moderate' (600 - <1600 MET.mins) or 'high' (≥1600 MET.mins). Tertiles for average daily time spent sitting were created from self-reported time during weekdays and weekends visiting friends, driving, reading, watching television or working at a desk or computer (<4 hrs/day, 4 – 6.5 hrs/day, and >6.5 hrs/day). The independent effects of physical activity and sitting time on mean BMI were tested using a regression model with income, education, language spoken at home, and smoking status included as covariates. It was hypothesised that physical activity level would moderate the deleterious effects of sitting on BMI. That is, the slope for BMI across tertiles of sitting time would be steeper among inactive women than active women.

As expected, significant main effects were detected for activity status ($F_{3,6278}$ = 64.3, p <0.0001) and sitting time ($F_{2,6278}$ = 30.9, p <0.0001). Mean BMI decreased significantly with increasing levels of physical activity, while mean BMI increased significantly with increasing levels of sitting. The presence of a significant physical activity-by-sitting time interaction ($F_{1,6278}$ = 2.38, p=0.027) indicated that the effect of sitting time on BMI was not constant across the four levels of physical activity. The effect of sitting time on mean BMI was stronger among sedentary women and those with low PA than among women with moderate and high levels of physical activity. This suggests that sitting time and leisure time physical activity have synergistic effects on body composition, with participation in leisure-time physical activity partially attenuating the increase in BMI associated with prolonged periods of daily sitting.

Figure 14: Physical activity, sitting time and BMI in mid-age women. (Survey 3 data).



A second analysis was performed to explore the effects of sitting time and physical activity on the relative odds of obesity among the mid-age women. Logistic regression was used to calculate the relative odds of being obese for active compared with inactive women and for women in the medium and high tertiles for sitting versus women in the low sitting tertile, adjusting for income, education, language spoken at home, and smoking status. To determine if physical activity moderated the association between sitting time and obesity status, separate logistic models evaluating the effect of sitting time were run for active ('moderate' and 'high' PA) and inactive ('sedentary' and 'low' PA) women. The results are shown in Table 6. Odds for being obese were more than 40% lower among active women than among inactive women. Sitting for 4 to 6.5 hours per day was associated with 30% higher odds of obesity, while sitting for more 6.5 hours increased the odds of obesity by nearly two fold. The results from Model 2 (inactive women) and Model 3 (active women) provide limited evidence of a moderating effect for physical activity. Among inactive women, the OR for BMI >30 exhibited a clear linear trend, increasing significantly from 1.26 to 2.05, with increasing tertiles of sitting time. In contrast, among the active women, the OR for BMI >30 was significantly higher for both the second and third tertiles of sitting time compared with the first, but was not significantly different for the second and third tertiles of sitting time. These findings suggest that physical activity partially offsets the increase in obesity associated with prolonged periods of sitting.

Table 6: Adjusted odds ratios and 95% CIs for physical activity and sitting time and the likelihood of being obese. (Survey 3 data).

	Odds Ratio *	95% CI	P-value
Model 1 – Total Sample N= 6294			
Daily Sitting Time			
< 4 h	1.0	-	
4 – 6.5 h	1.30	1.11 – 1.51	0.001
> 6.5 h	1.91	1.63 – 2.23	< 0 .0001
Physical Activity Status			
Inactive	1.0	-	
Active	0.59	0.52 – 0.66	< 0.0001
Model 2 – 'Inactive' N=3419			
Daily Sitting Time			
< 4 h	1.0	-	
4 – 6.5 h	1.26	1.03 – 1.55	0.028
> 6.5 h	2.05 #	1.68 – 2.51	< 0.0001
Model 3 – 'Active' N= 2875			
Daily Sitting Time			
< 4 h	1.0	-	
4 – 6.5 h	1.33	1.05 – 1.68	0.02
> 6.5 h	1.44	1.11 – 1.86	0.006

* Odds ratio adjusted for education, income, language spoken at home, and smoking status.
\# Significantly greater than OR for 4 – 6.5 hours of sitting per day (χ^2 = 31.09, df=1 , p < 0.0001)

References and Relevant ALSWH Publications

References

Ainsworth B, Haskell W, Whitt M, Irwin M, Swartz A, Strath S, O'Brien W, Bassett D, Schmitz K, Emplaincourt P, Jacobs D, & Leon A. (2000) Compendium of physical activities: an update of activity codes and MET intensities. *Medicine and Science in Sports and Exercise*; 32(9): S498-S516.

Armstrong, T., Bauman, A., & Davies, J. (2000). Physical activity patterns of Australian adults. Results of the 1999 National Physical Activity Survey. Canberra: Australian Institute of Health and Welfare.

Ball K, Brown W & Crawford D. (2002) Who does not gain weight? Prevalence and predictors of weight maintenance in young women. *International Journal of Obesity*; 26: 1570-1578.

Ball K, Mishra GD & Dobson AJ. (in press) Socioeconomic predictors of the development of health conditions related to obesity. *Preventive Medicine*.

Bauman A, Chey T, Brown W & Booth M. (1998) Validity and reproducibility of an Australian self-reported generic physical activity questionnaire. *Medicine and Science in Sports and Exercise*; S176:1005.

Brown W, Bauman A. (2000) Comparison of estimates of population levels of physical activity using two measures. *Aus NZ Journal of Public Health*; 24(5): 520-5.

Brown W, Bauman A, Chey T, Trost S & Mummery K. (2002) Physical activity measurement project: Convergent validity of three pairs of surveys. *Report to the Commonwealth Department of Health and Ageing, May 2002*.

Brown W, Dobson A, & Mishra G. (1998) What is a healthy weight for middle aged women? *International Journal of Obesity*; 22: 520-528.

Brown W, Mishra G, Kenardy J, & Dobson A. (2000) Relationships between body mass index and well-being in young Australian women. *International Journal of Obesity*; 24: 1360-1368.

Brown W, Mishra G, Lee C, & Bauman A. (2000) Leisure Time Physical Activity in Australian Women: Relationship With Well Being and Symptoms. *Research Quarterly for Exercise and Spor*t; 71(3): 206-216.

Brown WJ & Trost SG. (2001) Socio-economic status, physical activity and obesity – does one size fit all? *Proceedings of the 10th annual scientific meeting of the Australasian Society for the Study of Obesity.* Queensland.

Brown WJ & Trost SG. (in press) Life transitions and changing physical activity patterns in young women. *American Journal of Preventive Medicine*.

Food and Nutrition Board, Institute of Medicine. (2002). Dietary Intake References for Energy, Carbohydrate, Fiber, Fat, Protein and Amino Acids (Macronutrients). (http://books.nap.edu/books/0309085373/html/index.html).

Lee C, & Russell A. (2003) Effects of physical activity on emotional well-being among older Australian women. Cross-sectional and longitudinal analyses, Journal of Psychosomatic Research 54(2):155-160.

McLennan W. & Podger A. (1995) *National Nutrition Survey: Nutrient Intakes and Physical Measurements.* Australia 1995. Canberra: Australian Bureau of Statistics. Catalogue Number 4805.0.

National Heart Foundation Risk Factor Prevalence Studies No.1. Canberra: National Heart Foundation, 1980.

National Heart Foundation Risk Factor Prevalence Study No. 2. Canberra: National Heart Foundation, 1983.

National Heart Foundation Risk Factor Prevalence Study No. 3. Canberra: National Heart Foundation, 1989.

Salmon J, Bauman A, Crawford D, Timperio A, & Owen N. (2000) The association between television viewing and overweight among Australian adults participating in varying levels of leisure-time physical activity. *International Journal of Obesity*; 24:600-606.

Ware JE, Sherbourne CD. (1992) The MOS 36-item short-form health survey (SF-36): I. Conceptual framework and item selection. *Medical Care*; 30: 473-483.

ALSWH publications relevant to obesity, nutrition and physical activity (available from the Study team on request)

Published

Dobson A, Mishra G, Brown W & Reynolds R. (1997) Food habits of young and middle-aged women living outside the capital cities of Australia. *Australian and New Zealand Journal of Public Health*; 21(7): 711-715.

Brown WJ, Dobson AJ & Mishra G. (1998) What is a healthy weight range for middle aged women? *International Journal of Obesity*; 22: 520-528.

Brown WJ, Fuller B, Lee C, Cockburn J & Adamson L. (1999) Never too late: older people's perceptions of physical activity. *Health Promotion Journal of Australia*, 9(1): 55-63.

Brown WJ, Mishra G, Lee C & Bauman A. (2000) Leisure time physical activity in Australian women: relationship with well-being and symptoms. *Research Quarterly for Exercise and Sport*; 71(3): 206-216.

Brown WJ & Bauman A. (2000) Comparison of estimates of population levels of physical activity using two measures. *Australian and New Zealand Journal of Public Health*; 24: 520-525.

Brown WJ, Mishra G, Kenardy J & Dobson AJ. (2000) Relationships between body mass index and well-being in young Australian women. *International Journal of Obesity*; 24(10): 1360-1368.

Kenardy J, Brown WJ & Vogt E. (2001) Dieting and health in young Australian women. *European Eating Disorders Review*; 9: 242-254.

Patterson AJ, Brown WJ, Roberts DCK & Seldon MR. (2001) Dietary treatment of iron deficiency in women of childbearing age. *American Journal of Clinical Nutrition*; 74: 650-656.

Brown WJ & Miller YD. (2002) Too wet to exercise? Leaking urine as a barrier to physical activity in women. *Journal of Science and Medicine in Sport*; 4(4): 373-378.

Ball K & Kenardy J. (2002) Body weight, body image and eating behaviours: relationship with ethnicity and acculturation in a community sample of young Australian women. *Eating Behaviors*; 3(3): 205-216.

Patterson AJ, Young AF, Powers JR, Brown WJ & Byles JE. (2002) Relationships between nutrition screening checklists and the health and well being of older Australian women. *Public Health Nutrition*; 5(1): 65-71.

Brown WJ & Miller YD. (2002) Too wet to exercise? Leaking urine as a barrier to physical activity in women. *Journal of Science and Medicine in Sport*; 4(4): 373-378.

Ball K, Brown W & Crawford D. (2002) Who does not gain weight? Prevalence and predictors of weight maintenance in young women. *International Journal of Obesity*; 26: 1570-1578.

In press

Lee C & Russell A. (In press) Effects of physical activity on emotional well-being among older Australian women: cross-sectional and longitudinal analyses. *Journal of Psychosomatic Research*.

Brown WJ & Trost SG. (In press) Life transitions and changing physical activity patterns in young women. *American Journal of Preventive Medicine*.

Submitted

Ball K, Mishra GD & Dobson AJ. Socioeconomic predictors of the development of health conditions related to obesity. *Preventive Medicine*.

Appendix

1 Odds ratios for summary data shown in Table 2 (from Brown, Mishra, Lee & Bauman, 2000).

Young women

	Tiredness	Constipation	Back Pain	Sleeping difficulties	PMS	Heavy Periods	Severe period pain
PA Score							
<5	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5-<15	0.73 (0.65-0.83)	0.76 (0.65-0.89)	0.83 (0.74-0.94)	0.99 (0.88-1.34)	0.92 (0.82-1.03)	0.96 (0.84-1.11)	0.98 (0.88-1.11)
15-<25	0.71 (0.62-0.80)	0.70 (0.60-0.83)	0.76 (0.68-0.86)	0.93 (0.82-1.07)	0.92 (0.82-1.03)	0.95 (0.82-1.09)	0.87 (0.77-0.98)
25-<40	0.62 (0.54-0.71)	0.57 (0.47-0.68)	0.73 (0.64-0.83)	0.84 (0.74-0.97)	0.84 (0.74-0.94)	0.89 (0.76-1.03)	0.87 (0.77-0.98)
>=40	0.55 (0.47-0.64)	0.58 (0.47-0.73)	0.72 (0.62-0.84)	0.93 (0.79-1.10)	0.78 (0.67-0.90)	0.74 (0.61-0.88)	0.82 (0.71-0.95)

Mid-age women

	Tiredness	Constipation	Back Pain	Sleeping difficulties	Stiff painful joints	Hypertension
PA score						
<5	1.00	1.00	1.00	1.00	1.00	1.00
5-<15	0.70 (0.63-0.78)	0.89 (0.80-1.00)	0.89 (0.80-0.99)	0.90 (0.81-1.00)	0.86 (0.78-0.96)	1.05 (0.92-1.20)
15-<25	0.64 (0.57-0.71)	0.75 (0.66-0.84)	0.85 (0.76-0.95)	0.79 (0.70-0.88)	0.85 (0.76-0.95)	1.01 (0.88-1.17)
>=25	0.50 (0.44-0.57)	0.72 (0.63-0.83)	0.84 (0.74-0.95)	0.77 (0.68-0.87)	0.77 (0.68-0.87)	0.90 (0.77-1.06)

Older women

	Tiredness	Constipation	Back Pain	Sleeping difficulties	Stiff painful joints	Leaking urine	Hypertension	Osteoporosis
PA Score								
<5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5-<15	0.75 (0.66-0.85)	0.80 (0.79-1.00)	0.91 (0.80-1.02)	0.95 (0.84-1.07)	0.89 (0.78-1.00)	0.96 (0.84-1.10)	0.92 (0.82-1.04)	0.78 (0.68-0.90)
15-<25	0.59 (0.52-0.67)	0.82 (0.72-0.93)	0.78 (0.69-0.88)	0.84 (0.75-0.95)	0.84 (0.74-0.95)	0.89 (0.78-1.02)	0.87 (0.79-0.98)	0.72 (0.62-0.83)
>=25	0.47 (0.40-0.56)	0.72 (0.1-0.85)	0.67 (0.58-0.79)	0.67 (0.57-0.78)	0.65 (0.56-0.76)	0.85 (0.71-1.01)	0.68 (0.58-0.80)	0.69 (0.57-0.83)

2 Data for graphs shown in Figure 13

MCS - YOUNGER

BMI	**<18.5**	**18.5-<20**	**20-<25**	**25-<30**	**>=30**
PA					
None	47.8	50.2	**48.3**	47.2	48.7
Low	48.0	49.6	49.8	***50.9***	48.9
Mod	49.3	49.9	50.4	50.3	***51.2***
High	49.6	51.1	51.6	***51.8***	50.0

MCS - MID-AGE

BMI	**<18.5**	**18.5-<20**	**20-<25**	**25-<30**	**>=30**
PA					
None	46.4	46.3	**48.9**	49.9	49.1
Low	43.8	51.2	50.1	***50.7***	***50.8***
Mod	48.0	50.5	51.6	***51.3***	***52.1***
High	47.8	51.4	52.5	***52.3***	***51.5***

MCS - OLDER

BMI	**<18.5**	**18.5-<20**	**20-<25**	**25-<30**	**>=30**
PA					
None	48.2	49.0	**50.4**	51.1	51.3
Low	51.2	50.3	51.6	***52.6***	***52.1***
Mod	49.3	51.1	52.1	***52.3***	***52.1***
High	51.7	50.3	52.2	***52.9***	***53.1***

PCS- YOUNGER

BMI	**<18.5**	**18.5-<20**	**20-<25**	**25-<30**	**>=30**
PA					
None	47.5	46.5	**46.1**	44.8	44.2
Low	50.8	50.8	50.3	***49.2***	46.6
Mod	50.5	51.5	52.2	***50.7***	47.6
High	52.2	52.8	52.7	***50.8***	***48.8***

PCS - MID-AGE

BMI	**<18.5**	**18.5-<20**	**20-<25**	**25-<30**	**>=30**
PA					
None	44.5	47.1	**47.4**	46.5	42.5
Low	48.6	50.6	51.0	***49.4***	46.1
Mod	54.3	53.0	52.1	***50.2***	47.9
High	50.1	54.2	52.9	***51.1***	47.3

PCS - OLDER

BMI	**<18.5**	**18.5-<20**	**20-<25**	**25-<30**	**>=30**
PA					
None	41.8	46.6	**46.1**	43.9	41.2
Low	49.7	51.8	51.4	***49.7***	47.1
Mod	51.0	56.0	53.4	***50.7***	47.9
High	54.7	55.3	54.8	***53.0***	***50.4***

Data shown in ***bold italics*** are statistically significantly greater than the referent category (healthy weight, no PA, shown in **bold**)