Development of Evidence-based Physical Activity Recommendations for Adults (18-64 years)

Authors

Professor Wendy J Brown	Professor, Physical Activity and Health School of Human Movement Studies The University of Queensland
Professor Adrian E Bauman	Sesquicentenary Professor of Public Health Director, Prevention Research Collaboration School of Public Health The University of Sydney
Professor Fiona C Bull	Director, Centre for the Built Environment and Health School of Population Health University of Western Australia
Dr Nicola W Burton	Senior Research Fellow, Physical Activity and Health School of Human Movement Studies The University of Queensland

Final Report August 2012

Development of Evidence-based Physical Activity Recommendations for Adults (18-64 years)

Print ISBN: 978-1-74186-069-6

Online ISBN: 978-1-74186-070-2

Publications approval number: 10515

Suggested citation: Brown WJ, Bauman AE, Bull FC, Burton NW. Development of Evidence-based Physical Activity Recommendations for Adults (18-64 years). Report prepared for the Australian Government Department of Health, August 2012.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

DEFINITIONS OF TERMS USED IN THIS REPORT

Physical activity is any bodily movement produced by skeletal muscles that expends energy. In the context of this report this includes activities that use one or more large muscle groups, for movement in the following domains: occupation (including paid and unpaid work); leisure (including organised activities such as sports, as well as exercise and recreational activities); and transport (for example walking, cycling or skating to get to or from places).

Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. Health has physical, mental, social and psychological dimensions, and provides the capacity to withstand challenges and to accomplish life's activities with pleasure and energy.

Physical fitness relates to the ability to perform physical activity. Components of fitness include cardiorespiratory endurance, muscle strength and endurance, body composition, and balance, all of which are associated with health and functional capacity.

Aerobic activities are those that depend on an adequate supply of oxygen. They usually involve large muscle groups moving at a pace that can be continued for more than a few minutes. Over time, these activities improve the transport and uptake of oxygen by the cardiorespiratory and metabolic systems, to provide energy for working muscles. Examples include walking, swimming, cycling, dancing and some types of ball games.

Anaerobic activities do not depend on a supply of oxygen to the working muscles, and therefore can usually only be continued for a very short time. Examples include sprinting and lifting heavy weights. Most physical activities involve both aerobic and anaerobic components.

Strength (resistance) training involves activities for improving strength, power, endurance and size of skeletal muscles. Examples include exercises that use either body weight (eg push-ups), free weights (eg dumbbells) or machines as resistance.

Sedentary activities are those that involve sitting or lying down, with little energy

expenditure (ie <1.5 METs). Examples include activities in the (1) occupational (eg sitting at work); (2) leisure (eg watching TV, reading, sewing, computer use, using a computer for games, social networking etc); and (3) transport (eg sitting in a car, train, bus or tram) domains.

Metabolic equivalent (MET) is the unit used to define levels of activity, in multiples of resting metabolic rate. One MET is defined as energy expenditure at rest, usually equivalent to 3.5mL of oxygen uptake per kg per minute.

Light activities include those that require standing up and moving around, in the home, workplace or community. Energy expenditure is 1.6 to 2.9 METs.

Moderate activities are at an intensity which requires some effort, but allow a conversation to be held. Examples include brisk walking, gentle swimming, social tennis, etc. Energy expenditure is 3.0 – 5.9 METs.

Vigorous activities make you breathe harder or puff and pant (depending on fitness). Examples include aerobics, jogging and some competitive sports. Energy expenditure is ≥6 METs.

Frequency is the number of times a behaviour (eg walking, running, sitting) is carried out, usually in bouts per day or sessions per week.

Duration is the time spent in each bout or session of a behaviour (eg minutes of walking or sitting per session), or the total time spent in a behaviour in a specific period (eg minutes of walking per week).

Intensity is the rate of energy expenditure required for an activity, usually measured in metabolic equivalents (METs), kilojoules (kJ), oxygen uptake (ml O_2 per minute), speed (km per hour) or cadence (steps per minute).

Absolute intensity is currently conceptualised as: light 1.6-2.9 METs; moderate 3.0-5.9 METs, and vigorous ≥6 METS.

Relative intensity is rarely used in physical activity epidemiology, but is used by exercise scientists to describe intensity in terms of percent of maximum capacity (%VO_2 max).

Sometimes people are asked to report *relative intensity* ie how hard the activity is perceived to be, and responses are typically categorised as: very light, light, moderate, hard, very hard or maximal.

Accumulation is the term used to describe 'collecting' short bouts of a behaviour (eg walking or sitting) to achieve a total amount of that behaviour over a specified time (eg a day or a week).

Primary prevention involves the prevention of diseases and conditions before their l onset.

Secondary prevention consists of the identification and slowing of diseases that are present in the body, but that have not progressed to the point of causing signs, symptoms, and dysfunction. These preclinical conditions are most often detected by disease screening.

Tertiary prevention (management) consists of the prevention of disease progression and attendant suffering after it is clinically obvious and a diagnosis established. This also includes the rehabilitation of disabling conditions**.**

LIST OF ABBREVIATIONS USED IN THIS REPORT

BMD	Bone Mineral Density
BMI	Body Mass Index
CHD	Coronary Heart Disease
CI	Confidence Interval
CRP	Cardiac Rehabilitation Programs
CVD	Cardiovascular Disease
ES	Effect Size
ESSA	Exercise and Sport Science Australia
HHS	Health and Human Services
IARC	International Agency for Research on Cancer
MET	Metabolic Equivalent of Task
MVPA	Moderate to Vigorous Intensity Physical Activity
NHMRC	National Health and Medical Research Council
OA	Osteoarthritis
OR	Odds Ratio
PA	Physical Activity
RRR	Relative Risk Reduction
RCT	Randomised Controlled Trial
RT	Resistance Training
SB	Sedentary Behaviour
SD	Standard Deviation
UK	United Kingdom
TV	Television
URTI	Upper Respiratory Tract Infection
US	United States (of America)
USA	United States of America
WHO	World Health Organization

SUMMARY

1. The purpose of this report is to provide a summary of the scientific evidence on the relationships between physical activity and a range of health outcomes, and to describe the process used to develop new evidence-based Australian guidelines for physical activity for adults aged 18-64 years.

2. Sources of evidence included the report from the US Physical Activity Guidelines Advisory Committee; recently published systematic reviews, meta-analyses, and original research papers; and reports of the development of physical activity guidelines from several other countries.

3. Narrative reviews were conducted on the physical and psychosocial health benefits of physical activity, physical activity and weight gain prevention, sedentary behaviours and health, and the risks or negative effects of physical activity.

4. A review of existing national and global physical activity guidelines was conducted to identify how other jurisdictions have reconciled the sometimes complex evidence relating to different health outcomes into clear summary guidelines.

5. On the basis of the evidence reviewed, it was concluded that in most cases there is a curvilinear relationship between physical activity and health. The curve has a steep initial slope, with greater rate of risk reduction at the lower end of the activity scale; this suggests that encouraging adults who do no moderate intensity or vigorous activity to do some activity, would have significant public health benefits. There is no obvious lower threshold, indicating that some activity is better than none. There is also no definitive optimal amount, but substantial health benefits are gained from an *overall* volume or amount of activity ranging from about 500 to 1000 MET.min/week. This can be achieved by doing 150 - 300 minutes of moderate intensity activity, or 75 - 150 minutes of vigorous activity each week, or various combinations of moderate and vigorous activity. There is no obvious upper threshold, but there may be risks (eg from overuse, injury or infection) when physical activity reaches levels >5000 MET.min/week.

6. It is emphasised that, while the lower end of this range (500 MET.min/week) will provide considerable health benefits (including reduced risk of cardiovascular diseases, diabetes, psychosocial and musculoskeletal problems), activity at the upper end of the range (1000 MET.min/week) is required for the prevention of weight gain and some cancers.

7. The range reflects an achievable quantum of physical activity for health promotion.

8. Draft guidelines were developed using this evidence, and the NHMRC quality rating system was used to assess the strength of the evidence relating to each guideline.

9. Draft guidelines, and related scientific summary statements, were circulated to key informants, including both international and national experts in this field, and practitioners and policy makers from the government and non-government sectors. Feedback was used to revise the guidelines, and to develop explanatory notes to be used in interpreting the guidelines.

New Australian physical activity guidelines for adults (age 18-64)

Doing any physical activity is better than doing none. If you currently do no physical activity, start by doing some, and gradually build up to the recommended amount.

Accumulate 150 to 300 minutes of moderate intensity physical activity or 75 to 150 minutes of vigorous intensity physical activity, or an equivalent combination of both moderate and vigorous activities, each week.

Be active on most, preferably all, days every week.

Do muscle strengthening activities on at least 2 days each week.

Minimise the amount of time spent in prolonged sitting. Break up long periods of sitting as often as possible.

10. Several 'next steps' were identified, including the need for a public health messaging strategy that encourages awareness and adoption of the new guidelines, and continued monitoring of compliance with the guidelines. More research is required to clarify the health effects of different frequencies, intensities, durations, and types of activity and sedentary behaviour, especially the overall contribution of light intensity to health outcomes.

INTRODUCTION AND METHODS

INTRODUCTION

In January 2012 the Department of Health and Ageing engaged a group of Consultants to undertake a review of recent relevant systematic reviews and research literature, in order to inform the development of Australian Government policy on the relationship between physical activity and health outcome indicators, and to develop a set of evidence-based physical activity and sedentary behaviour guidelines for adults (18-64 years).

The Consultants were requested to present a summary of the recent evidence (with discussion of relevant issues), and to explain how the proposed guidelines concur with or vary from other international evidence-based guidelines.

NEED FOR REVISIONS TO THE EXISTING GUIDELINES

The Australian Physical Activity Guidelines were published in 1999 (see following). Since then, considerable additional scientific evidence has been published, and other countries around the world have updated their guidelines accordingly.

PURPOSE

To provide a summary of the scientific evidence on the relationships between physical activity and a range of health outcomes, and to use this summary to develop new evidence-based Australian guidelines for physical activity for adults.

INTENDED AUDIENCE

The guidelines are intended for

1. Adults (age 18-64);
2. all health professionals who have a role in advising their patients/clients on physical activity and sedentary behaviour;
3. those who monitor physical activity and sedentary behaviour in populations;
4. those involved with health promotion strategies for the prevention of non-communicable diseases; and
5. those who develop policy relating to physical activity and sedentary behaviour.

CURRENT AUSTRALIAN PHYSICAL ACTIVITY GUIDELINES FOR ADULTS

There are four steps for better health for Australian adults.

Together, steps 1-3 recommend the minimum amount of physical activity you need to do to enhance your health. They are not intended for high-level fitness, sports training or weight loss. To achieve best results, try to carry out all three steps and combine an active lifestyle with healthy eating.

Step 4 is for those who are able, and wish, to achieve greater health and fitness benefits.

Step 1 – Think of movement as an opportunity, not an inconvenience

Where any form of movement of the body is seen as an opportunity for improving health, not as a time-wasting inconvenience.

Step 2- Be active every day in as many ways as you can

Make a habit of walking or cycling instead of using the car, or do things yourself instead of using labour-saving machines.

Step 3 – Put together at least 30 minutes of moderate-intensity physical activity on most, preferably all, days.

You can accumulate your 30 minutes (or more) throughout the day by combining a few shorter sessions of activity of around 10 to 15 minutes each.

Step 4 – If you can, also enjoy some regular, vigorous activity for extra health and fitness

This step does not replace Steps 1-3. Rather it adds an extra level for those who are able, and wish, to achieve greater health and fitness benefits.

METHODS USED TO UPDATE THE EVIDENCE

The narrative reviews presented here were based largely on the most recently published systematic reviews and meta-analyses of the evidence on the relationships between physical activity and sedentary behaviour and a range of health outcomes. Studies of exercise and fitness were included if they were integrated in the reviews, but the main focus is on physical activity, with most of the distillations of the evidence published in the last five years (ie since 2007).

A primary source was the 683 page report from the US Department of Health and Human Services, which summarised the findings of a two year review of the evidence according to health outcomes.[1] We also drew on other comprehensive narrative reviews (including a seminal paper by Powell, 2011[2]), on additional recent original research papers, and on reports of the development of physical activity guidelines from Canada,[3] the UK,[4] Sweden,[5] and the World Health Organisation.[6]

The quality, consistency and amount of evidence were used to develop summary recommendations, and the strength of the evidence relating to each recommendation was initially assessed by the consultants, then reviewed by external experts.

The quality rating system was based on the National Health and Medical Research Council (NHMRC criteria for assessing evidence for the development of guidelines[7,8] as follows:

A The body of evidence can be trusted to guide practice.

B The body of evidence can be trusted to guide practice in most situations.

C The body of evidence is weak and must be applied with caution.

The focus of this review is on:

1. Prevention. The emphasis is on primary prevention, using evidence from reviews of studies of healthy population based samples. In some cases evidence from secondary prevention studies (eg from the randomised controlled trials of physical activity in people with elevated blood glucose who are at increased risk of developing diabetes) and tertiary prevention studies (eg management of people with cancer) is briefly discussed.
2. Adults aged 18-64 years.
3. Health promotion, rather than fitness development or athletic performance.
4. Physical activity in the domains of leisure time (including sport and recreation), occupation (paid and unpaid work) and transport.
5. Both physical activity and sedentary behaviour.
6. The outcomes of all-cause mortality, cardiovascular disease, diabetes, cancer, musculoskeletal problems, mental health and psychosocial well-being, and prevention of weight gain; as well as the risks of physical activity.

REFERENCES (Introduction and Methods)

1. US Department of Health and Human Services. Physical Activity Guidelines Advisory Committee Report. 2008. Accessed June 2012.

2. K E, Paluch A E, Blair S N. Physical activity for health: what kind? How much? How intense? On top of what? Annual Rev Public Health. 2011; 32: 349-365.

3. Canadian Society for Exercise Physiology. 2011 Canadian Physical Activity Guidelines. Ottawa, Canada: Canadian Society for Exercise Physiology; 2011.

4. UK Department of Health, Physical Activity, Health Improvement and Protection. Start Active, Stay Active: A Report on Physical Activity for Health from the Four Home Countries' Chief Medical Officers. London, UK: Department of Health; 2011.

5. Professional Associations for Physical Activity, Sweden [Yrkesföreningar för Fysisk Aktivitet, YFA]. Physical Activity in the Prevention and Treatment of Disease. Stockholm Swedish National Institute of Public Health, 2010. 2nd Edition.

6. World Health Organisation. Global Recommendations on Physical Activity for Health. Geneva, Switzerland: World Health Organisation; 2010.

7. (Australian) National Health and Medical Research Council. Additional Levels of Evidence and Grades for Recommendations for Developers of Guidelines. Canberra: National Health and Medical Research Council. Accessed June 2012 from http://www.nhmrc.gov.au/_files_nhmrc/file/guidelines/developers/nhmrc_levels_grades_evidence_120423.pdf.

8. (Australian) National Health and Medical Research Council. Procedures and Requirements for Meeting the 2011 NHMRC Standard for Clinical Practice Guidelines Canberra: National Health and Medical Research Council. Accessed June 2012

RESULTS PART ONE:

UPDATING THE EVIDENCE

ON PHYSICAL ACTIVITY AND HEALTH IN ADULTS

1.1 EVIDENCE ON THE PHYSICAL HEALTH BENEFITS OF PHYSICAL ACTIVITY

Relationships between physical activity and (1) all-cause mortality; (2) cardiovascular diseases (CVD); (3) diabetes; (4) some cancers; and (5) musculoskeletal disorders, are considered in this section on physical health benefits.

PHYSICAL ACTIVITY AND ALL-CAUSE MORTALITY

The relationship between physical activity and all-cause mortality has been known for several decades, based on results from population-based cohort studies, many of which were established in the 1950s, '60s and '70s. The US review examined all-cause mortality in 73 studies published to 2008.[1] Of these, 71 were longitudinal cohort studies, from diverse populations, with an average follow-up duration of 11-12 years. Most were primary prevention studies with disease-free samples, but some studies examined the effects of physical activity among people with chronic disease (mostly CVD) at baseline.

Of the 73 studies, 92% showed a significant reduction in risk in the physically active group, compared with the inactive or least active group in the study. A total of 59 studies assessed at least three levels of physical activity (for example, low active, moderate, and high active) and could therefore assess dose-response relationships. (The aim in these studies was to assess whether each increase in physical activity category was associated with a decrease in all-cause risk of death. For example, were there significant risk reductions in the 'moderate' compared with the 'low' activity categories, and in the 'high' compared with 'moderate' categories?)

The results suggested an overall 30% reduction in risk of death in the 'active' (usually defined in recent studies as meeting current physical activity recommendations) compared with the least active group, or when comparing categories such as tertiles or quartiles of the population. The summary of the evidence was described as 'strong', and was of similar magnitude for men and women, for different population groups and in studies from different countries.[1] The findings were statistically significant, even after controlling for body mass index, and a similar risk reduction was observed for each of the categories of 'acceptable weight range', 'overweight' and 'obese' adults. The findings

were unrelated to the decade of publication, with earlier studies showing similar effect sizes to those reported in studies published since 2000.

Several recent systematic reviews and meta-analyses of observational studies have confirmed that physical activity is inversely associated with all-cause mortality in men and women, after adjustment for other demographic and behavioural risk factors.[2-4] Two of these meta-analyses also suggested that the reduction in mortality risk attributable to physical activity was around 10-12% lower in women than men,[3,4] but this trend did not reach statistical significance in the mostly mid-age samples. There is, however, growing evidence to support a sex difference in the relative risk reduction (RRR), with lower risk in older women than in older men.[5]

Another recent review and meta-analysis assessed all domains of physical activity and subsequent risk of all-cause mortality.[6] For leisure time physical activity, the average RRR was 35%, for activities of daily living it was 36%, and a smaller effect was observed for occupational physical activity (RRR of 17%). For total physical activity across domains, each hour/week of vigorous physical activity showed a 9% RRR, and each hour/week of moderate physical activity was associated with a 4% RRR. Achieving a total physical activity level of 150 minutes/week of moderate-vigorous physical activity was associated with a RRR of 16%, and for the higher threshold of 300 minutes/week, a RRR of 26% was reported. This review found that studies from low/middle income countries reported similar findings to those from developed countries.

Additional evidence from individual studies has also shown that active commuting to and from work, through walking or cycling, is associated with similar risk reductions to those reported in studies that relied largely on measurement of leisure-time physical activity.[7]

PHYSICAL ACTIVITY AND CARDIOVASCULAR DISEASE (CVD) MORTALITY AND EVENTS

The term cardiovascular disease (CVD) is used here to describe all cardiovascular diseases, including incident and fatal ischemic heart attack, other cardiovascular disease, peripheral vascular disease, and stroke.

The inverse association between physical activity and CVD was initially reported in 1987,[8] and confirmed in a 1990 meta-analysis that reported a relative risk of 1.90 for CVD mortality among the inactive (compared with the active).[9] Twenty years of additional epidemiological data have re-confirmed this association, with subsequent research demonstrating similar or slightly smaller pooled odds ratios for the activity - CVD relationship.

As most of the initial cohort studies reported only on studies of men, a review of the relationship between physical activity and cardiovascular disease in women was conducted in 2006. Brown et al (2007) reported on 17 cohort studies with female data, and 12 of these 17 studies showed a significantly decreased RR for active, compared with inactive, women.[10] Several of the included studies showed risk reductions at physical activity levels below the commonly recommended threshold of 150 minutes per week.

In a systematic review of 33 studies published to 2007, Nocon et al (2008) reported a pooled RRR of 35% for men and women, with an all-cause mortality RRR of 33%.[2] A more recent meta-analysis examined the effects of physical activity on CVD and stroke prevention using data from 30 years of studies to the end of 2010.[11] The pooled RRR was around 24% for active people, compared with those who were inactive, with very similar RRRs for men and women. Others have also reported similar risk reductions for women and CVD.[12] The 2012 meta-analysis suggested a smaller effect size (ES) for occupational activity alone (RRR 11% for men and 17% for women), and reported that the cardio-protective benefits were similar in developed and developing countries.[11] Almost all studies with multiple categories of activity have shown a typical dose response pattern, with decrements in risk across categories of increasing physical activity.[11,13]

The cardiovascular outcomes associated with physical (in)activity were also studied as part of the extensive background evidence review underpinning the development of the US physical activity guidelines.[1] The review examined more than 60 studies, published up to 2007, including both cohort and case-control study designs. CVD studies are one of the few categories where true case-control studies are used in physical activity epidemiology; given that recall issues, although substantial, are not generally thought to demonstrate differential measurement error, this method is considered reasonable in this context, and was widely used in studies that were completed before ~1990.

Most of the studies reviewed used validated self-report physical activity measures, and had well documented reliable CVD incidence and mortality assessments. Most examined aerobic activities, with few reports of the effect of resistance and flexibility activities. The findings suggested that those undertaking reasonable amounts of physical activity had a 20% RRR of CVD, and those reporting higher amounts or more vigorous activity had a 30% RRR, compared with the least active individuals. The studies identified a protective relationship with the *total volume* of physical activity. Due to measurement error, and to the influence of physical activity on other intermediate CVD risk factors (such as weight, HDL cholesterol, blood pressure and glycaemic control) these RRR values are considered an underestimate, by as much as 10%.[1]

These effects are considered to be biologically plausible, mediated through the effect of physical activity on cardiac endothelial cell function, haemostatic factors and inflammation, as well as on other CVD risk factors, especially blood pressure, lipid levels, glycaemic control and body weight.[14]

The US report (2008) summarised the RRRs for men and women separately, stratified by effects on coronary heart disease, general cardiovascular diseases, and stroke; the results are shown in Figure 1.1. There were dose-response relationships, with significant risk reductions between the low active (reference category) and moderately active groups, and even greater risk reductions for the high active versus low active comparisons. This pattern was consistent for coronary heart disease (CHD) studies alone, general cardiovascular diseases (CVD), and for stroke in women.[1]

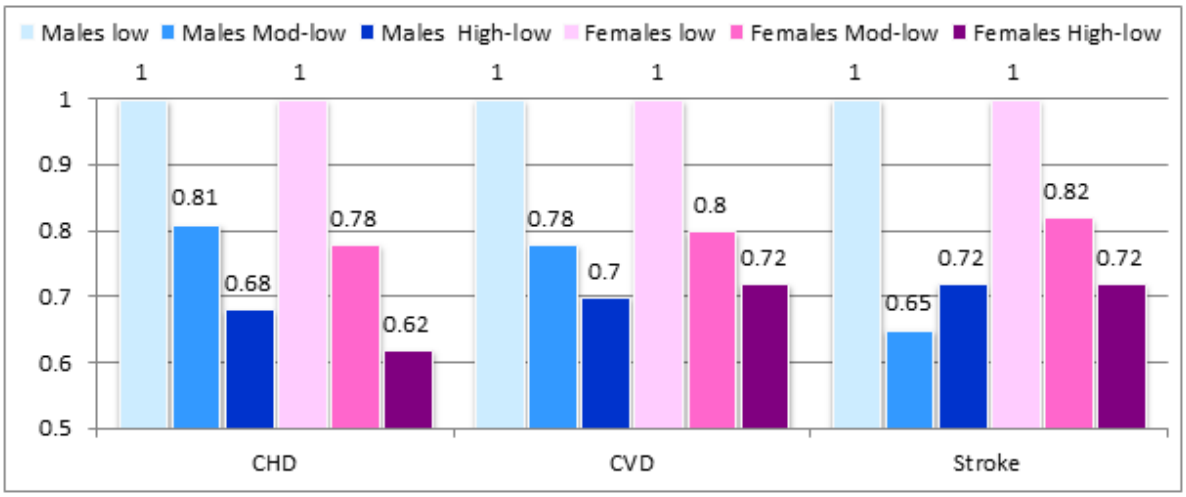

Figure 1.1: Relationship between levels of physical activity and the risks of coronary heart disease (CHD), cardiovascular disease (CVD) and stroke in men and women (HHS, 2008).

Most of these cohort studies provide primary prevention evidence for the health benefits of physical activity on CVD. There is also a long history of tertiary prevention studies of the benefits of physical activity or exercise training for those with existing heart disease. The longest history of studies in this area has provided an evidence base for cardiac rehabilitation programs (CRP), in which activity plays a major role. Systematic reviews of CRP indicate that they are associated with improved quality of life, reduced re-infarction rates, and probably slightly prolonged survival.[15] Physical activity and training may also have beneficial roles in patients with heart failure,[16] peripheral vascular disease, and hypertension (consistently reducing blood pressure by 2-3%)[1] and thereby reducing stroke risk for men and women.[17] There is also evidence of a role for physical activity in the prevention of deep vein thrombosis.[18]

In summary, there is now strong evidence to support dose-relationships between physical activity and a range of cardiovascular disease outcomes. Some studies show benefits at levels below previously recommended thresholds, and almost all show progressively decreasing risk with increasing amount of activity.

PHYSICAL ACTIVITY AND TYPE 2 DIABETES

The evidence base on the role of physical activity in type 2 diabetes prevention and control is quantitatively different from that of the other chronic diseases. In addition to the primary prevention evidence (from cohort studies dating back to the 1970s) there is also now a large amount of secondary prevention evidence, which has accumulated in the last decade.

Primary Prevention

A systematic review of the results of 20 primary prevention cohort studies has shown, without exception, that there is a substantial and consistent association between (increasing) physical activity and reduced risk of type 2 diabetes.[19] This relationship is robust; it exists irrespective of the physical activity measure used, and there is a consistent dose-response relationship. Moreover, physiological research is developing good evidence for the mechanisms underpinning this protective effect.[20]

In summarising the primary prevention epidemiological research, Warburton et al (2010) found that the median magnitude of the risk reduction is around 42% across all studies.[19] Another way of expressing this is that the least active group is 30-50% more likely to develop diabetes, compared with the most active group. The data supporting this estimate come from studies of both physical activity and physical fitness. Based on the prevalence of inactivity in different developed countries, it appears that the population attributable risk ranges from 12-21%.[19] This means that if the whole population was to meet the minimum physical activity recommendations, somewhere between 1/8 and 1/5 of all new diabetes (incident) cases would be prevented.

In terms of diabetes prevention, there is evidence of increased risk reduction with increasing total *volume* of activity; with benefits starting at fairly low levels of activity and increasing up to a level of about one hour of walking a day (ie 300 minutes/week of moderate intensity activity, or 1000 MET.min/week).[1]

Secondary Prevention

The area of secondary prevention of diabetes has a very strong evidence base, underpinned by several large scale randomised trials that demonstrate reduced diabetes incidence among those at-risk of diabetes.[21-24] In these studies, the at-risk populations were those with impaired glucose tolerance, or those who scored high on screening instruments that classify individuals as being at very high risk of diabetes. The interventions were lifestyle-change studies, with large trials conducted in the USA, Finland, China and India, and smaller ones in Japan and Sweden.

In most studies the intervention effects were due to a combination of lifestyle changes, typically 5-7% weight loss, 150 minutes of physical activity, and reducing fat/increasing fibre in the diet. The challenge is that the risk reductions observed (around 58% reduced risk in the USA and Finnish Diabetes Prevention Programs, and a little less from the others) were due to the whole lifestyle change intervention. The Chinese Da Qing study was the only one to include an exercise only group.[22] The results of this study, and sub-analyses from the Finnish and Indian studies have shown that physical activity change alone has an independent effect on risk, even in the absence of weight loss.[22-24]

The quantum of activity tested in most of these trials was explicitly 150 minutes per week, the same as the generic primary prevention recommendation. These studies provide evidence that physical activity should be recommended for the secondary prevention of diabetes, to the 10-15% of adult Australians who have defined clinical and metabolic precursors, and are therefore at increased risk of developing type 2 diabetes. Data from long term follow-up of the participants in these secondary prevention trials has shown that these lifestyle interventions may postpone the development of diabetes for several years,[25,26] but the specific long-term effects of physical activity have not yet been established.

Tertiary prevention

The role of physical activity in the tertiary prevention or management of diabetes is less clear, as people with diabetes have management plans that include dietary advice, physical activity and pharmacological therapy. For this group, some moderate-intensity physical activity seems beneficial for regulating glucose metabolism, but it is not clear to what extent this is due to physical activity alone. A position statement from Exercise and Sport Science Australia (ESSA) suggests that people with type 2 diabetes should accumulate a minimum of 210 minutes/week of moderate intensity activity (or equivalent vigorous activity), as well as two sessions of resistance training each week.[27] However, people with diabetes in the general population mostly fail to do this.[28] Recent evidence suggests that there may be benefits of physical activity on microvascular disease (especially peripheral neuropathy and retinopathy) among people with diabetes.[29,30]

There is less clear evidence of the independent effects of physical activity for the *prevention* of Type 1 diabetes, other than as a generic healthy lifestyle recommendation.[31] The studies are too limited in number to make definite guideline statements. Similarly, there is some evidence that physical activity may prevent gestational diabetes, but the evidence is mixed, and again, a generic healthy lifestyle recommendation is made, rather than formal and specific guidelines[1]

There is however evidence, from both cohort and intervention studies, that physical activity has a role in both the prevention and management of Metabolic Syndrome (a cluster of CVD and diabetes risk factors including impaired glucose regulation, insulin resistance, hypertension, high blood lipids and central obesity).[32,33] The quantum of activity recommended in the US report is 180 minutes/week of moderate-vigorous activity, which is slightly higher than the generic recommendation for the prevention of diabetes,[1] but less than is recommended by ESSA.[27]

Implications of the Evidence from Studies of Diabetes

The evidence presented here has important implications for the development of updated physical activity guidelines. First, there is more evidence than a decade ago that the effects of physical activity are independent of obesity. In other words, the benefits of weight reduction, or of not being obese, are important in diabetes prevention. However, some of the benefits of physical activity in reducing diabetes risk occur irrespective of weight loss, most likely because of the direct metabolic effects of physical activity.[34]

Four important policy relevant issues arise from the evidence presented here. Firstly, physical activity promotion should not be subsumed under obesity prevention goals. Secondly, the developing field of sedentary behaviour and health (see Part 1.4 of this report for more details) posits health consequences of prolonged sitting, irrespective of physical activity levels. Again this is a metabolic effect, as prolonged sitting increases insulin resistance and circulating blood sugar levels, and may have diabetes-risk effects independent of physical activity. Thirdly, there is some evidence that other forms of activity, particularly resistance (or strength) training, may also assist glucose uptake into muscles, reducing blood sugar levels.

Finally, the quantum of physical activity recommended for primary and secondary prevention of diabetes appears to be similar to, or slightly greater than that recommended for the prevention of other chronic diseases, namely 150-210 minutes/week. There is however, some evidence that glucose metabolism is best regulated with physical activity/exercise done at least several times per week,[29] and the ESSA statement recommends no more than two consecutive days without activity.[27] Some Diabetes Prevention Programs recommend activity every day, with a total of 210 (7 x 30) minutes of moderate intensity activity every week.

PHYSICAL ACTIVITY AND CANCER

The International Agency for Research on Cancer, IARC, estimates that around a quarter of all cancer incidence is attributable to obesity and a sedentary lifestyle.[35] The main focus in this section is on evidence relating to the role of physical activity in the primary prevention of cancer risk in population studies. Given the increasing evidence in the area of tertiary prevention, however, a short section on the role of physical activity on health outcomes among those with cancer is also included.

Breast Cancer

More than 90 studies have examined some aspects of the association between physical activity and breast cancer. About half used a cohort (longitudinal) design, and the remainder reported data from case-control studies.[1] One meta-analysis has demonstrated a 23% reduction in risk among young adult women who were active, compared to inactive.[36] Other recent systematic reviews have demonstrated a greater risk reduction amongst post-menopausal women, with study estimates of reduced risk ranging from 20-80%.[37] A further analysis of the same data showed a 6% reduction in risk for each additional hour of physical activity per week, with a smaller risk reduction for pre-menopausal women.[37] Overall, the US review reported a median 20% reduction in risk across studies[1] while a more recent review reported a median RRR of 25%.[38]

There is some evidence of a dose-response relationship between physical activity and breast cancer incidence, with most studies suggesting that one hour of activity per day confers greater risk reduction than 30 minutes per day, and that the significant risk reduction occurs in the range of 4-7 hours of moderate-vigorous physical activity each week.[1] The role of lower intensity activity, such as household tasks, is not yet clear.

There has been substantial interest in the question of whether physical activity participation is necessary across the life-course to reduce breast cancer risk. The most recent evidence suggests that physical activity seems beneficial in all decades of life but may be more protective against breast cancer in post-menopausal women.[39] This suggests that the biological mechanism may involve changes in oestrogen or

progesterone metabolism. The protective relationships between physical activity and breast cancer appear to be similar across population sub-groups, and in studies from different countries. Researchers have also been concerned about the potential interaction between obesity and the relationship between physical activity and breast cancer. Although some studies show effect modification by obesity, several others suggest that physical activity is protective at all levels of obesity.[1]

Colon Cancer

Colorectal cancers are excluded from this section because the risk factors for rectal carcinoma may differ from those for colon cancer alone. More than 25 studies (around half being cohort studies and half case-control studies) have recently assessed the relationships between physical activity and colon cancer.[1] About three-quarters of these show consistent associations, with an overall median risk reduction of 30%, in the most active compared to the least active groups. [1] The relative risk reduction may be slightly greater in data from case control studies, around 30%, compared with just over 20% risk reduction in cohort studies. [1]

A recent review suggested slightly smaller effects (pooled RRR 20% in men, 14% in women), but still a clearly significant and protective association with physical activity.[40] The protective effect of physical activity was found to be independent of obesity, hormone replacement therapy, diet or family history. The biological mechanisms for the protective role of physical activity on colon cancer are thought to include the effects of activity on adiposity, insulin resistance, immune function, inflammation and cytokines.[41]

A recent review of 8 studies among Japanese populations found consistent evidence of a graded relationship between increasing physical activity and reduced risk of colon cancer (and a weak or no relationship with rectal cancers).[42] There was clear evidence across studies of a dose-response relationship, with preventive benefit starting at 4 hours per week of moderate-vigorous intensity physical activity. The threshold for benefit is variously described, typically ranging from 20-30 MET.hours per week, which equates with about 60 minutes of daily moderate-vigorous physical activity. Greater intensity of activity has been shown to be associated with lowered colon cancer mortality risk.[43]

Rectal Cancer

Both earlier systematic reviews,[44,45] the US report[1] and more recent reviews,[46] have reported equivocal findings on the relationship between physical activity and rectal cancer, with more than half of all studies showing no association. These data indicate that no preventive recommendation can be made at this stage for physical activity and rectal cancer.

Prostate Cancer

More than 25 prospective cohort studies have examined the association between physical activity and prostate cancer. The results are inconsistent, with around 60% reporting a protective effect, and the remainder showing no effect, or a slight increase in risk among the physically active.[1] A more recent systematic review of 33 studies reported a small consistent reduction in prostate cancer risk, of the order of 10%, in the most compared to the least active.[47] Despite this review, it is still too early and the effects too small to make definitive recommendations on prostate cancer prevention, given the evidence to date.

Lung Cancer

More than 15 cohort studies and 6 case-control studies have shown a median risk reduction of 20-24% for developing lung cancer in the physically active, compared with inactive adults.[1] These relationships are similar in men and women. Concerns have been expressed about residual confounding by smoking status, but the associations remained after stratification by smoking status. Further efforts to control for residual confounding include stratification by cancer subtype, and for types of lung cancer not related to smoking (adenocarcinoma, n=3 studies).[1] Overall, there is a protective effect of physical activity of 20-30% risk reduction. As the biological mechanisms are not known, further work is needed before clear public health recommendations for the role of physical activity on lung cancer risk can be made.

Endometrial Cancer

There are a few studies of physical activity and endometrial cancer, with a recent review reporting data from 15 studies, around half of which used a cohort design.[1] The median risk reduction among those who were active, compared with the inactive, was 27%, which was maintained when adjusted for BMI and post-menopausal hormonal therapy.[1]

Ovarian Cancer

A meta-analysis to explore the relationship between physical activity and ovarian cancer concluded that there is a 19% pooled or average risk reduction among the physically active, compared with the inactive.[48] Most of the included studies were case control designs. The results were not influenced by BMI or oral contraceptive use.

Pancreatic Cancer

Ten studies were identified in the US report, of which 8 used a cohort design.[1] Only half of these adjusted for BMI, and the relative risk reduction varied by whether they adjusted for BMI or not, as well as by study design. Bao and Michaud (2008) also assessed the evidence, and suggested that total and leisure time physical activity were not related to pancreatic cancer, but that there might be a small protective association with occupational activity; this review concluded there was insufficient evidence.[49] In summary, reviews indicate that the evidence base is too early in development, and BMI should be adjusted for as a potential confounder, before any recommendation is made about physical activity and pancreatic cancer.

Summary of the Primary Prevention Evidence for Cancer

The observational study evidence for physical activity in the primary prevention of cancer is strongest for colon and breast cancer; epidemiological studies show a consistent moderate inverse association between physical activity and these cancer outcomes. The data are summarised as suggesting that 20-30 MET.hours/week of activity are required for cancer prevention, which can be expressed varyingly as a 60-90 minutes of moderate intensity, or 30 -60 minutes of vigorous activity on most days each week. Across studies, the risk reduction is around 30% for colon cancer and around 20% for breast cancer. There is some evidence of a dose response relationship. Fewer studies have been conducted for other cancers, but for lung, endometrial and ovarian cancer, there is suggestive evidence of a reduced risk among people who are physically active, but this reduction is of a smaller magnitude than for colon or breast cancer. Despite a growing number of studies, the evidence is mixed for rectal or prostate cancer risk, and there are too few studies to assess the role of physical activity on cancers at other sites.

Tertiary Prevention – Physical Activity Among People with Existing Cancer

Although the main focus here is on primary prevention, in light of the developing research interest, especially in Australia, a brief summary of the evidence that physical activity has benefits for people who already have some forms of cancer is included.

As might be expected of research in an emerging field, methodological limitations make it difficult to draw firm conclusions about the efficacy or effectiveness of activity interventions for cancer survivors.[50-52] Although there is little information about an optimal volume of activity, the Nurses' Health Study researchers have identified that 3-9 MET.hours/week of physical activity is associated with a reduced cancer recurrence and reduced all-cause mortality.[53] For breast cancer patients, the quantum of physical activity recommended in the US guidelines appears to be sufficient to reduce morbidity and mortality.[54] Evidence also exists for colon cancer patients, with increased survival among patients who completed at least 18 MET.hours/week.[55,56]

A summary meta-analysis by Schmitz in 2005 included results from 22 controlled trials.[57] Activity was associated with a range of outcomes in cancer patients, including increased fitness, muscle strength (from resistance training), quality of life measures, anxiety measures and self-esteem.[57] The effects were greater in people who were overweight or obese. There were also strong effects on quality of life indicators, and nearly half the trials showed an impact on cancer-related fatigue. Although dose-response relationships are not clear, most agree that a recommendation of 150 minutes/week of physical activity is appropriate for cancer survivors.[57,58] Studies with more rigorous designs are now required to advance this field.

PHYSICAL ACTIVITY AND MUSCULOSKELETAL CONDITIONS

The most common musculoskeletal conditions include osteoarthritis and osteoporosis, which, while more prevalent in older people, are relevant for adults aged 18-64 years, as they often start to develop in mid-age. Common biological precursors include reduced muscle strength and mass, and reduced bone mineral density (BMD). Common outcomes include reduced functional status, and falls and fractures.

Both aerobic activity, and resistance training (RT) contribute to bone and muscle health, but in different ways. Aerobic activity, such as that underpinning the majority of physical activity guidelines (eg 150 minutes of moderate intensity activity per week) has benefits in the musculoskeletal health area, independent of whether other forms of activity are undertaken. Resistance training (progressive muscle strengthening activities) can however increase muscle strength and muscle mass, and improve bone mineral density. It may also improve cardio-respiratory fitness, which has other chronic disease prevention benefits. Flexibility-type activities are of less clear benefit.

In this section, relationships between physical activity and osteoarthritis, bone mineral density, and falls and fractures are considered. The specific risks for osteoporosis are not included, as this condition is not commonly diagnosed in people under 65 years of age.

Osteoarthritis

Osteoarthritis (OA) is the most common musculoskeletal disorder and the leading cause of pain and disability in Australia.[59] It affects 7.8% of the population, and contributes substantially to the overall burden of disease.[60,61] Risk factors for OA include being female, and overweight or obese. There is also an increased risk in those with previous joint injury, and the benefits of physical activity are less clear in this group.

There is some evidence, from case-control studies, some cross sectional studies, and a few cohort studies that physical activity has a protective role in reducing the incidence of OA. Results from the Australian Longitudinal Study on Women's Health show an inverse association between both leisure time activity and walking and incident OA.

A minimum of 75-150 minutes of moderate-intensity activity, or 100-200 minutes of walking per week, was associated with decreased reports of arthritis over 6 years in women.[62] A systematic review of 12 studies has confirmed the potential role of physical activity in OA prevention, especially for low impact physical activity.[1] Higher impact activities, with the confounding element of increased joint injury, may actually increase OA risk; this is probably true for activities such as most types of football, basketball and other high impact sports, which may particularly influence hip and knee arthritis risk.

The role of activity in the management of OA has been studied in numerous randomised controlled trials, mostly in people with OA of the knee. Most of these have focused on improving stability of joints, range of movement, aerobic fitness and weight management in order to decrease pain and disability. Although functional status and quality of life outcomes are consistently reported, there is little evidence of effects of physical activity on biomarkers (measures of inflammation) or on radiological progression of arthritis. There have been few trials of resistance training in people with arthritis.

Despite the accumulating international evidence suggesting that aerobic exercise is effective in reducing symptoms of OA of the knee, and to a lesser degree of the hip, the heterogeneity of study designs makes it difficult to specify the required amount of activity for optimal benefits. There is also a behavioural challenge in these studies, because it is necessary to maintain physical activity levels to see effects, and behavioural adherence is difficult to achieve in people with arthritis.[61]

The 2008 US guidelines report recommended that individuals with OA engage in moderate-intensity, low-impact activities such as walking, cycling or water exercise, 3 to 5 times per week for 30 to 60 minutes per session.[1] There is no evidence that regular moderate-intensity physical activity worsens arthritis in general populations without pre-existing joint disease or other risk factors.

Among other inflammatory musculoskeletal conditions, rheumatoid arthritis is also quite common, more so among women; the evidence on physical activity and rheumatoid arthritis is mixed, and no clear recommendation is possible.[63]

Bone Mineral Density

The effects of physical activity on bone mineral density (BMD) have been widely investigated. Both weight bearing endurance activity and resistance training improve BMD, by slowing the age-related decline in BMD in the spine and hip. The evidence comes from a plethora of RCTs, with summary meta-analytic evidence available.[1] Most RCTs (10/13) have shown a significant increase in lumbar spine BMD, but fewer studies have investigated the effects of BMD in the femoral neck or whole femur. Few studies have compared endurance and resistance training activity, but where these studies have made the comparison, both modalities seem to be protective. The exact dose response relationship between activity and BMD is not yet clear.

Functional Status and Falls Risk

In the whole population, regular moderate-intensity physical activity is associated with improved quality of life, maintained functional status, reduced symptoms of disability, and improved capacity to participate in activities of daily living.[1,64,65] These benefits ('global functional measures') are consistent across studies, and generalizable to whole populations, especially with increasing age. There is evidence of a dose-response relationship, based on volume of physical activity, and overall, among those that are active, there is around a 30% reduced risk of developing functional status limitations, compared with those who remain inactive.

Most of the research on functional status and falls risk has been conducted with people over 65 years of age. Numerous studies have shown that physical activity contributes to maintained or improved functional status by increasing lower limb muscle strength, which reduces falls risk.[65,66] One meta-analysis has examined studies of physical activity alone, and suggested a 30% reduced risk of falls among those who were active, compared with the inactive.[67] Multi-component intervention studies, as well as studies involving only physical activity and balance training and strengthening activity, have also shown benefits in terms of falls prevention. Evidence on the effects of interventions on balance is however controversial, as few studies have specifically examined this outcome.[68]

Fractures

There is consistent evidence from longitudinal epidemiological studies that physical activity reduces fracture-related risks in people with osteoporosis, especially for fractures of the proximal femur. Overall, there is a 2.5 fold increase in risk of hip fracture in the least active, compared with the most active groups.[1] There is a volume gradient, with the minimal amount of activity typically expressed as 9-14.9 MET.hours/week, or 4 or more hours of walking per week. There is mixed evidence regarding vertebral fracture risk, and some evidence for reduction in 'any fracture' risk.

Studies suggest that the preventive benefit is not different for population subgroups, such as by sex, even though osteoporosis is much more common among women. Although the association between physical activity and reduced fracture risk is consistent, the causal mechanisms are not yet described. Laboratory studies suggest that bone adaptation to mechanical load is dose dependent, but in human studies, the dose-response evidence is still mixed.[1] Increases in physical activity, among those who were inactive, seem to be protective, conferring a twofold reduction in risk for those adopting regular activity.[69]

Summary of the Evidence for Musculoskeletal Conditions

In summary there appear to be independent protective roles for both weight bearing physical activity and resistance and muscle strengthening activities on osteoarthritis, bone mineral density, functional status, and risk of falls and fractures. Many of these effects are mediated through muscle and bone metabolism, but are also likely to involve neuromuscular mechanisms. The evidence supports the current US activity guidelines, which include both aerobic activity, and strength training activity on at least two days each week.

REFERENCES (Part 1.1)

1. U S Department of Health and Human Services. Physical Activity Guidelines Advisory Committee Report. Part G. 2008. Accessed June 2012 from:

2. Nocon M, Hiemann T, Muller-Riemenschneider F, Thalau F, Roll S, Willich SN. Association of physical activity with all-cause and cardiovascular mortality: A systematic review and meta-analysis. Eur J Cardiovasc Prev Rehabil. 2008; 15: 239-246.

3. Löllgen H, Bockenhoff A, Knapp G. Physical activity and all-cause mortality: An updated meta-analysis with different intensity categories. Int J Sports Med. 2009; 30: 213-224.

4. Woodcock J, Franco OH, Orsini N, Roberts I. Non-vigorous physical activity and all-cause mortality: Systematic review and meta-analysis of cohort studies. Int J Epidemiol. 2011; 40: 121-138.

5. Brown WJ, McLaughlin D, Leung J, McCaul KA, Flicker L, Almeida OP, Hankey GJ, Lopez D, Dobson AJ. Physical activity and all-cause mortality in older women and men. Br J Sport Med. 2012; 46: 664-8.

6. Samitz G, Egger M, Zwahlen M. Domains of physical activity and all-cause mortality: systematic review and dose-response meta-analysis of cohort studies. Int J Epidemiol. 2011; 40(5): 1382-1400.

7. Andersen LB, Schnohr P, Schroll M, Hein H. All-cause mortality associated with physical activity during leisure time, work, sports, and cycling to work. Arch Intern Med. 2000; 160: 1621-1628.

8. Powell KE, Thompson PD, Caspersen CJ, et al. Physical activity and the incidence of coronary heart disease. Ann Rev Public Health. 1987; 8: 253-87.

9. Berlin J, Colditz GA. A meta-analysis of physical activity in the prevention of coronary heart disease. Am J Epidemiol. 1990; 132: 612-28.

10. Brown WJ, Burton NW, Rowan PJ. Updating the evidence on physical activity and health in women. Am J Prev Med. 2007; 33(5): 404-411

11. Li J, Siegrist J. Physical activity and risk of cardiovascular disease-a meta-analysis of prospective cohort studies. Int J Environ Res Public Health. 2012; 9(2): 391-407.

12. Lee DC, Sui X, Ortega FB et al. Comparisons of leisure-time physical activity and cardiorespiratory fitness as predictors of all-cause mortality in men and women. Br J Sports Med. 2011; 45(6): 504-510.

13. Wen CP, Wai JPM, Tsai MK, et al. Minimum amount of physical activity for reduced mortality and extended life expectancy: a prospective cohort study. Lancet. 2011; 378(9798): 1244-1253.

14. Lavie CJ, Church TS, Milani RV, Earnest CP. Impact of physical activity, cardiorespiratory fitness, and exercise training on markers of inflammation. J Cardiopulm Rehabil Prev. 2011; 31(3): 137-145.

15. Lawler PR, Filion KB, Eisenberg MJ. Efficacy of exercise-based cardiac rehabilitation post-myocardial infarction: A systematic review and meta-analysis of randomized controlled trials. Am Heart J. 2011; 162(4): 571-584.

16. Davies EJ, Moxham T, Rees K. et al. Exercise based rehabilitation for heart failure. Cochrane Database Syst Rev. 2010; 14 (4). CD003331.

17. Goldstein LB. Physical activity and the risk of stroke. Expert Rev Neurother. 2010; 10(8): 1263-1265.

18. Kahn SR, Shrier I, Kearon C. Physical activity in patients with deep venous thrombosis: A systematic review. Thromb Res. 2008; 122(6): 763-773.

19. Warburton DER, Charlesworth S, Ivey A, Nettlefold L, Bredin SSD. A systematic review of the evidence for Canada's Physical Activity Guidelines for Adults. Int J Behav Nutr and Physical Activity, 2010; 7. doi: 10.1186/1479-5868-7-39.

20. Hamer M, Ingle L, Carroll S, Stamatakis E. Physical activity and cardiovascular mortality risk: possible protective mechanisms? Med Sci Sport Exerc. 2012; 44(1): 84-88.

21. Diabetes Prevention Program Research Group. The Diabetes Prevention Program (DPP): description of lifestyle intervention. Diabetes Care 2001; 25(12): 2165-2171.

22. Pan XR, Li GW, Hu YH. et al. Effects of diet and exercise in preventing NIDDM in people with impaired glucose tolerance. The Da Qing IGT and Diabetes Study. Diabetes Care, 1997; 20(4): 537-544.

23. Tuomilehto J, Lindström J, Eriksson JG. et al. Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance. New Engl J Med. 2001; 344(18): 1343-1350.

24. Ramachandran A, Snehalatha C, Mary S. et al. The Indian Diabetes Prevention Programme shows that lifestyle modification and metformin prevent type 2 diabetes in Asian Indian subjects with impaired glucose tolerance (IDPP-1). Diabetologia. 2006; 49(2): 289-297.

25. Diabetes Prevention Program Research Group, Knowler WC, Fowler SE et al. Ten year follow-up of diabetes incidence and weight loss in the Diabetes Prevention Program Outcomes Study. Lancet. 2009; 374(9702): 1677 - 1686.

26. Li G, Zhang P, Wang J. et al. The long-term effect of lifestyle interventions to prevent diabetes in the China Da Qing Diabetes Prevention Study: a 20-year follow-up study. Lancet. 2008; 371 (9626): 1783-1789.

27. Hordern MD, Dunstan DW, Prins JB, Baker MK, Fiatarone-Singh MA, Coombes JS. Exercise prescription for patients with type 2 diabetes and pre-diabetes: a position statement from Exercise and Sport Science Australia. J Med Sci Sport. 2012; 15: 25-31.

28. Neville L, Bauman A. Self-reported risk factors and management strategies used by people with diabetes mellitus identified from the 1997 and 1998 NSW Health Surveys. NSW Public Health Bulletin. 2004; 15(4): 57-62.

29. Thomas D, Elliott EJ, Naughton GA. Exercise for type 2 diabetes mellitus. Cochrane Collaboration: Metabolic and Endocrine Disorders Group. Published Online: 21 Jan 2009. doi:10.1002/14651858.CD002968.pub.

30. Vepsalainen T, Soinio M, Marniemi J. et al. Physical activity, high-sensitivity C-reactive protein, and total and cardiovascular disease mortality in type 2 diabetes. Diabetes Care. 2011; 34(7): 1492-1496.

31. Chimen M, Kennedy A, Nirantharakumar K, Pang TT, Andrews R, Narendran P. What are the health benefits of physical activity in type 1 diabetes mellitus? A literature review. Diabetologia. 2012; 55(3): 542-551.

32. Stensvold D, Nauman J, Nilsen TI, Wisløff U, Størdahl SA, Vatten L. Even low level of physical activity is associated with reduced mortality among people with metabolic syndrome. A population based study (the HUNT 2 study, Norway). BMC Med. 2011; 9.

33. Tjønna AE, Nilsen TIL, Størdahl SA, Vatten L, Wisløff U. The association of metabolic clustering and physical activity with cardiovascular mortality: The HUNT study in Norway. J Epidemiol Community Health. 2010; 64(8): 690-695.

34. Katzmarzyk PT, Lear SA. Physical activity for obese individuals: a systematic review of effects on chronic disease risk factors. Obesity Rev. 2012; 13(2): 95-105.

35. Vainio H, Bianchini F, International Agency for Research on Cancer. Weight control and physical activity. Lyon: IARC Press; 2002.

36. Lagerros YT, Hsieh SF, Hsieh CC. Physical activity in adolescence and young adulthood and breast cancer risk: a quantitative review. Eur J Cancer Prev. 2004; 13(1): 5-12.

37. Monninkhof EM, Elias SG, Vlems FA, van der Twell I, Schuit AJ, Voskuil DW, van Leeuwen FE. Physical activity and breast cancer: a systematic review. Epidemiol. 2007; 18(1): 137-57.

38. Friedenreich CM. Physical activity and breast cancer: review of the epidemiologic evidence and biologic mechanisms. Recent Results Cancer Res. 2011; 188: 125-139.

39. Neilson HK, Friedenreich CM, Brockton NT, Millikan RC. Physical activity and postmenopausal breast cancer: proposed biologic mechanisms and areas for future research. Cancer Epidemiol Biomarkers Prev. 2009; 18(1): 11-27.

40. Harriss DJ, Atkinson G, Batterham A. et al. Lifestyle factors and colorectal cancer risk (2): a systematic review and meta-analysis of associations with leisure-time physical activity. Colorectal Dis. 2009; 11(7): 689-701.

41. Slattery ML, Edwards S, Curtin K, Ma K, Edwards R, Holubkov R, Schaffer D. Physical activity and colorectal cancer. Am J Epidemiol. 2003; 158(3): 214-24.

42. Pham NM, Mizoue T, Tanaka K. et al. Physical activity and colorectal cancer risk: an evaluation based on a systematic review of epidemiologic evidence among the Japanese population. Jpn J Clin Oncol. 2012; 42(1): 2-13.

43. Laukkanen JA, Rauramaa R, Mäkikallio TH, Toriola AT, Kurl S. Intensity of leisure-time physical activity and cancer mortality in men. Br J Sport Med. 2011; 45(2): 125-129.

44. Lee IM, Manson JE, Ajani U, Paffenbarger RS, Jr., Hennekens CH, Buring JE. Physical activity and risk of colon cancer: the Physicians' Health Study (US). Cancer Causes Control. 1997; 8(4): 568-74.

45. Lee KJ, Inoue M, Otani T, Iwasaki M, Sasazuki S, Tsugane S. Physical activity and risk of colorectal cancer in Japanese men and women: the Japan Public Health Center-based prospective study. Cancer Causes Control. 2007; 18(2): 199-209.

46. Spence RR, Heesch KC, Brown WJ. A systematic review of the association between physical activity and colorectal cancer risk. Scand J Med Sci Sports. 209; 19 (6): 764-781.

47. Liu YP, Hu FL, Li DD. et al. Does physical activity reduce the risk of prostate cancer? a systematic review and meta-analysis. Eur Urol. 2012; 60(5): 1029-1044.

48. Olsen CM, Green AC, Whiteman DC, Sadeghi S, Kolahdooz F, Webb PM. Obesity and the risk of epithelial ovarian cancer: a systematic review and meta-analysis. Eur J Cancer. 2007; 43(4): 690-709.

49. Bao Y, Michaud DS. Physical activity and pancreatic cancer risk: A systematic review. Cancer Epidemiol Biomarkers Prev. 2008; 17(10): 2671-2682.

50. Schmitz KH, Holtzman J, Courneya KS et al. Controlled physical activity trials in cancer survivors: a systematic review and meta-analysis. Cancer Epidemiol Biomarkers Prev. 2005; 14(7): 1588-95.

51. Spence RR, Heesch KC, Brown WJ. Exercise and cancer rehabilitation: A systematic review. Cancer Treat Rev. 2010; 36(2): 185-194.

52. Davies NJ, Batehup L, Thomas R. The role of diet and physical activity in breast, colorectal, and prostate cancer survivorship: a review of the literature. Br J Cancer. 2011; 105: S52-S73.

53. Holmes MD, Chen WY, Feskanich D, Kroenke CH, Colditz GA. Physical activity and survival after breast cancer diagnosis. JAMA. 2005; 293(20): 2479-86.

54. Beasley JM, Kwan ML, Chen WY. et al. Meeting the physical activity guidelines and survival after breast cancer: findings from the after breast cancer pooling project. Breast Cancer Res Treat. 2012; 131(2): 637-643.

55. Meyerhardt JA, Giovannucci EL, Holmes MD, Chan AT, Chan JA, Colditz GA, Fuchs CS. Physical activity and survival after colorectal cancer diagnosis. J Clin Oncol. 2006; 24(22): 3527-34.

56. Meyerhardt JA, Heseltine D, Niedzwiecki D, et al. Impact of physical activity on cancer recurrence and survival in patients with stage III colon cancer: findings from CALGB 89803. J Clin Oncol. 2006; 24(22): 3535-41.

57. Schmitz KH, Holtzman J, Courneya KS, Masse LC, Duval S, Kane R. Controlled physical activity trials in cancer survivors: a systematic review and meta-analysis. Cancer Epidemiol Biomarkers Prev. 2005; 14(7): 1588-95.

58. Speck RM, Courneya KS, Masse LC, Duval S, Schmitz KH. An update of controlled physical activity trials in cancer survivors: a systematic review and meta-analysis. J Cancer Surviv. 2012; 4(2): 87-100.

59. Access Economics: Painful Realities: The Economic Impact of Arthritis on Australia in 2007. Sydney: Arthritis Australia; 2007.

60. Bosomworth NJ. Exercise and knee osteoarthritis: benefit or hazard? Can Fam Physician. 2009; 55(9): 871-878.

61. Bennell KL, Hinman RS. A review of the clinical evidence for exercise in osteoarthritis of the hip and knee. J Sci Med Sport. 2011; 14(1): 4-9.

62. Heesch KC, Brown WJ. Do walking and leisure-time physical activity protect against arthritis in older women? J Epidemiol Community Health. 2008; 62(12): 1086-91.

63. Kuther, G. Exercise therapy in rheumatoid arthritis: a systematic review. Aktuelle Rheumatologie 2010; 35(6): 364-374.

64. Barreto PD. Exercise and health in frail elderly people: a review of randomized controlled trials. Eur Rev Aging Physical Activity. 2009; 6(2): 75-87.

65. Paterson DH, Warburton DER. Physical activity and functional limitations in older adults: a systematic review related to Canada's Physical Activity Guidelines. Int J Behav Nutr Physical Activity. 2010; 7. doi: 10.1186/1479-5868-7-38.

66. Tiedemann A, Sherrington C, Close JCT, Lord SR. Exercise and Sports Science Australia Position Statement on exercise and falls prevention in older people. J Sci Med Sport. 2012; 14(6): 489-495.

67. Campbell AJ, Robertson MC. Rethinking individual and community fall prevention strategies: a meta-regression comparing single and multifactorial interventions. Age Ageing. 2007; 36(6): 656-62.

68. Howe TE, Rochester L, Neil F, Skelton DA, Ballinger C. Exercise for improving balance in older people. Cochrane Database of Systematic Reviews 2011; (11): doi: 10.1002/14651858.CD004963.pub3.

69. Garber CE, Blissmer B, Deschenes M. et al. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. Med Sci Sport Exerc. 2011; 43(7): 1334-1359.

1.2 EVIDENCE ON THE PSYCHOSOCIAL BENEFITS OF PHYSICAL ACTIVITY

The potential psychosocial benefits of physical activity include (1) a reduced risk of poor mental health, eg symptoms of anxiety or depression; and (2) enhanced wellbeing.

BACKGROUND

Poor mental health is a prevalent and significant public health issue in Australia. The 2007 National Survey of Mental Health and Wellbeing (SMHWB) indicated that almost half (45% or 7.3 million) of Australians aged 16-85 years had a mental disorder at some point in their life, and that one in five (20% or 3.2 million) met the criteria for a mental disorder in the previous 12 months.[1] With a focus on the common mental disorders of mood, anxiety and substance use disorders (ie excluding psychotic and other disorders), and a 60% response rate, these figures are likely to be underestimates. The *Burden of Disease and Injury in Australia* study indicated that mental disorders constitute the leading cause of non-fatal health loss in Australia, accounting for an estimated 24% of the total years lost due to disability.[2] Depression is predicted to become the leading cause of burden of disease in mid- and high-income nations by 2030.[3]

Anxiety and mood disorders are the most common mental disorders among Australian adults, with 12 month prevalence rates of 14.4% (2.3 million) and 6.2% (995,900) respectively.[1] Symptoms may however, be at a level that does not meet the diagnosis of a mental disorder or that requires professional assistance, but can still cause significant distress. Of those people experiencing at least one of the common mental health disorders, 46% are at a mild level, 33% moderate and 21% severe.[1] In a year, 1.1 million adults report experiencing high levels of psychological distress, and 409,000 report experiencing very high levels of distress.[1] Such distress can exacerbate pre-existing conditions, and increase the risk of poor physical health and mental health disorders.

Good mental health is, however, not just the absence of a mental health disorder or psychological distress. The *National Health Priority Areas Report on Mental Health* defines mental health as the capacity of individuals and groups to interact with one another and the environment, in ways that promote subjective well-being, optimal development and the use of cognitive, affective and relational abilities.[4] Good mental health also encompasses, therefore, aspects such as quality of life, positive affect, subjective wellbeing, and social functioning.

Rationale for a Relationship Between Physical Activity and Psychosocial Health

The potential biochemical and physiological mechanisms underlying relationships between physical activity and mental health include: an increase in endorphins (endorphin hypothesis); changes associated with an increase in core body temperature (thermogenic hypothesis); changes in central serotonergic systems (serotonin hypothesis); increased availability of neurotransmitters such as norephinephrine, dopamine, and serotonin (monoamine hypothesis); enhanced blood flow to brain regions involved in emotional regulation; disruption of the hypothalamic-pituitary-adrenocortical axis that regulates endocrine response to stress (HPA hypothesis); and improved sleep.[5-9]

The potential psychological mechanisms include distraction or time out from stressful contexts and negative thoughts; enhanced feelings of control and mastery; improved self-esteem and physical worth; and behavioural activation.[5-9] Physical activity with others (supervisors, groups or companions) can provide opportunities for social engagement, which in turn can provide a sense of belonging and attachment, reduce social isolation, and enhance social networks to buffer against stress and enhance coping.

The Evidence Summarised

The following discussion focuses on the associations between physical activity and poor mental health and psychosocial wellbeing in a *primary prevention* context (i.e. in otherwise healthy adults). Studies of clinical or patient populations, where physical activity was used as a *treatment or management* of poor mental health, or for people with a physical illness, or where results for healthy and clinical populations could not be differentiated, are not included. It is generally well established, however, that the effects of physical activity on psychosocial well-being are greater for those with mild-moderate levels of poor mental health than those with no symptoms,[10-13] making it difficult to demonstrate improvements in mental health among those who are not experiencing any mental health problems. Evidence was taken from The US Department of Health and Human Services Physical Activity Guidelines Advisory Committee Report Part G. Section 8: Mental Health[9] and from other systematic, meta analytic, or comprehensive narrative reviews.

PHYSICAL ACTIVITY AND ANXIETY

The US Department of Health and Human Services Report conclusion was that the evidence from a small number of nationally representative and population-based cross-sectional and prospective cohort studies supported regular physical activity as protective against the onset of anxiety disorders and symptoms. The report cited an Australian prospective population-based study which found that the odds of developing any anxiety disorder were reduced by an average of 53% among those who reported more than 3 hours per week of vigorous physical activity compared with those reporting no activity.[14] The effect was, however, not statistically significant, in part due to the small number of participants who developed an anxiety disorder. Results were also cited from a German study that indicated statistically significant 48% lower odds of developing any anxiety disorder among regularly active young adults compared with those reporting no activity.

The US Report concluded that evidence from RCTs indicated that participation in physical activity programs reduces anxiety symptoms in healthy adults. The effect of exercise compared to control conditions was 0.40SD (40 comparisons; 95% CI 0.27-0.53).[9] Just over half the trials used moderate to vigorous intensity activity with a frequency of 3 or more days per week. The magnitude of anxiety reduction was weakly correlated with the magnitude of fitness increase (r=0.24) after adjusting for sample size. There was an absence of evidence from prospective cohort studies or RCTs that examined whether effects varied by type, timing or intensity of physical activity.

We identified one additional review for this report. Conn et al. integrated data from 19 reports (published and unpublished studies 1983-2008) and 3,289 participants to conduct a meta-analysis on the relationship between physical activity and anxiety outcomes in healthy adults.[15] Studies that included some form of psychological treatment were excluded, so as to focus on the anxiolytic effects of physical activity. Types of physical activity varied from walking to supervised aerobic training/exercise prescription.

The *overall* average effect of physical activity on anxiety outcomes for studies comparing physical activity and control groups was statistically significant, but small (*d*=0.22, 95% CI 0.32-0.41; k=15), with significant heterogeneity. The average effect size across studies of pre/post physical activity differences was also small (*d*=0.29, 95% CI 0.17-0.40; k=17). Significantly larger (but still modest) improvements in anxiety were demonstrated among studies with larger sample sizes (vs. smaller; p=0.001), and in studies with random allocation of participants to experimental and control conditions (vs. non-random allocation; p<0.001).

Although some results should be interpreted with caution because of the low number of comparisons, the evidence suggested greater effects for: single focus physical activity interventions (vs. activity in conjunction with other behaviours; p=0.001); programs delivered to individuals (vs. group; p=0.028), supervised activity (vs. unsupervised; p<0.001), and programs of moderate-high intensity activity (vs. low intensity; p=0.048). Effects did not vary by the weekly duration (minutes/week) or the overall dose (minutes/session x number of sessions) of physical activity.

PHYSICAL ACTIVITY AND DEPRESSIVE SYMPTOMS

The conclusion of the US Department of Health and Human Services report was that population-based prospective cohort studies provide substantial evidence that regular physical activity protects against the onset of depression symptoms and major depressive disorder, but that evidence was insufficient to make conclusions about bipolar disorder and other mood disorders.[9] Results from 28 prospective cohort studies demonstrated that the average odds of symptoms were approximately 25-40% lower among active than inactive people, before adjustment for depression risk factors (OR=0.67, 95% CI 0.59-0.77); and 15-25% lower after adjustment for factors such as age, sex, education, income, smoking, alcohol use, chronic conditions and other psychosocial variables (OR=0.82, 95%CI 0.78-0.86). Protective effects were not limited to studies with self-rated symptoms assessed by questionnaire; studies that used a clinical diagnosis indicated an average 30% reduction in incident cases (OR=0.71; 95% CI 0.61-0.77).

The US report also concluded that RCT results indicated that participation in physical activity programs reduces depression symptoms in healthy adults. The average effect of exercise compared with a control condition was 0.35SD (7 studies; 95% CI 0.59-0.11).[9] Prospective and RCT data indicated that moderate and high levels of activity similarly reduced the odds of incident depression compared with low levels of activity, which in turn were more protective than very low levels of activity or inactivity. People doing the US recommended levels of activity (moderate intensity activity for a minimum of 30 minutes/day on five days, or vigorous intensity activity for 20 minutes on 3 days/week) had a more favourable odds reduction (OR=0.77, 95% CI 0.72-0.82) than those who did not (OR=0.84, 95% CI 0.84, 95%CI 0.78-0.90), after adjustment for other risk factors.[9] It was not possible to determine the minimal or optimal level of physical activity, but the report stated that an increase in physical fitness is not required.

We identified four additional quantitative reviews, including two meta-analyses, that examined the relationships between physical activity and depressive symptoms. Azar et al.,[16] reviewed studies of physical activity and depressive symptoms in young women (aged 18-35 years). Eight observational studies with non-clinical samples (published 1997-2007) were identified (see Table 1.1). Six of the seven cross sectional studies showed a

significant inverse association. The one prospective study was over ~15 years and demonstrated an inverse association between engaging in team sports and/or regular training (≥2 times/week) while at university and self-reported physician-diagnosed depression in the previous 10 years, after adjustment for other factors including current activity level (adjusted odds ratio = 0.68, 95% confidence limits 0.56 - 0.83, p < 0.0001). There was also an inverse association with symptoms of psychological distress in the past month (age adjusted OR = 0.66, 95% CL 0.58-0.75, p<0.0001). The only intervention study (6 week pre/post) demonstrated a small inverse association between aerobic exercise and depressive symptoms (effect size = 0.37), and no association for anaerobic exercise (weight lifting); no information on activity dose was provided.

Table 1.1: Summary of selected reviews showing the number of studies in each that reported significant associations between physical activity and psychosocial wellbeing.[a]

	Azar et al., 2011[16]	Bize et al., 2007[20]	Gerber et al., 2009[19]	Puetz, 2006[22]	Teychenne et al., 2008[17]
Study type	Quantitative review	Quantitative review	Quantitative review	Meta-analyses	Quantitative review
Psychsocial Wellbeing indicators	Depressive symptoms (young women only)	Vitality, mental health, social functioning	Stress induced complaints	Feelings of energy and fatigue	Depressive symptoms
Number of studies[b, c]	9 XS 6/7 P 1/1 EXP 1/1	12 XS 5/6 P 2/2 RCT 3/4	15 XS 7/12 P 3/3	10 XS 7/7 P 3/3	35[d] XS 9/9 P 7/10 RCT 7/14 EXP 3/4

[a] Studies assessing only perceived health or physical functioning excluded.

[b] XS=cross sectional; P=prospective; RCT=randomised controlled trial, EXP=intervention with non or undefined randomisation

[c] Fractions indicate proportion of studies with a significant beneficial association.

[d] As some researchers reported both cross sectional and prospective results, the number of unique studies is counted.

Teychenne et al.,[17] identified 27 observational and 40 intervention studies (published <2007) on physical activity and depressive symptoms. Of those with non-clinical samples, and excluding those that focussed on older adults or with mean participant age >65 years, all 9 cross sectional, 7 of 10 prospective, and 10 of 18 intervention studies demonstrated a significant inverse association (see Table 1.1). Among the prospective studies, the lowest doses of activity associated with a significantly lower level of symptoms included 1-2 hours/week of light to moderate intensity leisure and domestic activity, an increase of at least 60 mins/week of moderate-vigorous intensity activity (inactive and low active women); 1-2.5 hours/week of moderate intensity activity, 1 hour/week of vigorous intensity activity (women), and 1-3 times/month of vigorous activity. The three prospective studies that did not show a significant association provided only limited information on activity dose, with one assessing frequency per week, and the other two assessing "regular exercise" with frequency and duration not specified.

Among the intervention studies, only three had information on effect size: two indicated a small effect (0.23, 0.3) and one indicated a moderate effect (0.7). The lowest doses of physical activity associated with a significant decline in depressive symptoms were a total weekly duration of 1 hour (2 sessions) of moderate-vigorous activity (sedentary women), 1.6-2.25 hours (2-3 sessions) of light to moderate activity (men), 1.3 hours-1.6 hours (3-4 sessions) of moderate to vigorous activity, 2.5 hours (5 sessions) of moderate activity, and 1.5 hours (2 sessions) of vigorous activity. Some intervention studies indicating no effect on depression had very limited assessment, but did demonstrate improvement in measures of wellbeing.

Rethorst et al.,[12] conducted a meta-analysis of the results of 40 RCT studies (published <2005) of the antidepressive effects of physical activity in non-clinical samples (N=2408). Studies were trials of moderate-vigorous exercise (aerobic or resistance) with a no treatment or waitlist control. The authors reported a moderate overall effect size (-0.59) with an average change of 2.64 points on the Beck Depression Inventory.

Conn et al.,[18] also conducted a meta-analysis of the results of 70 controlled and uncontrolled trials (published and unpublished <2008) of supervised (i.e., verified) or unsupervised (i.e., unverified) physical activity. Among the studies of supervised activity, there was a small effect on depressive symptoms for control group comparisons (mean effect size 0.37, 95%CI 0.24-0.50; k=38), and pre/post intervention studies (ES=0.26; 95%CI 0.18-0.34; k=67), with significant heterogeneity. The results suggested significantly greater effects for low intensity than for moderate intensity physical activity (ES=0.91 vs. 0.27; p=0.029; k=4, 25), and no significant differences between types or overall dose of activity (minutes/session x number of sessions). Among the studies of unsupervised activity, there was a moderate effect for control group comparisons (ES=0.52; 0.28-0.77; k=22) and a small effect for pre/post intervention studies (ES=0.38; 0.56-0.05; k=45), with significant heterogeneity. Effects did not vary by intensity of activity. Across all studies (i.e., supervised and unsupervised activity), the effects were similar for group and individual programmes, for single focus and multi-behaviour interventions and for different types of activity (endurance, resistance/flexibility activity, walking).

PHYSICAL ACTIVITY AND STRESS

The US Department of Health and Human Services report combined the evidence for psychological distress with the evidence on wellbeing, with the conclusion that the available evidence from prospective cohort studies indicated a small to moderate association that favours people who are physically active.[9] The data suggested that the odds for reduced distress (or enhanced wellbeing) among active people was approximately 30% (OR=0.69, 95% CI 0.61-0.78) before adjustment for risk factors, and approximately 20% (0.82, 95%CI 0.77-0.86) after adjustment.[9] RCT results indicated small benefits that often did not exceed the effects of placebo control conditions, such as health education or stretching.

Population-based studies indicated that participation in either moderate or high levels of physical activity was associated with reduced feelings of distress (or enhanced wellbeing), when compared with inactivity or low levels of activity. It was not possible to identify a minimal or optimal type or amount of activity, but it was stated that an increase in fitness is not required. Unadjusted analyses indicated that odds favoured people meeting US activity recommendations (OR=0.77, 95% CI 0.70-0.91) compared with those who did not (OR=0.84, 95% 0.78-0.91).

We identified one additional study. Gerber et al.,[19] assessed physical activity as a moderator of the development of stress induced complaints in healthy people. Twenty-seven studies (published <2008) were considered; those relevant for this discussion (adults <65 years) included 12 cross sectional and 3 prospective studies (see Table 1.1). Stress-induced complaints included measures of negative mood, distress, somatic complaints, general health complaints, illness severity, and health care use. The impact of physical activity was determined as the proportion of significant interaction effects between stress, activity and complaint in each study, with categories of full support (>2/3 of all interactions significant), partial support (>1/3 of all interactions significant) and no support (<1/3 of all interactions significant). Of the 12 cross sectional studies, 4 were classified as providing full support, 3 as partial support, and 5 as no support. Of the three longitudinal studies, 2 were classified as providing full support and one as providing partial support. No information was provided on dose-response relationships.

PHYSICAL ACTIVITY AND PSYCHOSOCIAL WELLBEING

As previously stated, The US Department of Health and Human Services report combined evidence for psychological wellbeing and distress, with the conclusion was that the available evidence from prospective cohort studies indicated a small to moderate association that favours people who are physically active.[9] These results have been reported in the previous section on physical activity and stress. The report also identified enhanced self-esteem and reduced chronic fatigue as significant aspects of mental health that could benefit from physical activity. Results were cited from a meta-analysis of approximately 50, mostly small, RCTs of exercise and self-esteem: this demonstrated an average increase in self-esteem of 0.25SD.[9] There was little evidence on the relationship between physical activity and chronic fatigue syndrome. Five RCTs were described as showing a small positive effect, and population-based observational studies suggested a protective effect against feelings of fatigue or low energy (OR=0.61, 95%CI 0.52-0.72).[9]

We identified five quantitative reviews that examined the results of studies of physical activity and psychological wellbeing. Two of these (one systematic review,[20] one meta-analysis[21]) focussed on quality of life, one meta-analysis focussed on positive affect,[10] and one review focussed on feelings of energy and fatigue.[22]

Bize et al.,[20] conducted a systematic review of studies (published 1996-2006) on the association between physical activity level and health related quality of life (HRQoL). Of the 14 studies identified, 12 included a *psychological* subcomponent of HRQoL (vs for example, perceived health) and were considered relevant for this report (see Table 1.1). There were positive cross-sectional associations between physical activity and vitality (4 studies), mental health (3 studies), and social functioning (1 study). Both cohort studies demonstrated a positive association between a one hour increase in physical activity and improved social functioning - one study was over 3 years (significant association for women only) and the other was over 5 years. The 3 year study also indicated a positive association between a one hour increase in physical activity and vitality and mental health. The 5 year study demonstrated a positive association between total leisure time activity and both vitality and mental health in men. Three of the four randomised controlled trials (RCT) demonstrated a significant association between physical activity

and wellbeing. Two of these were for vitality; one study had a physical activity dose of at least 72 minutes/week walking, the other involved 2-3 hours/week of aerobic exercise. The third RCT found an improvement in psychological HRQoL from 1-2 sessions/week of fitness training.

Gillison et al.,[21] conducted several meta analyses of the results of RCTs (published <2007) of exercise interventions on quality of life. Of the 56 original studies, 14 were with well populations. Among six studies of psychological wellbeing, there were significant small improvements at 3-6 months relative to no exercise control groups (ES=0.21, 95% CI 0.05-0.36). Greater improvements in psychological wellbeing were associated with light than with moderate to vigorous intensity exercise (ES=0.16 vs. -0.54, $p<0.001$), while the opposite effect was found for physical wellbeing. Individual exercise was associated with greater improvements in psychological wellbeing than group-based exercise (ES=0.54 vs. 0.09, $p<0.05$). Five studies on physical activity and social relationships showed no significant associations. No information was provided on dose-response relationships.

Reed and Buck[10] conducted a meta-analysis to examine the effect of regular aerobic exercise on positive affect. Data from 105 published and unpublished studies (1980-2008) were included (N=9840), yielding 370 effect sizes. The majority of effect sizes were based on outcome measures of vigour (214) or vitality (31); other common measures were positive affect (36) and positive wellbeing (28). The results indicated that exercise produced moderate improvements in positive affect relative to control groups (mean sample size weighted effect size $\hat{d}_{corr}=0.60$, $SD_{corr}=0.39$). There were larger effects among participants with below average affect. Although the results should be interpreted with caution, because of the low number of comparisons and the lack of formal significance testing, the effects on positive affect were slightly greater (a difference of 0.20-0.30) when the physical activity was of low intensity ($d_{corr} = 0.72$), done >3 days/week ($d_{corr} = 0.79$), and of duration 30-35 minutes ($d_{corr} = 0.68$).

Puetz[22] analysed data from seven cross sectional and five prospective cohort studies (published 1945-2005) on physical activity level and feelings of energy and fatigue (N=137,351). Of the 12 studies, all showed a positive association, with a reduced odds of low energy and fatigue (mean odds ratio 0.61, 95% CI 0.52-0.72) when active adults were compared with those in the least active group. The relationship was slightly attenuated in prospective cohort studies (0.68; 0.54-0.85) than in cross sectional studies (0.56; 0.47-0.68). Excluding one of the five cohort studies that used a patient sample (people with diabetes, myocardial infarction, and hypertension) and another with older adults, an overview of the results from ten studies is presented in Table 1.1. In the three relevant cohort studies, significant associations were found for the lowest doses of physical activity (one level above the least active), including 2-7 sessions/week of exercise (men only), "any regular exercise" and "brisk walking" ($\geq$20 minutes/week at least once a week), and 3-5 hours/week of moderate activity.

PHYSICAL ACTIVITY AND ADVERSE PSYCHOSOCIAL EVENTS

The US report notes that some adverse psychological events have been reported among extremely active people, but it was not known whether these were causally influenced by physical activity exposure.[9] Little is understood about "exercise addiction" where motivation exceeds other commitments and professional advice. This can occur in e.g., athletes who over-train, in people with eating disorders who over-use exercise for weight management and in those with a pathological preoccupation with muscularity. Results from studies on the potential adverse effects of exercise training and sports were described as inconclusive because of a lack of standard definitions or valid measures of activity, a lack of common psychopathology, and a lack of comparison with suitable controls.[9] Anxiety can be elevated slightly immediately after maximal exercise testing or heavy resistance exercise, but this is temporary.[9] There was evidence to refute the potential association between exercise and panic attacks, and research showing that lactate accumulation from exercise is not related to increased risk of panic attacks or post exercise anxiety.[9]

ISSUES RELATING TO THE EVIDENCE ON PHYSICAL ACTIVITY AND PSYCHOSOCIAL BENEFITS

Studies of physical activity and psychosocial health tend to have high levels of heterogeneity, which may in part reflect the variability of psychosocial functioning. Unlike many physical conditions (e.g., diabetes, cardiovascular disease), the temporality of psychosocial difficulties may be unpredictable, short term, and moderated by factors such as life experiences and social support. Symptoms of depression, anxiety and stress can remit and recur, and there may be critical periods for the emergence of symptoms. Accordingly, the timing of the relationship between physical activity and psychosocial benefits may be more acute and sensitive than for physical health outcomes.

High levels of heterogeneity may also reflect the range of psychosocial health outcomes. Just as "physical health" can encompass a variety of outcomes (cancer, diabetes, cardiovascular disease, mortality), "psychosocial health" is a multidimensional construct that can encompass symptoms of anxiety, depression, and distress; as well as positive affect; wellbeing; social functioning; vitality, etc. Unlike many physical conditions (e.g., diabetes, mortality), there is often no objective or gold standard of measurement for these psychosocial outcomes, and the constructs are amorphous. Psychosocial outcomes are often measured by self-report, which is vulnerable to a range of biases, such as recall and social desirability bias. Multiple questionnaires are available to assess psychosocial health, and these can include multiple subcomponents. Depression, for example, can include affective, somatic and cognitive symptoms; and psychological wellbeing can include social or emotional role functioning, affective states, and life attitudes. Subcomponents may not be equally represented in assessment measures, or equally sensitive to physical activity effects. With so many related outcomes, it is difficult to assess the consistency of the research evidence, and therefore to confirm causal relationships.

In contrast with the evidence on physical activity and physical health outcomes, few review studies have quantified the dose-response relationship between physical activity and psychosocial health. More work is needed to examine whether the effects of physical activity on psychosocial health vary by type, timing or intensity of activity.

CONCLUSIONS

The evidence presented here provides strong support that physical activity is associated with psychosocial health benefits in otherwise healthy adults. The research demonstrates small to moderate effects with significant heterogeneity, indicating the wide individual variation in psychosocial benefit. Effects are likely to be greater among those who are inactive, and those with lower levels of psychosocial functioning. The evidence is strongest for a protective effect against depression, and for enhancement of quality of life/wellbeing (e.g., vitality). There is developing evidence to suggest a protective effect against anxiety. There may also be benefits for social functioning, but the research evidence is mixed, with cohort studies showing positive associations, and experimental trials showing no association. It may be that social benefits take time to accrue and are difficult to demonstrate in controlled trials.

On the basis of this review, there is insufficient evidence to make recommendations on the specific dose of physical activity required for psychosocial health benefits, although some general trends were observed. For almost all studies, "some" activity was better than "none". The type of physical activity, or an improvement in fitness, did not appear to be important. There is some evidence of positive effects from low intensity activity and low doses of activity, eg 1-3 sessions/week, 1-2 hours/week, increases of 1 hour/week, etc. for some psychosocial health outcomes.

REFERENCES (Part 1.2)

1. Australian Bureau of Statistics. National Survey of Mental Health and Wellbeing: Summary of Results, 2007. Canberra 2008. Accessed June 2012.
2. Begg SJ, Vos T, Barker B, Stanley L, Lopez AD. Burden of disease and injury in Australia in the new millennium: measuring health loss from diseases, injuries and risk factors. Med J Aust. 2008; 188: 36-40.
3. Mathers CD, D L. Projections of global mortality and burden of disease from 2002 to 2030 PLoSMed. 2006 ;3(11): e442.
4. Commonwealth Department of Health and Aged Care and Australian Institute of Health and Welfare. National Health Priority Areas Report: Mental Health 1998. AIHW Cat. No. PHE 13. Canberra: Health and AIHW; 1999.
5. Daley A. Exercise and depression: A review of reviews. J Clin Psychol Med Settings. 2008; 15: 140-7.
6. Biddle S, Mutrie N. Psychology of physical activity. Determinants, well-being and interventions. 2nd ed. New York: Routledge; 2008.
7. Dishman RK, Washburn RA, Health GW. Physical activity and mental health. Physical Activity Epidemiology. Champaign, IL: Human Kinetics; 2004.
8. Stathopoulou G, Powers M, Berry A, Smits J, Otto M. Exercise interventions for mental health: A quantitative and qualitative review. Clin Psychol - Sci Pract. 2006; 13(2): 179-93.
9. US Department of Health and Human Services. Physical Activity Guidelines Advisory Committee Report Part G. Section 8: Mental Health.. 2008. Accessed June 2012.
10. Reed JB, S. The effect of regular aerobic exercise on positive-activated affect: A meta-analysis. Psychol Sport Exerc. 2009; 10(6): 581-94.
11. Barbour K, Edenfield T, Blumenthal J. Exercise as a treatment for depression and other psychiatric disorders. J Cardiopulm Rehabil Prev. 2007; 27(6): 359-67
12. Rethorst CD, Wipfli BM, Landers DM. The antidepressive effects of exercise: A meta-analysis of randomized trials. Sports Med. 2009; 39(6): 491-511.
13. Reed J, Ones D. The effect of acute aerobic exercise on positive activated affect: a meta analysis. Psychol Sport Exerc. 2006; 7: 477-514.
14. Beard J, Heathcote K, Brooks R, Earnest A, Kelly B. Predictors of mental disorders and their outcome in a community based cohort. Soc Psychiatr Psychiatr Epidemiol. 2007; 42(8): 623-30.
15. Conn VS. Anxiety outcomes after physical activity interventions: meta-analysis findings. Nurs Res. 2010; 59(3): 224-31.
16. Azar D, Ball K, Salmon J. Individual, social, and physical environmental correlates of physical activity among young women at risk of depression J Phys Act Health. 2011; 8(1): 133-40.
17. Teychenne M, Ball K, Salmon J. Physical activity and likelihood of depression in adults: A review. Prev Med. 2008; 46(5): 397-411.

18. Conn VS. Depressive symptom outcomes of physical activity interventions: meta-analysis findings. Ann Behav Med. 2010; 39(2): 128-38.

19. Gerber M, Puhse U. Do exercise and fitness protect against stress-induced health complaints? A review of the literature. Scand J Public Health. 2009; 37(8): 801-19.

20. Bize R, Johnson J, Plotnikoff R. Physical activity level and health-related quality of life in the general adult population: A systematic review. Prev Med. 2007; 45(6): 401-15.

21. Gillison FB, Skevington SM, Sato A, Standage M, Evangelidou S. The effects of exercise interventions on quality of life in clinical and healthy populations; a meta-analysis. Soc Sci Med. 2009; 68(9): 1700-10.

22. Puetz T. Physical activity and feelings of energy and fatigue - Epidemiology evidence. Sports Med. 2006; 36(9): 767-80.

1.3 EVIDENCE ON PHYSICAL ACTIVITY AND WEIGHT GAIN PREVENTION

BACKGROUND

Overweight and obesity are defined as BMI 25-29.9 and ≥ 30 kg/m^2 respectively. It is estimated that 60% of the adult Australian population is now either overweight or obese.[1] Given the relationships between BMI and a range of chronic illnesses, as well as the social and economic consequences of BMI,[2,3] prevention of obesity is now a national health priority. Physical activity is recommended as an important part of weight *management* by almost all public health agencies both in Australia and overseas. The recently released NHMRC draft guidelines for the *management* of overweight and obesity recommend that physical activity equivalent to approximately 225-300 minutes of moderate intensity activity per week (or lesser amounts of vigorous activity) be prescribed as part of lifestyle weight management programmes.[4]

The issue of weight gain prevention is not addressed in the draft NHMRC management guidelines, except that clinicians are advised to routinely assess and monitor BMI in those with BMI<25, and to discuss BMI with patients in the BMI 25-29.9 category if BMI is increasing. However, since more than half of all adults gain weight with age, it might be strategic to consider the amount of physical activity required for the primary prevention of weight gain. This issue has, however, received comparatively little research attention, compared with weight loss or treatment studies of overweight and obese people.[2] If weight gain could be prevented, weight loss and maintenance of healthy weight following weight loss would not be necessary.

EXISTING RECOMMENDATIONS

There are currently two contrasting recommendations on the amount of physical activity required for prevention of weight gain. In their 2002 report on dietary intake, the US Institute of Medicine suggested that 60 minutes/day (420 minutes per week) of moderate intensity physical activity is required to prevent the transition from healthy weight to overweight or obesity.[5] In contrast, the 2009 Position Stand of the American College of Sports Medicine suggests that between 150 and 250 minutes of moderate intensity physical activity per week will prevent weight gain (with greater amounts needed for significant weight loss).[6]

The differences in these recommendations reflect the challenges of conducting research into weight gain prevention. Most notably, there is high individual variation in the relationship between physical activity and weight gain, as effects depend not only on starting BMI and activity levels, but also on energy intake, medication use (including oral contraceptive pill and hormone replacement therapy, antidepressants etc), smoking, alcohol and co morbidities.[7, 8, 9]

Previous weight and weight loss history is also important. For example, studies of the amount of activity needed to prevent weight gain *after weight loss* seem to show that more than one hour per day is required. The evidence on this comes from studies with very different designs. An observational study based on the US National Weight Loss Registry has shown that walking 28 miles a week – which amounts to 9 hours per week (about 77 mins/day) walking at 5 km/hour, will prevent weight re-gain.[10] Measurement studies with doubly labelled water also suggest that inactive individuals would need to do 80 mins/day of moderate intensity activity (or 35 mins/day vigorous activity) to prevent weight regain after weight loss.[11]

PRIMARY PREVENTION OF WEIGHT GAIN

Studies of the *primary prevention* of weight gain in previously healthy weight individuals are rare. While the main cause of weight gain (energy imbalance) is well known, in addition to energy intake and physical inactivity, a systematic review of the determinants of weight gain in young adult women found that contraception, quitting smoking, and the transition from school to university were additional causes of weight gain at this lifestage.[9]

Cross sectional evidence indicates an inverse relationship between physical activity and body weight or BMI. The direction of the association cannot however be shown with this type of study as high body weight may be a barrier to activity. Several short term prospective studies have also demonstrated small dose-response relationships between changes in physical activity (increasing) and changes in body weight (decreasing). Once again, the direction of the relationship in many studies is unclear. Moreover, findings vary according to starting levels of physical activity and BMI.

Results from longer term prospective studies, including large cohort studies as well as randomized controlled trials, are more valuable for informing the development of physical activity recommendations for weight gain prevention. Study results are however often difficult to interpret in terms of absolute weight gain prevention, because to date, all have used weight gain of less than a nominated percentage of initial weight as the main outcome variable. For example, data from one large randomized controlled trial show that moderately vigorous activity for 150-250 minutes per week (500-850 MET.min at a MET level of 3.33) will prevent "one year weight gain of >3% per year" in most adults.[12] However, over 5 years, weight gain of 2.5% (ie less the 3%) per year, for an 80 kg man, will mean an increase to more than 90kg.

Few large cohort studies have examined the primary prevention of weight gain. Data from the Nurses' Health study have shown an average weight gain of 5.7kg in 8 years among 46,754 women who were aged 23-45 years in 1989.[13] Those who maintained a 'high level' of physical activity (>30 mins walking /day or >20 mins jogging/day), or *increased* their physical activity by at least 30 mins/day were less likely to gain weight (defined as >5% of initial weight). Overall the researchers concluded that sustained

physical activity for at least 30 minutes per day, particularly if more intense, was associated with reduction in long term weight gain. They also concluded that the form of physical activity was not as important as total energy expenditure for weight gain prevention.[13] Once again, it is important to note that, while 38% of this sample 'avoided weight gain >5% in five years', a 4.5% (five year) increase in weight for a 70kg woman would increase BMI by more than two points in ten years.

Researchers from the US Women's Health Study have also recently reported on the amount of physical activity required to prevent weight gain.[14] Average weight gain in this sample of 34,079 mid-older age women (age 54.2 years at baseline) was 2.6 kg over 13 years, which is much less than in the younger nurses' cohort described above, but sufficient to adversely affect health.[2] Physical activity was associated with less weight gain *only* in women with initial BMI <25 kg/m2. Women in this BMI category, who maintained their weight and gained <2.3 kg over 13 years, averaged physical activity equating with 21.5 MET.hours/week over six follow-ups in 13 years. This translates to about an hour a day of moderate intensity activity.

This study is important as it highlights the fact that physical activity was not protective against weight gain in women who were overweight at baseline. Results from the Australian Longitudinal Study on Women's Health have also shown that the rate of weight gain over ten years is higher in younger (age 18-23 years at baseline) adult women with BMI>25 than those with healthy BMI. Data from that study also show that women who reported doing no physical activity gained an average of 7.9kg in 10 years, while those in the low (40-<600MET.min/week), moderate (600-<1200) and high (>1200) physical activity categories gained 7.1, 6.6 and 4.3 kg respectively. As the women in the highest physical activity category (corresponding to about 50 minutes of daily moderate intensity activity) gained (on average) more than 4kg in ten years, it is reasonable to assume that more activity is required for prevention of weight gain.[15,16]

CONCLUSION

Overall, the conclusion from the very limited available evidence is that at least 60 minutes per day of moderate intensity activity, or the equivalent volume of more vigorous activity, is the dose of physical activity required for the primary prevention of weight gain. For those who are already overweight or obese it is unlikely that this level of physical activity will prevent further weight gain without concurrent dietary change. A daily energy deficit of 2,500 KJ is recommended for weight loss in the NHMRC guidelines.[4]

REFERENCES (Part 1.3)

1. Australian Institute of Health and Welfare. Australia's Health 2010. Australia's health series number 12. Cat no. AUS 122. Canberra: Australian Institute of Health and Welfare.

2. Kumanyika SK, Obarzanek E, Stettler, N, et al. Population based prevention of obesity: the need for comprehensive promotion of healthful eating, physical activity and energy balance: A scientific statement for the American Heart Association Council on Epidemiology and Prevention, Interdisciplinary Committee for Prevention. Circulation. 2008; 118(4):428-464.

3. Whitlock G, Lewington S, Sherliker P et al. Body mass index and cause-specific mortality in 900,000 adults: collaborative analyses of 57 prospective studies. Lancet. 2009; 373 (9669): 1083-1096.

4. NHMRC Management of overweight and obesity in adults, adolescents and children. Clinical guidelines for primary health care professionals. Public consultation draft 29th March 2012, and evidence summary. Accessed June 2012 from http://consultations.nhmrc.gov.au/public_consultations/clinical-practice-guideline-m.

5. Institute of Medicine. Dietary reference intake for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein and amino acids. Washington DC: Washington National Academic Press; 2002.

6. Donnelly JE, Blair SN, Jakicic JM, Manore MM, Rankin JW, Smith BK, American College of Sports Medicine. American College of Sports Medicine position stand. Appropriate physical activity intervention strategies for weight loss and prevention of weight regain for adults. Med Sci Sports Exerc. 2009; 41(2): 459-71

7. Ball K, Brown WJ, Crawford D. Who does not gain weight? Prevalence and predictors of weight maintenance in young women. Int J Obes. 2002; 26: 1570-1578.

8. Brown W, Williams L, Ford J, Ball K, Dobson A. Identifying the 'energy gap': magnitude and determinants of five year weight gain in mid age women. Obesity Res. 2005; 13(8): 1431-41.

9. Wane S, van Uffelen JGZ, Brown WJ. Determinants of weight gain in young women. J Womens Health. 2010; 19(7): 1327-1340.

10. Klem ML, Wing RR, McGuire MT, Seagle HM, Hill JO. A descriptive study of individuals successful at long term maintenance of substantial weight loss. Am J Clin Nutr. 1997; 66: 239-246.

11. Schoeller DA, Shay K, Kushner RF. How much physical activity is needed to minimize weight gain in previously obese women? Am J Clin Nutr. 1997; 66: 551-556.

12. McTiernan A, Sorensen B, Irwin ML et al. Exercise effect on weight and body fat in men and women. Obesity. 2007; 15: 14961512.

13. Mekary RA, Feskanich D, Malspeis S, Hu FB, Willet WC, Field AE. Physical activity patterns and prevention of weight gain in premenopausal women. Int J Obesity. 2009; 33(9): 1039-1047.

14. Lee I-M, Djoussé L, Sesso HD, Wang L, Buring JE. Physical activity and weight gain prevention. JAMA. 2010; 303(12): 1173-1179.

15. Brown WJ, Hockey R, Dobson AJ. Effects of having a baby on weight gain. Am J Prev Med. 2010; 38 (2): 163-170.

16. Brown WJ, Hockey R, Dobson AJ. Physical activity, sitting and weight gain in Australian women. J Sci Med Sport. 2011; 14(7) (supp):93.

1.4 EVIDENCE ON SEDENTARY BEHAVIOURS AND HEALTH

BACKGROUND

In light of changing patterns of physical activity and sedentariness, with decreasing levels of physical activity and increased sitting in most populations, there has in the last ten years been increased interest in the health effects of sedentary behaviour (SB). Sedentary behaviour (from the Latin, *sedere* - to sit) is conceptualised here as time spent sitting or lying down, in low intensity activities with a MET value of 1- 1.5 METs, where one MET is equivalent to resting metabolic rate.[1]

Although most research in this area has focussed on the health effects of sitting to watch TV, there has recently been increased research interest in the health effects of sitting in all domains of life. 'Sedentary behaviour' is now, therefore, considered to include time spent sitting at work (occupational sitting time), sitting for transport (eg in a car, on a bus or train etc), sitting to use a computer at home (eg for social networking, finding information, emailing, playing computer games etc) and sitting (or sometimes lying down) in all forms of leisure (eg while watching TV, playing video games, reading books, newspapers, magazines, listening to or playing music, doing crafts such as knitting and sewing, and watching movies or dining outside the home etc).

Recent estimates suggest that Australian adults spend between 7 and 10 hours per day sitting, of which 2-3 hours is spent watching TV.[2] Among working adults, who, on average, spend about half their working day sitting, occupational sitting is the largest contributor to daily sitting time, in both developed and developing countries.[3-6]

Rationale for a Relationship Between Sedentary Behaviour and Health

Underpinning the growth in research interest in sitting time, is an increased awareness of the biological plausibility that there could be health risks from too much sitting, which are independent of the risks associated with not meeting guidelines for physical activity.[2] There is evidence, for example, from animal models and from studies of long term bed rest, microgravity, space flight and spinal cord injury studies with humans, to indicate that there may be effects of 'not moving' on metabolic and vascular function, as well as on bone mineral density.[7]

Although there is limited evidence from in vivo studies of people in normal living and working conditions, the hypothesis is that loss of local contractile stimulation of skeletal muscles results in significant metabolic changes. The most notable is a decrease in lipoprotein lipase (LPL, an enzyme involved in skeletal muscle uptake of triglycerides and free fatty acids) activity, with subsequent increases in plasma triglycerides and decreases in HDL-cholesterol, which are risk factors of coronary and cardiovascular disease.[8-10] Suppression of LPL activity may also reduce glucose uptake through its action on GLUT-4 receptors in skeletal muscle.[7] Current thinking is, therefore, that these deleterious metabolic effects, which are now being demonstrated in controlled trials of the effects of sitting and standing/walking on metabolic markers,[11] are distinct from (although similar in nature to) the detrimental effects of not meeting physical activity guidelines. In other words, people may meet the physical activity guidelines and yet sit for many hours each day, with adverse metabolic effects over time resulting in the development of diabetes and cardiovascular disease.[12] Whether or not these effects can be countered by increasing levels of physical activity at any intensity is currently unclear.

THE EVIDENCE SUMMARISED

Three systematic reviews have considered the health effects of sedentary behaviour in adults in the last three years. The first focussed on occupational sitting time and included cross-sectional, case control and prospective studies.[13] The second focussed mostly on leisure time sedentary behaviours,[14] and the third focussed largely on TV time and other sedentary behaviours.[15] The latter two reviews included only prospective studies. A further recent review focussed only on the relationship between sedentary behaviour and depression,[16] and another provided a review of the correlates of sedentary behaviour.[17] A summary of the findings of these reviews on the relationships between sitting time and health outcomes is provided in Table 1.2.

Table 1.2. Summary of recent reviews of relationships between sedentary behaviour (SB) and health outcomes.
Numbers indicate proportion of studies that showed positive associations.

	van Uffelen et al 2010[13] **Occupational SB**	**Proper et al 2011[14]** **Leisure time SB**	**Thorp et al 2011[15]** **TV and SB**	**Teychenne et al 2010[16]** **Depression**	**Conclusion:** ***Evidence is:***
No. of studies	43	19	48	11	
Study design	x-s c-c p	p	p	x-s p	
BMI and weight gain	x-s 5/10 c-c 0 p 1/3	p 4/10	p 13/18		Mixed
Diabetes	x-s 1/1 c-c - p 2/3	p 2/2	p 4/4		Moderate
Cardio-metabolic biomarkers			p 3/7		Mixed
Cardio-vascular disease	c-c ½ p 3/6	p 2/4	p 1/1		Mixed
Cancers	p 4/4	p	p		Mixed

	van Uffelen et al 2010[13] Occupational SB	Proper et al 2011[14] Leisure time SB	Thorp et al 2011[15] TV and SB	Teychenne et al 2010[16] Depression	Conclusion: *Evidence is:*
		1/13	4/5		
Depression				x-s 6/10 p 2/2	Limited
All-cause mortality	p 4/6	p 2/3	p 6/6		Strong or convincing

Study design: x-s=cross sectional; c-c=case control; p=prospective.

The conclusions from the three main reviews were that the majority of the prospective studies found that occupational/leisure time sitting was associated with higher risk of all-cause mortality. There was moderate or mixed evidence of relationships between sitting time and diabetes and a range of weight related health outcomes, including weight gain and obesity, and insufficient evidence to support any relationship for cancer or CVD (including CVD biomarkers).[13-15] Although the level and strength of the evidence appears to be increasing, heterogeneity of study designs, measures and findings made it difficult to draw definitive conclusions. The review that focussed only on depression found limited evidence for any effect of sitting on depression.[16]

Issues Related to This Body of Evidence

A major limitation of interpreting the evidence in all these reviews was that relationships between SB and health outcomes could potentially be influenced by occupational, leisure time or total physical activity. In the review by van Uffelen and colleagues, only 22 of the 43 included studies 'adjusted' their results for physical activity or exercise, and of these, 12 showed significant associations between sitting time and a health outcome and 10 did not. Early results from the Australian *45 and Up* study, published since the reviews were conducted, have recently strengthened the finding that sitting time is associated with mortality, even after adjustment for physical activity assessed using the Active Australia survey.[18]

The issue of 'adjusting for' physical activity is interesting, as most researchers adjust only for time in leisure related activity of at least moderate intensity, and not for occupational

activity, which can be substantial in terms of daily energy expenditure, even though occupational activity is mostly at light intensity. The majority of studies that conduct this kind of adjustment, or examine results after stratification of physical activity levels, do not find that the results are changed. In other words, the relatively small amounts of moderate-vigorous activity that are usually reported as part of leisure activity or active transport, do not appear to offset the metabolic effects of prolonged sitting. However, three studies have shown that physical activity may protect against the adverse effects of sitting.[19-21]

It will be interesting in future studies with objective measures of both physical activity and sitting time, to see whether time spent in all forms of physical activity (and not just moderate to vigorous physical activity: MVPA) is protective against the adverse effects of sitting, as it might be expected that the muscle activity associated with light intensity activity, maintained over long periods, could have positive effects on both metabolism and energy expenditure, and subsequently on energy balance and weight gain.

The concept of energy balance was considered in the review by Thorp et al,[15] in terms of the notion that TV watching could increase energy intake through increased snacking. Although one systematic review has found that adults' TV/screen time is associated with unhealthy diet (eg lower fruit and vegetable intake, higher consumption of energy dense and fast foods;[22] another recent comprehensive review of the correlates of sitting time found limited evidence of any relationship between sitting and eating behaviours.[17] The latter review, which examined data from 109 samples (of which 76% were cross-sectional) found, not surprisingly, that different factors (including education, age, employment status, gender, BMI, income, smoking, MVPA, attitudes, depressive symptoms and quality of life) were all associated in various combinations with TV, work and computer-related sitting times.

Another limitation of the current studies is the complexity of deciphering the direction of any relationships. The possibility that BMI or weight gain could be mediators of the relationship between sitting and many health outcomes was raised in most of the reviews, and is important, because markers of obesity at baseline may predict sitting time at follow-up, raising the issue of reverse or even bidirectional causality.[23] Weight

gain and sedentary time may be mutually reinforcing over time, with increased weight gain leading to more sedentariness, and more sedentariness resulting in more weight gain. The same issue was also raised in the depression review.[16] Proper et al also addressed the issue of the role of body fatness and its role on inflammatory markers.[14] They suggested that fatness (or fitness) may be a mediator of the relationship between sedentary behaviour and health, but that few studies have examined this notion.

Dose-response Relationships

The heterogeneity of the measures used in most of the prospective studies of sitting and health outcomes make it difficult to draw conclusions about dose response relationships. Among studies that have examined relationships between TV/screen time and all-cause mortality, results from the Scottish Health Survey[19] and the AusDiab study[24] suggest that risk increases significantly in adults with ≥4h/day of TV/screen time, while a meta-analysis concluded that the risk increased when TV time was >3 hours/day.[25] For total sitting time, there seems to be some consensus that those who sit for more than 8 hours/day are at increased risk. For example, researchers from Japan[26] and Canada[27] have shown increased risk of all-cause mortality in adults who sit ≥8h/day (≥¾ of the waking day in Canada) and US researchers have shown increased risk of all-cause mortality in middle-aged US adults who sit ≥9h/day.[28] Data from the Australian 45 and Up study show clear dose-response relationships, with those who sit <8 hours/day and meet the physical activity guidelines protected most against all-cause mortality,[18] and data from the Australian Longitudinal Study on Women's Health indicate markedly increased risk of weight gain for mid-age women who sit >8 hours/day.[29]

The Melbourne based AusDiab researchers have been leading a program of research to examine the effects of breaking up prolonged sitting at work with short bouts of light or moderate intensity activity. Their most recent data demonstrate the metabolic benefits of interrupting sitting time at work with short (2 minute) bouts of light intensity activity every 20 minutes, in overweight and obese adults.[11] Increasing the intensity of activity to moderate levels did not have significant additional benefits. Further work will be needed to assess whether the muscular activity of simply 'standing up' would be sufficient to negate some of the adverse effects of prolonged sitting.

CONCLUSION

There is growing evidence to suggest that sitting time is related to poorer health outcomes, and that these are independent of time spent in moderate-vigorous activities, at levels consistent with current guidelines. Future research should focus on the potential interaction effects of time in light intensity, the moderating effects of weight related variables such as initial BMI and weight, and the mediating effects of weight gain and metabolic changes, in relationships between sitting and health outcomes.

We conclude that, whilst the evidence cannot yet be considered to be convincing, there is now sufficient evidence to suggest that all adults, but especially those who sit all day at work, should be encouraged to reduce the time they spend in prolonged periods of sitting - at work, in transport and in leisure time (including TV and screen time).

REFERENCES (Part 1.4)

1. Pate RR, O'Neill JR, Lobelo F. The evolving definition of "sedentary". Exerc Sport Sci Rev. 2008; 36(4): 173-178.

2. Healy GN, Wijndaele K, Dunstan DW et al. Objectively measured sedentary time, physical activity and metabolic risk: the Australian Diabetes, Obesity and Lifestyle Study (AusDiab). Diabetes Care. 2008; 31(2): 369-371.

3. Jans MP, Proper KI, Hildebrandt VH. Sedentary behaviour in Dutch workers: differences between occupations and business sectors. Am J Prev Med. 2007; 33(6): 450-454.

4. Brown WJ, Miller YD, Miller R. Sitting time and work patterns as indicators of overweight and obesity in Australian adults. Int J Obesity Relat Metab Disord. 2003; 27(11): 1340-1346.

5. Matthews CE, Chen KY, Freedson PS et al. Amount of time spent in sedentary behaviours in the US, 2003-2004. Am J Epidemiol. 2008; 167(7): 875-881.

6. Peters T, Moore SC, Xiang YB et al. Accelerometer measured physical activity in Chinese adults. Am J Prev Med. 2010; 38(6): 583-591.

7. Tremblay MS, Colley RC, Saunders TJ, Healy GN, Owen N. Physiological and health implications of a sedentary lifestyle. Appl Physiol Nutr Metab. 2010; 35: 725-740.

8. Yanagibori R, Kondo K, Suzuki Y et al. Effect of 20 days' bed rest on the reverse cholesterol transfer system in healthy young subjects. J Intern Med. 1998; 243(4): 307-312.

9. Hamburg, NM, McMackin CJ, Huang AL et al. Physical inactivity rapidly induced insulin resistance and microvascular dysfunction in healthy volunteers. Arterioscler Thromb Vasc Biol. 2007; 27(12): 2650-2656.

10. Bauman WA, Spungen AM. Coronary heart disease in individuals with spinal cord injury: assessment of risk factors. Spinal Cord. 2008; 46(7): 466-476.

11. Dunstan DW, Kingwell BA, Larsen R, Healy GN et al. Breaking up prolonged sitting reduces postprandial glucose and insulin responses. Diabetes Care. 2012; 35(5): 976-83.

12. Hamilton MT, Hamilton DG, Zderic TW. Role of low energy expenditure and sitting in obesity, metabolic syndrome, type 2 diabetes and cardiovascular disease. Diabetes. 2007; 56: 2655-2667.

13. van Uffelen JGZ, Wong J, Chau JY, van der Ploeg HP et al. Occupational sitting and health risks. A systematic review. Am J Prev Med. 2010; 39(4): 379-388.

14. Proper KI, Singh A, van Mechelen W, Chinapaw MJM. Sedentary behaviours among adults. A systematic review of prospective studies. Am J Prev Med. 2011; 40(2): 174-182.

15. Thorp AA, Owen N, Neuhaus M, Dunstan DW. Sedentary behaviours and subsequent health outcomes in adults. A systematic review of longitudinal studies. 1996-2011. Am J Prev Med. 2011; 41(2): 2207-215.

16. Teychenne M, Ball K, Salmon J. Sedentary behaviour and depression among adults: a review. Int J Behav Med. 2010; 17: 246-254.

17. Rhodes RE, Mark RS, Temmel CP. Adult sedentary behaviour. A systematic review. Am J Prev Med. 2012; 42(3): e3-e28.

18. van der Ploeg HP, Chey T, Korda RJ, Banks E, Bauman A. Sitting time and all-cause mortality risk in 222 497 Australian adults. Arch Intern Med. 2012; 172(6): 494-500.

19. Stamatakis E, Hamer M, Dunstan DW. Screen based entertainment time, all-cause mortality and hospital events follow-up. J Am Coll Cardiol. 2011; 57(3): 292-299.

20. Sanchez Villeges A, Ara I, Guillén-Grima F et al. Physical activity, sedentary index, and mental disorders in the SUN cohort study. Med Sci Sports Exerc. 2008; 40(5): 827-834.

21. Warren TY, Barry V, Hooker SP et al. Sedentary behaviours increase risk of cardiovascular disease mortality in men. Med Sci Sports Exerc. 2010; 42(5): 879-885.

22. Pearson N, Biddle SJ. Sedentary behavior and dietary intake in children, adolescents, and adults a systematic review. Am J Prev Med. 2011; 41: 178-188

23. Ekelund U, Brage S, Griffin SJ, Wareham NJ. ProActive UK Research Group. Objectively measured moderate and vigorous-intensity physical activity but not sedentary time predicts insulin resistance in high risk individuals. Diabetes Care. 2009; 32(6): 1081-1086.

24. Dunstan DW, Barr ELM, Healy GN et al. Television viewing time and mortality: the Australian Diabetes, Obesity and Lifestyle Study (AusDiab). Circulation. 2010; 121(3): 384-91.

25. Grøntved A, Hu FB. Television viewing and risk of type 2 diabetes, cardiovascular disease, and all-cause mortality. A meta-analysis. JAMA. 2001; 305(23): 2448-2455.

26. Inoue M, Iso H, Yamamoto S, et al. Daily total physical activity level and premature death in men and women: results from a large-scale population-based cohort study in Japan (JPHC study). Ann Epidemiol. 2008;18: 522-30.

27. Katzmarzyk PT, Church TS, Craig CL, Bouchard C. Sitting time and mortality for all causes, cardiovascular diseases and cancer. Med Sci Sports Exerc. 2009; 41(5); 998-1005.

28. Matthews CE, George SM, Moore SC, et al. Amount of time spent in sedentary behaviors and cause-specific mortality in US adults. Am J Clin Nutr. 2012; 95: 437-45.

29. Brown W, Williams L, Ford J, Ball K, Dobson A. Identifying the 'energy gap': magnitude and determinants of five year weight gain in mid age women. Obesity Res. 2005; 13(8): 1431-41.

1.5 EVIDENCE OF THE RISKS OR NEGATIVE EFFECTS OF PHYSICAL ACTIVITY

The information in this section is based on the review of physical activity adverse events in the US Physical Activity Guidelines Advisory Committee Report.[1] The report found that the risks of physical activity may be mild or severe. They include musculoskeletal injuries, cardiac arrhythmias, heat injuries and infectious diseases.[1] While the risk of activity-related injury is greater in people who are more active, active people are less likely to be injured in other contexts (eg at work), making the overall risk of injury no greater in active than in inactive people.

The US report addressed four main issues:

Which Activities Have The Lowest Risk of Injury?

The risk of injury during activity largely reflects the frequency and force of contact with people (eg in team sports), the ground, or other objects (eg a hockey stick). Activities with less frequent and less forceful contact have lower rates of injury than collision and contact sports. A Finish study has reported that rate of injury are lower in non-contact activities like walking (1.2 injuries per 1000 hours of participation), gardening (1.0), swimming (1.0) and golf (0.3) than in limited contact activities (eg volleyball, 7.0 per 1000 hours) and contact sports (eg basketball, 9.1).[2]

Does the Volume of Activity Affect the Risk of Injury?

Both the overall amount of activity, and the rate of change in this amount, are determinants of injury. In other words, the same amount of new activity is more likely to cause injury in inactive than in active people. Gradual augmentation of activity levels is therefore associated with fewer injuries in inactive populations. Although there is little research, it is thought that increasing the frequency, duration or intensity of activity can

be associated with injury, but that the overall volume is important. In general, injury rates from walking are thought to be lower than for running, but few studies have adjusted for the total amount of activity, and runners generally do more than walkers.

Is There a Risk of Adverse Cardiac Events During Activity?

There is an increased risk of adverse cardiac events (eg sudden death, myocardial infarction) during vigorous activity, even in regularly active people. The risks are however extremely small. One study has estimated that the risk of sudden cardiac death caused by vigorous exertion is $3.5x10^{-6}$ in men,[3] and another has estimated the rate is $3x10^{-6}$ in women.[4] Regularly active people are however at lower risk of an adverse cardiac event during both activity and while at rest. The risks are greater in those who remain inactive than in those who gradually increase their activity levels. Risks are lower for light and moderate intensity activity than for vigorous intensity, and relative intensity is more important than absolute intensity.

Current recommendations suggest that asymptomatic people do not need to consult a healthcare practitioner before gradually increase their activity. The risks of remaining inactive are greater than the risks of prudently increasing activity levels.

What Factors Affect the Risk of Injury and Adverse Events?

In addition to the type and amount (and rate of increasing the amount) of activity, risk of injury is influenced by demographic, behavioural and environmental factors. Among young people, those who are physically active report more injuries than those who are inactive, whereas among older people the reverse is true (the inactive report more injuries). Factors such as improved fitness, and some warming up and cooling down protocols are associated with lower rates of injury. Previous injury can increase the risk of injury, and can also be a barrier to participation.[5]

Fitness and training are also important, for prevention of injury and adverse events, and for other health outcomes, such as upper respiratory tract infection (URTI). Evidence suggests that there is a J shaped relationship between fitness and the incidence of URTI; compared with moderately active people, there is a slightly increased risk in inactive people and a significantly higher risk in elite athletes.[6]

Protective equipment (eg footwear, padding, use of reflective gear in cycling, bicycle helmets etc) can reduce the risk of injury, as can the environments in which activities take place (eg cycle lanes, traffic signals, hardness of grounds in contact sports like football, air pollution etc). There are specific guidelines for activity in extremely hot or cold conditions[7,8] and for maintaining hydration in these conditions.[9]

Overall the US report concludes that the benefits of physical activity outweigh the risks.[1]

REFERENCES (Part 1.5)

1. US Department of Health and Human Services. Physical Activity Guidelines Advisory Committee Report. Part G. 2008. Accessed June 2012 Physical Activity Guidelines for Americans - Advisory Committee Report.

2. Parkkari J, Kannus P, Natri A et al. Active living and injury risk. Int J Sports Med. 2004; 25(3): 209-216.

3. Albert CM, Mittleman MA, Chae CU et al. Triggering of sudden death from cardiac causes by vigorous exertion. N Eng J Med. 2000; 343(19): 1355-1361.

4. Whang W, Manson JE, Hu FB et al. Physical exertion, exercise and sudden cardiac death in women. JAMA. 2006; 295(12): 1399-1403.

5. Finch C, Owen N, Price R. Current injury or disability as a barrier to becoming more physically active. Med Sci Sports Exerc. 2001; 33(5): 778-782.

6. Spence L, Brown WJ, Pyne DB et al. Incidence, etiology and symptomatology of upper respiratory illness in elite athletes. Med Sci Sports Exerc. 2007; 39(4): 577-586.

7. Armstrong, LE, Casa DJ, Millard-Stafford M et al. American College of Sports Medicine position stand. Exertional health illness during training and competition. Med Sci Sports Exerc. 2007; 39(3): 556-572.

8. Castellani JW, Young AJ, Ducharme MB et al. American College of Sports Medicine position stand. Prevention of cold injuries during exercise. Med Sci Sports Exerc. 2006; 38(11): 2012-29.

9. American College of Sports Medicine, Sawka MN, Burke LM, Eichner ER, Maughan RJ, Montain SJ, Stachenfeld NS. American College of Sports Medicine position stand. Exercise and fluid replacement. Med Sci Sports Exerc. 2007; 39(2): 377-390.

RESULTS PART TWO:

SUMMARY OF THE TYPE, AMOUNT AND INTENSITY OF PHYSICAL ACTIVITY FOR HEALTH BENEFITS

INTRODUCTION

The evidence presented in the earlier parts of this report leaves no doubt that there is a strong and continually expanding body of evidence in support of the health benefits of physical activity. Most of this evidence came from prospective cohort studies that were established in the second half of the 20th century, with reliance on self-reported measures of physical activity and physical health outcomes.[1] The earliest studies, such as those by Morris, with London transport and postal workers focussed on occupational activity,[2] but the majority of later studies focussed on leisure time activities, with some also asking about walking and stair use. For example, the Harvard and Pennsylvania alumni studies, established in the '60s, assessed blocks walked, stairs climbed and participation in specific organised sports.[3] Later studies, such as the Nurses' and Health Professionals' cohort studies used more generic questions about moderate and vigorous physical activity.[4,5] Whichever measure of exposure was used, information about *frequency, duration and intensity* of activity was typically converted to an overall estimate of *energy expenditure* (for example in kJ or MET.hours per week), and usually reported in quartiles or quintiles, for analysis of associations with health outcomes.

THE CONCEPT OF 'VOLUME' OF ACTIVITY

Almost all studies of physical activity and health outcomes show a dose response relationship between volume of physical activity and relative risk, as depicted in Figure 2.1, which is adapted from a 2011 review paper.[6] In physical activity epidemiology, the 'dose' of physical activity for health benefit is now usually considered in terms of the *volume* of activity, which is derived from *intensity* (moderate, vigorous etc, measured in METs) and *duration* (frequency of bouts multiplied by length of each bout, measured in hours or minutes). For example the *volume* of activity accruing from taking a brisk walk (at moderate intensity, say 3.33 METs) for 15 minutes, ten times a week, would be 3.33 x 15 x 10 = 500 MET.minutes per week.

A simplified overview of the relationship between physical activity and all-cause mortality is shown in Figure 2.1. The relationship is inverse and curvilinear,[6] and is similar to that seen for physical activity/fitness and cardiovascular outcomes.[6,7] For other health outcomes the shape of the relationship may vary slightly. For example, there is greater risk reduction at lower activity levels for diabetes and some mental health outcomes, and lower risk reduction at higher levels of activity for some cancers.[6]

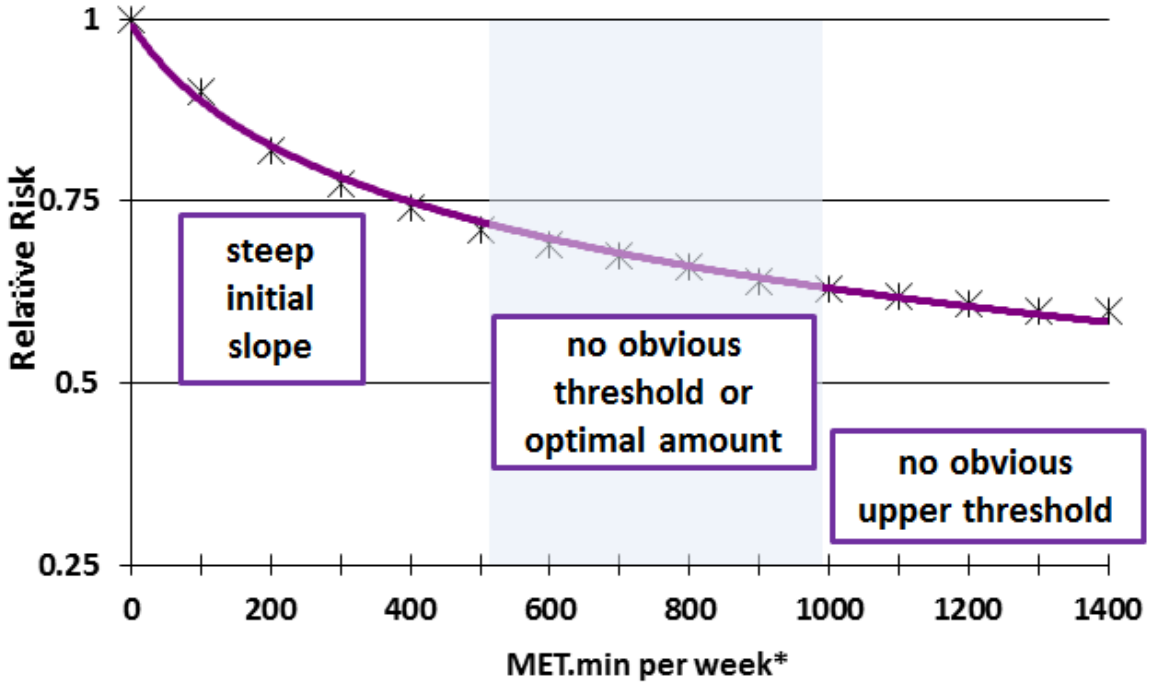

Figure 2.1: Relative risk of all-cause mortality by 'volume' or 'dose' of physical activity.

(*Data are based on studies that ask about brisk walking and activities of at least moderate intensity; so the MET.min week shown on the X axis do not generally include activities of light intensity). Shaded area indicates the optimal range for health benefits recommended in the most recent evidence based reviews. (Adapted from Powell et al 2011[6]).

Note. The table below shows the conversion of 'volume' to physical activity in minutes of moderate intensity and vigorous activity.

MET.min/week	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400
Moderate minutes per week @ 3.33 METs	60	90	120	150	180	210	240	270	300	330	360	390	420
Vigorous minutes per week @ 6.66 METs	30	45	60	75	90	105	120	135	150	165	180	195	210

Notwithstanding variations in the exact nature of the relationship, the figure highlights five important points:

1. The relationship between physical activity and health is curvilinear.

2. There is a ***steep initial slope:*** The rate of risk reduction is greatest at the lower end of the activity scale, in other words, relatively small increases are associated with greater benefit at the lower end of the activity range, between 30 and 90 minutes of moderate intensity activity (or 100 - 300 MET.minutes) per week.

3. There is ***no obvious lower threshold for benefit:*** In most studies there are reductions in risk at the first level of physical activity beyond baseline. This is particularly true for some mental health indicators and for diabetes. Some activity is always better than none.[8]

4. There is no ***obvious optimal amount,*** although guidelines around the world recommend specific amounts of activity for health benefit (eg 150 minutes of moderate intensity activity per week, or 30 minutes on at least 5 days each week). The optimal range for investment (benefit) in relation to effort (dose of physical activity) is between about 500 and 1000 MET.minutes each week, as indicated by the shading in Figure 2.1. This can be achieved by doing 150 - 300 minutes of moderate intensity activity, or 75 - 150 minutes of vigorous activity each week, or various combinations of moderate and vigorous activity. This reflects an achievable quantum of physical activity for health promotion.

5. There is no obvious ***upper threshold*****:** For the general population, although the reduction in risk diminishes, there does not appear to be an upper threshold. This may not be true for populations doing, say, more than two hours of vigorous activity on most days per week (or >5000 MET.minutes per week) in whom there may be risks, including those from overuse or injury and upper respiratory infections (see 1.5)

HOW MUCH PHYSICAL ACTIVITY SHOULD BE RECOMMENDED FOR HEALTH BENEFIT?

Because of the generic nature of the measures used in most studies, the results of most studies are not able to recommend an exact amount of physical activity for health benefit in terms of precise frequency, duration or intensity of activity.

Duration of Bouts

Although most national guidelines now recommend a minimum duration of 10 minutes for each bout of activity, few studies have compared the effects of different durations of activity, in order to see whether, for example, two bouts of 15 minutes per day, or three bouts of ten minutes, provide the same benefit in terms of disease outcomes as a single bout of 30 minutes activity each day. A recent review examined several studies of the short term effects of bouts of activity on the plasma triglyceride response to a meal. The researchers found that accumulation of 10 minute 'bouts' was as effective as a continuous bout of equivalent duration, at reducing post-prandial lipaemia. There was little evidence on accumulation of bouts of <10 minutes.[9] However, for health outcomes such as fitness, adiposity and psychological well-being, there was insufficient evidence to determine whether 'accumulation ' of short bouts was as effective as continuous activity.

Frequency of Bouts or Sessions

The optimal frequency of activity, in terms of the number of days per week that involve a session or bout of activity, has also not been extensively investigated. Few studies have demonstrated the benefits of activity carried out <3 times per week, but papers that have investigated the 'weekend warrior' concept (all activity on one day each week) indicate that there are benefits from weekly activity (for example playing golf).[10,11] However, given that there are acute, as well as chronic metabolic benefits of physical activity, current consensus is that daily activity should be encouraged.[12]

Intensity

For the purposes of reporting results from cohort studies, it is generally accepted that vigorous activity expends energy at twice the rate of moderate intensity activity; hence most researchers 'weight' time spent in vigorous activity by two when reporting activity time in minutes as the exposure variable. These studies rarely differentiate between the benefits of moderate and vigorous activity, and cannot distinguish their relative benefits.

Is there greater benefit from vigorous activity? There is some evidence to indicate that for coronary heart disease and its risk factors, there may be greater risk reductions from vigorous activity. Nine epidemiological studies have now shown a lower risk of heart disease (or risk factor profile) for people who do vigorous activity, after adjusting for total volume of activity. However, only 7 out of 20 clinical trials have confirmed that vigorous intensity activity confers greater improvement in maximal oxygen uptake than the same volume of moderate intensity activity.[6]

While vigorous exercise is important for improving many forms of athletic performance, it remains unclear whether doing vigorous activity adds to the substantial benefits that have been repeatedly demonstrated in population based cohorts that report walking as their main activity. For example, results from the US nurses study clearly show that, among women who do not do any other form of physical activity, as little as one hour of walking per week at a rate of only 3.2 – 4.8 km/hour is associated with a relative risk reduction for several CVD outcomes, including stroke (and diabetes) of 18-50%.[13, 14]

What about light intensity activities? At the lower end of the intensity scale, evidence is now emerging to show that there may be health benefits from light intensity activity, and from replacing sedentary activities with light intensity activities, when the amount of moderate/vigorous activity is held constant. The health risks of too much sitting were outlined in section 1.4. The results of physiological studies of 'breaking-up' sitting time with light intensity activity support the notion that contraction of skeletal muscle is the basis of all activity, and that when these muscles are not used, metabolic processes are dampened, and risk factors such as blood lipids and glucose may increase.

Type of Activity

Different types of activity influence a variety of health outcomes. For example, aerobic activities maintain and improve the cardio-respiratory and cellular systems that enable energy to be released from substrates and used for movement, through improving stroke volume, capillary density, endothelial function, mitochondrial volume, insulin sensitivity, etc. Weight bearing, resistance training and balance training activities improve muscle strength (through muscle fibre size, motor unit recruitment, neuromuscular coordination etc), bone density, lean body mass and balance.

What is the Baseline?

Most physical activity guidelines suggest that the recommended 'dose' of physical activity should be set against usual 'background' levels of activity.[6] Much of the evidence which underpins current guidelines comes from cohort studies that were established between 1950 and 1990, in which participants answered questions about activities such as participation in leisure time activities and active travel. Background levels of physical activity at that time were much higher than they are today, when there is greater reliance on motor cars for transport, and less occupational and domestic physical activity.

This raises the issue of whether current guidelines are relevant for populations with much lower background levels of activity than those on which the evidence was based. In any event, it is likely that 'background' levels of activity today might vary by as much as 10,000 to 30,000 MET.min/week.[6] As this background activity is largely at the light intensity level, the 'baseline' level, to which the 'dose' of recommended physical activity should be added, is very unclear. For example, should a cleaner who expends 1680 MET.min/day in their occupation be expected to add 500 MET.min/week to weekly activity, in the same way as an office worker who expends only 580 MET.min/day at work?

This is a problematic issue which is difficult to address using self-report measures, as light activities are not reliably recalled. With the introduction of objective monitoring of physical activity in populations, it may be easier in the future to suggest the total amount of physical activity in the light, moderate and vigorous domains, that is beneficial for

health. At present, the most commonly adopted assumption is that average physical activity levels across the entire day should be 1.6 to 1.7 METs.[15]

ISSUES TO CONSIDER IN DEVELOPING EVIDENCE BASED GUIDELINES

Nine important issues should be considered when developing evidence based physical activity guidelines.

1. It is now well established that the health benefits of physical activity are **continuous**, beginning with any increment in activity above zero. It has been known for 20 years that maximal *relative* benefit accrues from activating the completely inactive,[16] and a guideline that encourages activity among the completely inactive may be as important for public health as the (somewhat arbitrary) 150 minutes per week 'threshold'.[6]

2. There is no lower threshold for benefit. Indeed, for some health outcomes (including depression and diabetes) there are significant benefits from lower volumes of activity than the currently recommended 150 minutes/week. These benefits have been largely ignored in public health recommendations.

3. There is continuing benefit with increasing levels of activity, shown as an ongoing risk reduction Figure 2.1. However, in setting population guidelines and recommendations, it is important to balance population attributable risk with a realistic behavioural target for the general population. Therefore, instead of recommending that 'more is better' most countries provide a recommended minimum target, representing a balance of benefit, compared with the effort required to do it. This minimal target is accepted as being about 150 minutes of moderate intensity activity per week, or the equivalent amount of vigorous activity, or a combination.

4. For some health outcomes, such as prevention of weight gain and some cancers, this minimal target appears to be higher, at around 300 minutes of

moderate intensity activity /week, or equivalent. As weight gain is endemic in Australia, it might be preferable to provide an achievable *range* for the volume of physical activity that is associated with benefits across a wider range of health outcomes.

5. There is no upper limit to the benefits. However, the most recent US guidelines (2008)[17] describe a 'high active' threshold at 300 moderate-intensity minutes per week (approximately one hour per day). While benefits extend beyond this level, there may eventually be an increase in risk of overuse, with musculoskeletal injury at very high levels of activity.

6. Of vital importance to the development of new guidelines is that the available data show that the overall *volume* of physical activity is most consistently related to mortality risk in epidemiological studies. Data on volume are more consistent than the data on duration or frequency of sessions of activity. For the latter there is some evidence, but few studies.[17] This underpins our recommendation to change to a recommendation focussing on volume (eg 500 MET.min) or total time (150 minutes of moderate activity) rather than, for example, five bouts of 30 minutes/week.

7. The issue of frequency of activity has received little research attention in epidemiological studies, but is likely to be important for maintaining an optimal balance of metabolites and hormones for both physical and mental health. A concrete example is for blood glucose and lipid regulation, where frequent bouts of activity (or breaks on sitting time) are important for uptake of glucose and lipids from the blood stream. The evidence now suggests that glucose metabolism is best regulated with more frequent physical activity.

8. Domains of activity are important. The estimates contributing to this evidence review are from studies that have usually assessed leisure time physical activity and walking, rather than other domains of activity such as occupational or household activity, or activity as part of transport or commuting. There is increasing evidence that activity in the commuting domain is independently associated with reduced risk of death,[18] and that total physical activity may be summed across domains to summarise overall risk.[17] The effects of household activities on physical and mental health have, however, only just begun to receive research attention.[19]

9. The type of activity is also important. Although most of the epidemiological evidence comes from large cohort studies which assessed walking and aerobic leisure time activity, resistance training is also important, not only for maintaining strength (and therefore the ability to do daily tasks), but also for the prevention of falls, as well as CVD and diabetes risk factors.[1] Evidence suggests that resistance training and large-muscle aerobic activities have additive benefits in reducing vascular risk among people with diabetes and pre-diabetes.[17]

CONCLUSION

It is difficult to suggest an exact overall *dose* of activity for health benefit, but the range at which there is substantial benefit for the general population appears to be between about 500 and 1000 MET.min/ week. If we take 3.33 as an example of a generic MET value for moderate activity, 500 - 1000 MET.min/week equates with 150 – 300 minutes of moderate intensity activity per week. If we take 6.66 as a generic MET value for vigorous activity, 500 – 1000 MET.min/week equates with 75 – 150 minutes of vigorous activity per week. The minimal volume of 500 MET.min/week can be achieved by moderate-intensity activity alone, by vigorous activity alone, or through combinations of moderate and vigorous intensity activity, as indicated by the examples in Table 2.1.

Table 2.1: Examples of activity patterns that will accrue the minimal recommended amount of 150 minutes/week of moderate intensity, or 75 minutes/week of vigorous activity, or a combination.

(These patterns are examples; many other combinations of activities will provide this amount of activity).

	Frequency /week	**Duration (mins)**	**Total minutes**	**Intensity (METs)**	**Volume or dose (MET.min)**	**Example**
Moderate intensity only	5	30	150	3.33	500	Brisk walking (5 km/hour)
Moderate intensity only	10	15	150	3.33	500	Walk to work, 15 minutes, twice a day
Vigorous intensity only	3	25	75	6.66	500	'Aerobics' (Vigorous exercise class)
Vigorous intensity only	4	19	76	6.66	506	Jogging
Combination of moderate and vigorous using generic MET values	1 + 2	30 + 30	30 + 60	3.33 + 6.66	100 + 400	Brisk walking + Basketball
Combination of activities using different MET values	1 + 2	60 + 25	60 + 50	5 + 4	300 + 200	Soccer + Cycling to work (<16 kph)

Note. These data are based on the assumption that one minute of vigorous intensity activity expends approximately the same energy as two minutes of moderate intensity activity. Activities of any intensity can be mixed in any ratio.

REFERENCES (Part 2)

1. Brown WJ, Bauman AE, Owen N. Stand up, sit down, keep moving: turning circles in physical activity research? Br J Sports Med. 2009; 43(2): 86-88.

2. Morris JN, Heady JA, Raffle PA, Roberts CG, Parks JW. Coronary heart-disease and physical activity of work. Lancet. 1953; 265: 1111–20.

3. Paffenbarger RS, Wing AL, Hyde RT. Physical activity as an index of heart attack risk in college alumni. Am J Epidemiol. 1978; 108: 161-175.

4. Hu FB, Stampfer MJ, Colditz GA et al. Physical activity and the risk of stroke in women. JAMA. 2000; 283: 2961-2967.

5. Manson JE, Nathan DM, Krolewski AS et al. A prospective study of exercise and incidence of diabetes among US male physicians. JAMA. 1992; 268: 63-67.

6. Powell KE, Paluch AE, Blair SN. Physical activity for health: What kind? How much? How intense? On top of what? Annu Rev Public Health. 2011; 32: 349-365.

7. van der Ploeg H, Bauman A. Thirty minutes of incidental exercise is adequate exercise prescription. Chapter 17.1, pp309-312. In Taylor NAS, Groeller H (Eds). Physiological Bases of Human Performance During Work and Exercise. Elsevier Press, 2008.

8. Blair SN, Kohl HK, Gordon NF, Paffenbarger RS Jr. How much physical activity is good for health? Annu Rev Public Health. 1992; 13: 99-126.

9. Murphy HM, Blair SN, Murtagh EM. Accumulated versus continuous exercise for health benefit. Sports Med. 2009; 39(1): 29-43.

10. Lee I-M, Sesso HD, Oguma Y, Paffenbarger RS. The "weekend warrior" and risk of mortality. Am J Epidemiol. 2004; 160: 636-641.

11. Kohl HW, Fitzgerald SJ, Willis BL et al. Weekend warriors and cardiorespiratory fitness: Is it frequency or intensity? Med Sci Sports Exerc. 2009; 41(5): S1:146.

12. Thomas D, Elliott EJ, Naughton G. Exercise for type 2 diabetes mellitus. Cochrane Collaboration: Metabolic and Endocrine Disorders Group. Published Online: 21 Jan 2009. doi: 10.1002/14651858.CD002968.pub

13. Hu FB, Sigal RJ, Rich-Edwards JW et al. Walking compared with vigorous physical activity and risk of type 2 diabetes in women. JAMA. 1999; 282(15): 1433-39.

14. Manson JE, Greenland P, LaCroix AZ et al. Walking compared with vigorous exercise for the prevention of cardiovascular events in women. N Eng J Med. 2002; 347(10): 716-25.

15. Dietary Guidelines Advisory Committee. Report of the Dietary Guidelines Advisory Committee on the Dietary Guidelines for Americans 2005. Washington DC US Dep Agric, Agric Res Serv. http//www.health gov/dietary guidelines/dga2005/report.

16. Powell KE, Thompson PD, Caspersen CJ, et al. Physical activity and the incidence of coronary heart disease. Annu Rev Public Health. 1987; 8: 253-87.

17. US Department of Health and Human Services. Physical Activity Guidelines Advisory Committee Report. 2008. Accessed June 2012 from Physical Activity Guidelines for Americans - PA Guidelines Advisory Committee Report .

18. Andersen LB, Schnohr P, Schroll M, Hein H. All-cause mortality associated with physical activity during leisure time, work, sports, and cycling to work. Arch Intern Med. 2000; 160: 1621-1628.

19. Peeters G, van Gellecum Y, van Uffelen, JGZ, Burton NW, Brown WJ. Contribution of house and garden work to the association to the association between physical activity and well-being in younger, mid-age and older women. Br J Sports Med. Online first, published August 30, 2012 as 10.1136/bjsports-2012-091103.

RESULTS PART THREE:

EXISTING NATIONAL AND GLOBAL

PHYSICAL ACTIVITY RECOMMENDATIONS

INTRODUCTION

In this section of the report we provide examples of current national physical activity guidelines, and an overview of how several countries have approached the dissemination and communication of their guidelines to different audiences, as part of their planned dissemination strategies.

Some of the factors that have to be taken into account in the process of developing recommendations from a complex evidence base include:

1. Reconciling different interpretations of the meaning of *physical activity.*
2. Reconciling sometimes complex evidence relating to different health outcomes in to clear summary guidelines
3. Recommending a specific target (for example in minutes per week) when the evidence clearly shows a curvilinear dose-response relationship with no clear thresholds for minimal or maximal benefits.
4. Emphasising that the recommended dose is *in addition* to the amount of 'background' activity that we would expect to see in everyday life, most of which is at light intensity.

EXAMPLES OF NATIONAL, REGIONAL AND GLOBAL PHYSICAL ACTIVITY GUIDELINES

A summary of existing evidence based adult physical activity guidelines from 10 countries, as well as the recently launched regional (Western Pacific Region) and Global guidelines produced by the World Health Organisation, is provided in Table 3.1 (adapted from Bull and Bauman, in press.[1])

Table 3.1. Summary of existing guidelines showing phrases used to convey recommendations about different forms of activity.
Guidelines that Mention the Phrase:

COUNTRY	Moderate-intensity	Moderate-vigorous	Vigorous activity	Moderate-vigorous combination	Strength/ Balance/ Flexibility	Sedentary behaviours	Other
Global 2010	At least 150 minutes of moderate-intensity aerobic physical activity throughout the week. *For additional health benefits, adults should increase their moderate-intensity aerobic physical activity to 300 minutes per week.*		. . . .or do at least 75 minutes of vigorous-intensity aerobic physical activity throughout the week *. . . or engage in 150 minutes of vigorous-intensity aerobic physical activity per week.*	. . . . or an equivalent combination of moderate- and vigorous-intensity activity. *. . or an equivalent combination of moderate- and vigorous-intensity activity.*	Muscle-strengthening activities should be done involving major muscle groups on 2 or more days a week.		*Aerobic activity should be performed in bouts of at least 10 minutes duration*
WHO Western Pacific Region: 2008	30 minutes of moderate-intensity physical activity on five or more days each week.		If you can, enjoy some regular vigorous-intensity activity for extra health and fitness benefits.				

COUNTRY	Moderate-intensity	Moderate-vigorous	Vigorous activity	Moderate-vigorous combination	Strength/ Balance/ Flexibility	Sedentary behaviours	Other
Australia 1999	Put together at least 30 minutes of moderate-intensity physical activity on most, preferably all, days.		If you can, also enjoy some regular, vigorous activity for extra health and fitness.				Think of movement as an opportunity, not an inconvenience. Be active every day in an many ways as you can
Canada 2011	Accumulate at least 150 minutes/week of moderate-intensity aerobic physical activity . . .				Add muscle and bone strengthening activities using major muscles groups, at least 2 days per week.		More physical activity provides greater health benefits.
Finland 2009	Improve aerobic fitness by being active several days a week, for total of at least 2 h 30 min of moderate activity . . .		. . . . .or 1 h 15 min of vigorous activity.		In addition increase muscular strength and improve balance at least 2 times a week.		
Ireland 2009		All adults should undertake 30-60 minutes of		Physical activity can consist of a combination of	Activities to increase muscular strength and endurance should be		Shorter bouts of activity can be accumulated to

COUNTRY	Moderate-intensity	Moderate-vigorous	Vigorous activity	Moderate-vigorous combination	Strength/ Balance/ Flexibility	Sedentary behaviours	Other
		moderate-to-vigorous physical activity on 5 or more days of the week. (abbreviated to: At least 30 minutes on 5 days per week)		moderate- and vigorous-intensity periods.	added on 2 to 3 days per week.		reach the target. These bouts should be at least 10 minutes duration. All adults should avoid inactivity. Some activity is better than none, more is better than some, and adults who participate in any amount of physical activity gain some health benefits.
The Netherlands 2011	For adults (18 to 54 years) the norm is: at least half an hour of moderately intensive physical activity (4 to 6.5 MET; walking (5km/h) or cycling (16 km/h) briskly), on at least five days a week (summer and winter).						
New Zealand 2005	30 minutes moderate intensity physical activity on most, preferably all, days.		If you can, also enjoy some regular, vigorous activity for extra health and fitness.				

COUNTRY	Moderate-intensity	Moderate-vigorous	Vigorous activity	Moderate-vigorous combination	Strength/ Balance/ Flexibility	Sedentary behaviours	Other
Norway 2004		Adults are recommended to take at least 30 minutes of moderate or vigorous physical activity every day.					This activity could be made up of several sessions during the day, each lasting at least 10 minutes.
Switzerland 2006	Engage in physical activity every day for at least half an hour at moderate level intensity.				Endurance training 3 x per week 20-60 minutes. Strength and flexibility exercises 2 x per week.		
UK 2011	Over a week, activity should add up to at least 150 minutes (2½ hours) of moderate intensity activity in bouts of 10 minutes or more – one way to approach this is to do 30 minutes on at least 5 days a week.		Alternatively, comparable benefits can be achieved through 75 minutes of vigorous intensity activity spread across the week	. . . or combinations of moderate and vigorous intensity activity.	Adults should also undertake physical activity to improve muscle strength on at least two days a week.	All adults should minimise the amount of time spent being sedentary (sitting) for extended periods.	Adults should aim to be active daily.
USA 2008	For substantial health benefits, adults should do at least 150 minutes (2 hours and 30 minutes) a week of moderate intensity. .		. . .or 75 minutes (1 hour and 15 minutes) a week of vigorous – intensity aerobic activity.	. . or an equivalent combination of moderate- and vigorous-intensity activity.	Adults should also do muscle-strengthening activities that are moderate or high intensity and involve all major muscle groups on 2 or more		All adults should avoid inactivity. Some physical activity is better than none, and adults who participate in any

COUNTRY	Moderate-intensity	Moderate-vigorous	Vigorous activity	Moderate-vigorous combination	Strength/ Balance/ Flexibility	Sedentary behaviours	Other
	For additional and more extensive health benefits, adults should increase their aerobic physical activity to 300 minutes (5 hours) a week of moderate-intensity		*. . or 150 minutes a week of vigorous-intensity aerobic physical activity.*	*. . or an equivalent combination of moderate- and vigorous-intensity activity.* Additional health benefits are gained by engaging in physical activity beyond this amount.	days a week, as these activities provide additional health benefits.		amount of physical activity gain some health benefits. Aerobic activity should be performed in episodes of at least 10 minutes, and preferably it should be spread throughout the week.

The Table shows the recently developed guidelines from the USA (2008),[2] Canada (2011)[3] and the UK (2011),[4] and the older guidelines from New Zealand (2005)[5] and Australia (1999).[6] The UK guidelines have replaced the earlier ones from England and Wales, Scotland, and Northern Ireland, which, despite all being 'home countries' of the United Kingdom, had different guidelines for physical activity. The Table also includes guidelines from 5 additional European countries (Finland,[7] Ireland,[8] The Netherlands,[9] Norway,[10] and Switzerland[11]) where there has been quite a long history of each country developing their own national recommendations, usually alongside a policy on physical activity.

Outside Europe, the USA and Canada also have a long history of developing national physical activity guidelines. Most recently both countries have updated their guidelines based on very comprehensive reviews of the scientific literature. In the USA this process took over two years and was commissioned by the Federal Department of Health and Human Services.[12] The 760 page report on the scientific evidence is available and provides a significant point of reference for the recent and current development of guidelines by other agencies, including this work in Australia.

In the regions of South America, Asia, the Middle East and Africa, there are far fewer examples of national physical activity guidelines. This most likely reflects the relatively recent interest in physical activity and health in these regions. In the absence of national guidelines, many countries have adopted and used the USA guidelines from 1996[13] as a de facto global guide, and as such these have become an international bench mark. Overall, this process has been a useful strategy for allowing the progression of national physical activity strategies in countries without the resources to develop their own guidelines.

At the time of the launch by the World Health Organization (WHO) of the Global Strategy for Diet, Physical Activity and Health in 2004,[14] there was a notable lack of official global guidelines on physical activity. However, with the increasing need to increase national actions to prevent non-communicable disease, WHO commenced the development of global guidelines in 2007/8 and the final Global Recommendations on Physical Activity were launched in 2010, after widespread global and regional consultations.[15]

These global guidelines are now available for individual countries to adopt and tailor to their own needs, as has been done by Western Pacific Islands who now have their own guidelines in a format that is culturally appropriate for Pacific Island countries.[16]

The most recent guidelines in Table 3.1 are from the USA (2008),[17] Canada (2011),[18,19] the WHO (Global guidelines),[15] and the UK (2011).[4,20] All drew directly, or very heavily, on the scientific reviews conducted under the auspices of the Canadian and US guideline development processes. It is therefore not surprising that these sets of guidelines are very similar. A notable feature of all of them is a shift in focus from the earlier recommendations which specified "30 minutes of moderate intensity activity on five or more days of the week" as the primary guideline for adults. In these newer guidelines, the main focus is on the total volume of activity, with options to achieve this either by moderate-intensity activity (150 minutes or 2.5 hours per week), vigorous-intensity activity (75 minutes for UK, USA and Global) or combinations of the two (see Table 3.1). The new Canadian guidelines also reflect this shift from a focus on "5x30" to state a total volume of 150 minutes as the main recommendation. In common with several other countries, they also note that more activity (volume) provides more benefits.

This new position reflects the evidence, largely from cohort studies, that supports a recommendation about the total amount of physical activity each week. Recent reviews of this evidence do not strongly support statements about the frequency or duration of individual sessions, as was implied by the previous "5 x 30 minutes" guidelines which were included in many earlier guidelines (see Table 3.1). Interestingly, however, the new UK guidelines have retained the "5 x 30" concept as a plausible and valid way for adults to accumulate the recommended amount of activity if they so choose.

Seven of the ten sets of guidelines in Table 3.1 also recommend resistance or strength training; most suggest this should be on at least two days each week. Only the Swiss have a recommendation about flexibility activities, and to date, only the UK has a recommendation about sedentary behaviour (sitting).

DISSEMINATION AND COMMUNICATION OF NATIONAL PHYSICAL ACTIVITY GUIDELINES

National guidelines should provide clear statements, based on scientific evidence. They are however, sometimes written in a detailed format using terminology that may be unfamiliar to wider audiences. As such, an important step after the completion of national guidelines, and before the development of a coordinated communication strategy, is to develop a set of appropriate key communication messages based on the guidelines, as well as different formats for their distribution, within a planned dissemination strategy.[21,23] However, too frequently this step is overlooked and the physical activity guidelines remain as a formal document, used by few and with little professional or public awareness of them.[1]

It is therefore desirable to develop and test different ways in which the key messages can best be communicated to different audiences, concurrently with the final steps of guidelines development. This approach allows a set of resources, targeted to multiple audiences and users, to be available at the same time as the formal launch of guidelines. The formal launch is also an important component of the dissemination strategy that should not be overlooked, as it can provide a catalyst for action by both government and other sectors.

Although the development of key messages and communication resources is beyond the scope of this project, in the following sections we provide some examples of the key messages and resources developed for communication of physical activity guidelines in other countries.

An Example of Communications of the Current Australian Guidelines

Communication of the 1999 Australian adult physical activity guidelines[6,22] involved simplifying the core scientific statements into a four step communication using simplified language. These are shown below:

1. Think of movement as an opportunity, not an inconvenience.
2. Be active every day in as many ways as you can.
3. Put together at least 30 minutes of moderate-intensity physical activity on most, preferably all, days.
4. If you can, also enjoy some regular vigorous exercise for extra health and fitness.

It is notable that these four statements capture the important aspects of the scientific recommendations but do not attempt to include all details. For example, within these statements it is not explicit that activity should be accumulated in bouts of not less than 10 minutes, though this was included in the scientific report and was the intention of the guidelines. It is a matter of expert judgment as to whether this level of detail is likely to confuse the intended audience, and whether it should or should not be included in public facing communications. A wide range of stakeholders and expert opinion, as well as pilot testing can help inform the development process for the outward or public facing communications.

Examples of Recent Communications and Dissemination of Other National Guidelines

Fact sheets: The format of any communication of physical activity guidelines should match the intended audience in both the level of detail and the structure.[23] Fact sheets, usually comprising no more than 2-4 pages, are popular because few professionals have time to read detailed scientific reports. The most recent guidelines from Canada,[19] the UK[20] and the USA[17] have all been launched with a set of fact sheets (see Appendix One for examples from USA and the UK).

It is usual to not include all the details of the evidence-based recommendations in the fact sheets and guidelines prepared for dissemination to the public and professionals.

Table 3.2 (below) illustrates this point using the Canadian guidelines.

Table 3.2: The Canadian physical activity guidelines and associated 'key messages' used in the fact sheets .

Evidence-based Recommendations[21]	**Fact Sheets and Guidelines**[19]
ONE Adults aged 19-65 years should accumulate 150 minutes/week of moderate-intensity PA or 90 minutes/week of vigorous-intensity PA in periods of at least 10 minutes each. Greater amounts of activity and more vigorous activity provide additional benefits.	***ONE*** To achieve health benefits, adults aged 18-64 years should accumulate at least 150 minutes of moderate- to vigorous-intensity aerobic physical activity per week, in bouts of 10 minutes or more.
TWO Engage in resistance activities on 2-4 days/week.	***TWO*** It is also beneficial to add muscle and bone strengthening activities using major muscle groups, at least 2 days per week.
THREE Engage in flexibility activities on 4-7 days/week.	***THREE*** More daily physical activity provides greater health benefits.

Note that the first guideline simplifies the evidence-based recommendations for moderate intensity physical activity and vigorous intensity physical activity by using the synthesis of "moderate to vigorous" intensity physical activity. The second guideline uses the more definitive "at least 2 days a week" as the desirable frequency of strength training, rather than the more ambiguous "2-4 days/week" of the evidence-based recommendation. Using 2-4 days could create confusion and uncertainty as to whether it should be 2, 3 or 4 days. The third guideline addresses the "more is better" evidence in the first evidence based recommendation.

This example from Canada illustrates how scientific evidence can be reworded and presented, and how decisions were made about what to include as key messages for communication to prompt awareness, increase knowledge and stimulate action and

behaviour change.

Pamphlets and brochures: These print materials are useful for handing to patient populations and making available in public locations as free resources. This approach was used for the dissemination of the Australian guidelines in 1999[6] and 2005.[22]

A relatively recent development is to capture the different types and amounts of physical activity recommended in a picture or schema. Examples of these are shown below. In Finland the "Activity Pie" (Figure 3.1)[7] was developed to show different ways of combining types and duration of activity to reach the recommended threshold.

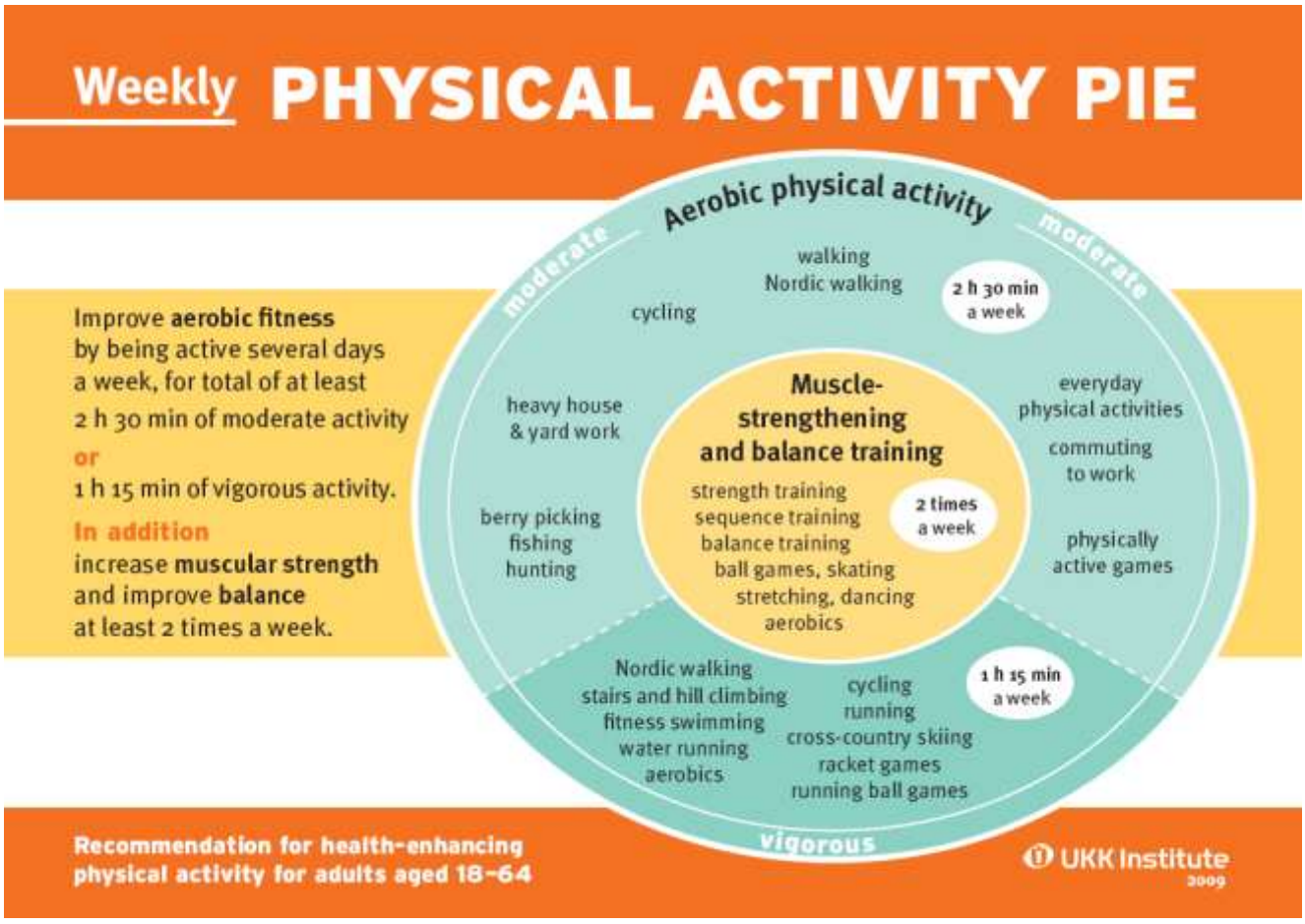

Figure 3.1: "Activity Pie" illustration for communication of the physical activity guidelines in Finland.[7]

In Switzerland the same concept was illustrated using a pyramid (Figure 3.2).[11]

Figure 3.2: Pyramid used for communication of the guidelines in Switzerland.[11]

Mass media: Campaigns using paid and unpaid media (such as television, radio and print communications) are often used for mass reach and aim to raise awareness and educate whole populations on the benefits of physical activity for health and wellness.[23] These population-based strategies aim to reach many people, and can be accessed by a large segment of the physically inactive population.

REFERENCES (Part 3)

1. Bull F, Bauman A. Physical Activity Policy: Guidelines and recommendations around the world. In: Clow A, Edmunds S, editors. Physical Activity and Mental Health: Theory and Practical Applications. Human Kinetics, in press.

2. Physical Activity Guidelines Advisory Committee. Physical Activity Guidelines Advisory Committee Report, 2008. Washington, D.C.2008.

3. Canadian Society for Exercise Physiology. 2011 Canadian Physical Activity Guidelines. Ottawa, Canada: Canadian Society for Exercise Physiology; 2011.

4. UK Department of Health, Physical Activity, Health Improvement and Protection. Start Active, Stay Active: A Report on Physical Activity for Health from the Four Home Countries' Chief Medical Officers. London, UK: Department of Health; 2011.

5. Sport and Recreation New Zealand. Guidelines for Promoting Physical Activity to Adults. Wellington, New Zealand: Sport and Recreation New Zealand; 2005.

6. Department of Health and Ageing. National Physical Activity Guidelines for Australians. Canberra: Commonwealth Government of Australia 1999.

7. UKK Institute. Physical Activity Pie. Tampere, Finland: UKK Institute, 2009. Accessed June 2012.

8. Department of Health and Children, Health Service Executive. The National Guidelines on Physical Activity for Ireland. Dublin, Ireland: Department of Health and Children and Health Service Executive; 2009. Accessed June 2012 from Get Ireland Active

9. Ministry of Health Welfare and Sport. Dutch Healthy Exercise Norm: NNGB Netherlands: 2011. Accessed June 2012 from Youth Monitor, Ministry of Health Welfare and Sport, Netherlands.

10. Becker W, Lyhne N, Pedersen AN, Aro A, Fogelholm M, Pho´rsdottir I, et al. Nordic nutrition recommendations 2004 - integrating nutrition and physical activity. Scand J Nutr. 2004;48(4):178-87.

11. Swiss Federal Office of Sports. Health -Enhancing Physical Activity. Zurich, Switzerland: Swiss Federal Office of Sports; 2006.

12. US Department of Health and Human Services. 2008 Physical Activity Guidlines for Americans: Be Active, Healthy and Happy! Washington, US: Department of Health and Human Services Centres for Disease Control and Prevention, 2008.

13. Pate RR, Pratt MP, Blair SN et al. Physical activity and public health: a recommendation from the Centres for Disease Control and Prevention and the American College of Sports Medicine. JAMA. 1995; 273: 402-407.

14. World Health Organisation. Global Strategy on Diet, Physical Activity and Health. Geneva

Switzerland: World Health Organisation; 2004.

15. World Health Organisation. Global Recommendations on Physical Activity for Health. Geneva, Switzerland: World Health Organisation; 2010.

16. World Health Organisation. Pacific Physical Activity Guidelines for Adults: Framework for Accelerating the Communication of Physical Activity Guidelines. Manila, Philippines: World Health Organisation; 2008.

17. US Department of Health and Human Services. Physical Activity Guidelines for Americans Resources. At-a-Glance: A Fact Sheet for Professionals.Washington, USA, 2008. Accessed June 2012.

18. Health Canada and the Canadian Society for Exercise Physiology. Canadian Physical Activity Guidelines 2011 Scientific Statements. Ottawa Canada, 2011.

19 Canadian Society for Exercise Physiology. Canadian Physical Activity Guideline Factsheets. Ottawa, Canada, 2011. Accessed June 2012 from Canadian Physical Activity Guideline Factsheets.

20. Department of Health. UK Physical Activity Guidelines - Factsheets 1-4. London, UK. Accessed June 2012.

21. Kesäniemi A, Riddoch CJ, Reeder B, Blair SN, Sørensen TIA. Advancing the future of physical activity guidelines in Canada: an independent expert panel interpretation of the evidence. Int J Behav Nutr Physical Activity. 2010;7(41).

22. Department of Health and Ageing. An Active Way to Better Health: National Physical Activity Guidelines for Adults. Canberra, Australia: Department of Health and Ageing, 2005.

23. Bauman A, Chau J. The role of media in promoting physical activity. J Physical Activity Health. 2009; 6: S196.

RESULTS PART FOUR:

PROPOSED NEW AUSTRALIAN PHYSICAL ACTIVITY GUIDELINES FOR ADULTS –

DRAFT ONE

INTRODUCTION

In this section we propose new Australian physical activity guidelines.

The guidelines are designed for use by all adults, as the health benefits of physical activity are similar for all adult populations, including those with chronic illness. People with physical and mental disabilities should adapt their activity according to their capacity. The guidelines are also intended for use by a variety of end users including: health professionals who have a role in advising their patients/clients on physical activity; those who monitor physical activity in populations; those involved with health promotion strategies for the prevention of non-communicable diseases; and those who develop policy relating to physical activity.

In these guidelines, physical activity is conceptualised as activities that use one or more large muscle groups, for movement in the following domains: leisure (including organised activities such as sports, as well as exercise and recreational activities); occupation (including paid and unpaid work); and transport (for example walking, cycling or skating to get to or from places).

The guidelines are based on our review of the scientific evidence on the relationships between physical activity and a wide range of health outcomes. It is implicit that any recommendation made is for activity that is *in addition to* the activities of daily living that would be expected in the lives of most Australians (including, for example, activities involved in personal care [showering etc], finding and preparing food [shopping, cooking, washing up, but excluding gardening which is conceptualised as a leisure activity], general home duties and child/elder care activities).

DIFFERENCES BETWEEN THE OLD AND NEW GUIDELINES

The proposed guidelines differ from the existing guidelines in the following ways:

1. We introduce the concept that 'some is better than none.' (Risk reductions begin with the first increase in activity beyond baseline, there is no evidence to support the notion that a threshold must be reached before benefits accrue).

2. We introduce the concept of a *range* of activity, with more activity providing more benefit, and a higher level of activity *necessary* for the prevention of weight gain and some cancers.

3. We introduce a new guideline for muscle strengthening activities.

4. We introduce a new guideline on sitting time. We concluded that there was insufficient evidence on which to base a completely separate set of guidelines on sedentary behaviour for adults. In the remainder of this report, the term 'physical activity guidelines' therefore includes both physical activity and sitting time.

On the following pages each guideline is presented in a table with related summary scientific recommendations. The scientific recommendations are rated according to the following NHMRC grading system:

A evidence can be trusted to guide clinical practice;

B evidence can be trusted in most situations;

C care should be taken in using this evidence for policy development.

Later in the report the guidelines are presented in a single table, in line with those prepared in the parallel report on guidelines for children and adolescents.

Table 4.1: Proposed Australian physical activity guidelines for adults – draft one

Preamble:

Regular physical activity reduces the risk of many adverse physical and psychosocial health outcomes. There is clear evidence that doing some activity is better than doing none at all and increasing amounts of activity provide increasing benefit.

Summary of the Scientific Evidence	Proposed Australian Guidelines
The relationship between physical activity and health benefit is curvilinear. This means that the benefits increase with increasing amounts of physical activity, with 'diminishing returns' at the highest levels of activity. Level of Evidence = A	**ONE** *Doing any regular physical activity is better than doing none. If you currently do no physical activity, start by doing some activity, and then build up to the recommended amount.*
There is no clear evidence on the optimal frequency of physical activity, but there is strong support for recommending that adults should accumulate their physical activity across the week. Being active on most, if not all, days each week, is likely to provide increased metabolic benefits. Level of Evidence = B	**TWO** *Spread your activity through the week*
The scientific data on the relationship between total *volume* (frequency x duration x intensity) of activity and health benefits are more convincing and consistent than those for frequency, duration or intensity of activity. Optimal benefits (ie. in terms of effort required, for health gain) are gained in the range from around 500 to around 1000 MET.min/week of physical activity. 500 MET.min/week is equivalent to 150 minutes of moderate-intensity activity, or 75 minutes of vigorous activity, or any combination of intensity and duration that provides this amount of activity. 1000 MET.min/week is equivalent to 300 minutes of moderate intensity or 150 minutes of vigorous activity (or a combination).	**THREE** *Accumulate at least 150 minutes of moderate intensity physical activity (including brisk walking) or 75 minutes of vigorous activity, or an equivalent combination of moderate and vigorous activities, each week.*

Summary of the Scientific Evidence	Proposed Australian Guidelines
For most health outcomes, additional benefits occur with more physical activity. In particular, more activity is *required* for prevention of weight gain and some cancers. This higher amount of physical activity can be achieved through longer duration (more minutes) or greater frequency (more often) or doing activities of higher intensity. Level of Evidence = A	**FOUR** *For additional health benefits, and for prevention of weight gain and some cancers, accumulate 300 minutes of moderate intensity activity, or 150 minutes of vigorous, or an equivalent combination of moderate and vigorous activities, each week.*
Resistance training (muscle strengthening) activities are important for metabolic, cardiovascular and musculoskeletal health (including prevention of falls), and for maintaining functional status and ability to conduct activities of daily living. There is limited evidence on the optimal frequency of strength training, but significant benefits are associated with strength training at least twice a week. Level of Evidence = A/B	**FIVE** *In addition, do muscle strengthening activities on at least 2 days each week*
Strong emerging evidence indicates that extended sitting time is associated with increased risk of diabetes and all-cause mortality. There is however insufficient evidence at this time to make a specific recommendation on the minimal or optimal duration of sitting. Level of Evidence = A/B	SIX *Minimise the amount of time spent sitting. Break up long periods of sitting as often as possible*

Footnote:

The benefits of physical activity far outweigh the risk of remaining inactive or the risks of adverse outcomes. There is a slightly increased risk of injury or accident in adults who are unaccustomed to any physical activity at all, and in those doing high intensity, long duration activities. To reduce risk, those unaccustomed to activity are advised to start slowly (for example, by walking), and to adapt gradually towards recommended levels. Do not over-exert without sufficient training. Individual physical and mental capabilities should be considered when interpreting the guidelines

PROPOSED NEW AUSTRALIAN PHYSICAL ACTIVITY GUIDELINES FOR ADULTS – DRAFT ONE

Preamble:
Regular physical activity reduces the risk of many adverse physical and psychosocial health outcomes

ONE
Doing any regular physical activity is better than doing none. If you currently do no physical activity, start by doing some activity, and then build up to the recommended amount shown below.

TWO
Spread your activity through the week.

THREE
Accumulate *at least* 150 minutes of moderate intensity physical activity (including brisk walking) or 75 minutes of vigorous activity, or an equivalent combination of moderate and vigorous activities, each week.

FOUR
For additional health benefits, and for prevention of weight gain and some cancers, accumulate 300 minutes of moderate intensity activity, or 150 minutes of vigorous, or an equivalent combination of moderate and vigorous activities, each week.

FIVE
In addition, do muscle strengthening activities on at least 2 days each week.

SIX
Minimise the amount of time spent sitting. Break up long periods of sitting as often as possible

Footnote:

The benefits of physical activity far outweigh the risk of remaining inactive or the risks of adverse outcomes. There is a slightly increased risk of injury or accident in adults who are unaccustomed to any physical activity at all, and in those doing high intensity, long duration activities. To reduce risk, those unaccustomed to activity are advised to start slowly (for example, by walking), and to adapt gradually towards recommended levels. Do not over-exert without sufficient training. Individual physical and mental capabilities should be considered when interpreting the guidelines.

RESULTS PART FIVE:

CONSULTATION, FEEDBACK AND REVIEW

INTRODUCTION

As part of the development process, feedback on a draft of the proposed *Evidence-Based Physical Activity and Sedentary Behaviour Recommendations for Adults* was sought from a group of people identified as key stakeholders and/or with research/academic expertise in adult physical activity and health.

METHODS

Participants

'Key informants' were identified by the consultant team and The Department of Health and Ageing, and endorsed by The Department of Health and Ageing. Invitees (N=74) included

- representatives from state government health departments (n=24), the Australian National Physical Activity Network (15), and the Australian National Health Prevention Agency (n=4)
- representatives of Non-Government Organisations (n=12)
- national (n=12) and international (n=7) researchers/academics with expertise in adult physical activity epidemiology; or experience in conducting critical reviews of research evidence, or developing physical activity guidelines.

Materials

The proposed *Evidence-Based Physical Activity and Sedentary Behaviour Recommendations for Adults* were provided (in confidence). Participants received only the preamble, summary scientific statements and proposed guidelines (see Table 5.1). This document was developed after feedback from The Department of Health and Ageing on an initial draft.

Table 5.1. Proposed new physical activity guidelines (draft one) circulated for comment.

PROPOSED AUSTRALIAN RECOMMENDATIONS FOR PHYSICAL ACTIVITY AND SEDENTARY BEHAVIOUR FOR ADULTS (18-64 YEARS)

Preamble: Regular physical activity reduces the risk of many adverse physical and psychosocial health outcomes. There is clear evidence that doing some activity is better than doing none at all and increasing amounts of activity provide increasing benefit.

Summary of the Scientific Evidence	**Proposed Australian Guidelines**
The relationship between physical activity and health benefit is curvilinear. This means that the benefits increase with increasing amounts of physical activity, with 'diminishing returns' at the highest levels of activity.	**ONE** *Doing any regular physical activity is better than doing none. If you currently do no physical activity, start by doing some activity, and then build up to the recommended amount.*
There is no clear evidence on the optimal frequency of physical activity, but there is strong support for recommending that adults should accumulate their physical activity across the week. Being active on most, if not all, days each week, is likely to provide increased metabolic benefits.	**TWO** *Spread your activity through the week.*
The scientific data on the relationship between total *volume* (frequency x duration x intensity) of activity and health benefits are more convincing and consistent than those for frequency, duration or intensity of activity. Optimal benefits (ie in terms of effort required, for health gain) are gained in the range from around 500 to around 1000 MET.min/week of physical activity. 500 MET.min/week is equivalent to 150 minutes of moderate-intensity activity, or 75 minutes of vigorous activity, or any combination of intensity and duration that provides this amount of activity. 1000 MET.min/week is equivalent to 300 minutes of moderate intensity or 150 minutes of vigorous activity (or a combination).	**THREE** *Accumulate at least 150 minutes of moderate intensity physical activity (including brisk walking) or 75 minutes of vigorous activity, or an equivalent combination of moderate and vigorous activities, each week.*
For most health outcomes, additional benefits occur with more physical activity. In particular, more activity is *required* for prevention of weight gain and some cancers. This higher amount of physical activity can be achieved through longer duration (more minutes) or greater frequency (more often) or doing activities of higher intensity.	**FOUR** *For additional health benefits, and for prevention of weight gain and some cancers, accumulate 300 minutes of moderate intensity activity, or 150 minutes of vigorous, or an equivalent combination of moderate and vigorous activities, each week.*
Resistance training (muscle strengthening) activities are important for metabolic, cardiovascular and musculoskeletal health (including prevention of falls), and for maintaining functional status and ability to conduct activities of daily living. There are insufficient data on which to base a specific recommendation about the frequency of strength	**FIVE** *In addition, do muscle strengthening activities on at least 2 days each week.*

Summary of the Scientific Evidence	Proposed Australian Guidelines
training, but significant benefits are associated with strength training at least twice a week.	
Strong emerging evidence indicates that extended sitting time is associated with increased risk of diabetes and all-cause mortality. There is however insufficient evidence at this time to make a specific recommendation on the minimal or optimal duration of sitting.	**SIX** *Minimise the amount of time spent sitting. Break up long periods of sitting as often as possible*

Procedure

The key informants were contacted by email and invited to complete an online survey (Appendix Two). They were asked to rate the

- appropriateness of including a preamble (yes/no) and if the wording was clear (yes/no).
- appropriateness of new guidelines 1 (encouraging those doing no activity to do some), 5 (muscle strengthening activities) and 6 (minimising sitting time).
- accuracy of the scientific statement for each guideline.
- content/wording of each guideline.

Respondents rated the appropriateness, accuracy and content/wording using a 5 point Likert scale (*excellent, very good, good, fair, poor*), and had the opportunity to provide additional written comments.

Respondents were also asked to indicate gender, age, education level, employment context and primary focus, and geographical location.

Quantitative and qualitative responses were collated and summarised. For some findings, data were grouped by employment context.

RESULTS

Response

Of the 74 people invited to participate, 30 responded within the time frame (40.5%). The response rate by employment context is provided in Table 5.2. Two respondents declined to provide demographic data. Of the 28 respondents who did provide demographic information,

- 11 were in research/academic roles, 10 were in policy, 5 were in management and 3 were in service provision/health promotion practice;
- all had a university level education
- all the states and territories were represented;
- almost two thirds (64%) were women.

An overview of the ratings of the appropriateness, accuracy and content/wording of the draft proposed guidelines is presented in Figures 5.1, 5.2, and 5.3.

Table 5.2: Consultation on proposed new Australian physical activity guidelines for adults (draft one): Response rate by employment context.

Group	Invited	Responded	Response rate (%)
State government health departments, Australian National Health Prevention Agency, Australian National Physical Activity Network	43	14	32.5
Non-Government Organisations	12	3	25.0
National researchers/academics	12	7	58.3
International researchers/academics	7	6	85.7

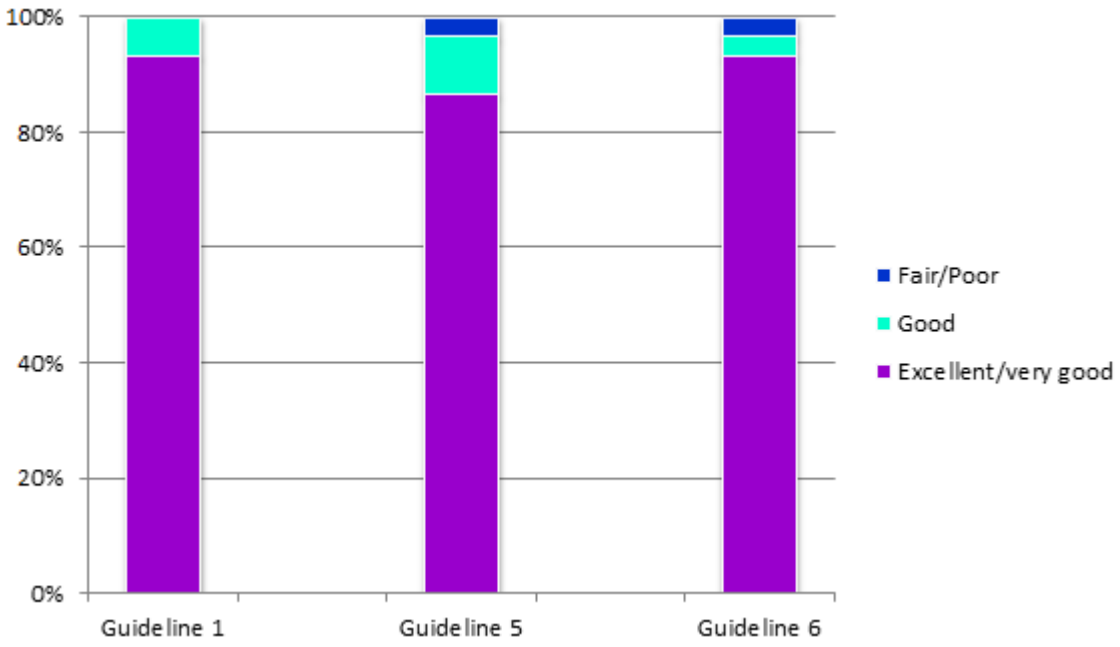

Figure 5.1: Ratings of the appropriateness of proposed new guidelines (draft one).
Note: Guideline 1: encouraging those doing no activity to do some; Guideline 5: muscle strengthening activities, Guideline 6: minimising sitting time.

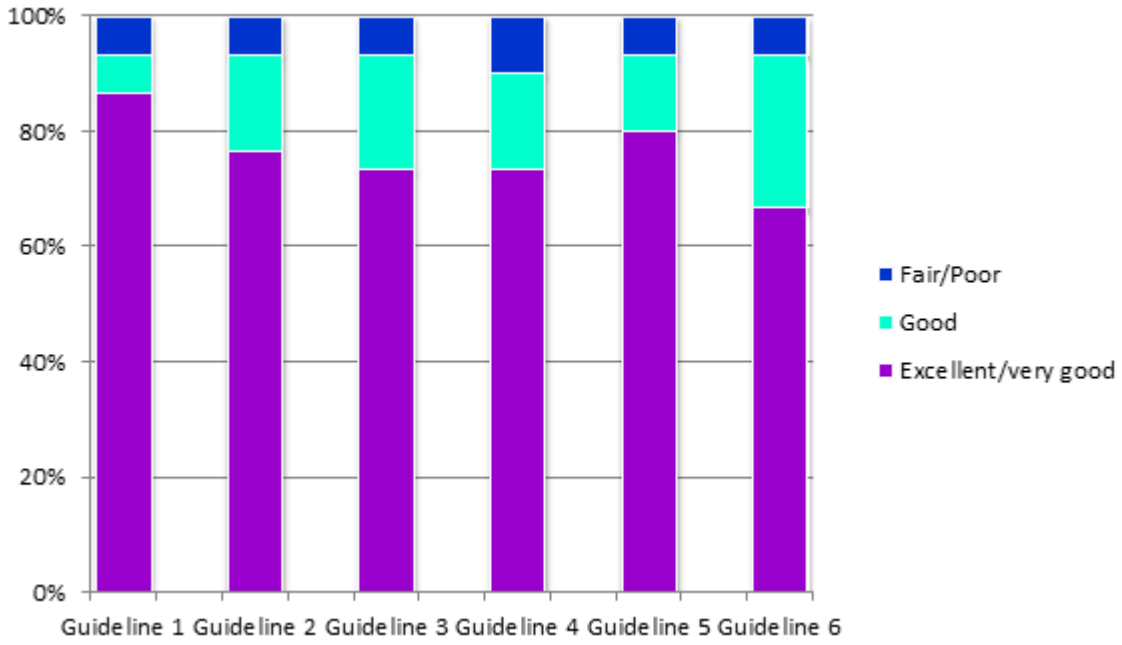

Figure 5.2 Ratings of the accuracy of each proposed guideline (draft one).
Note: Guideline 1: encouraging those doing no activity to do some; Guideline 2: daily activity; Guideline 3: volume for general health benefit; Guideline 4: higher volume for prevention of weight gain and some cancers; Guideline 5: muscle strengthening activities; Guideline 6: minimising sitting time.

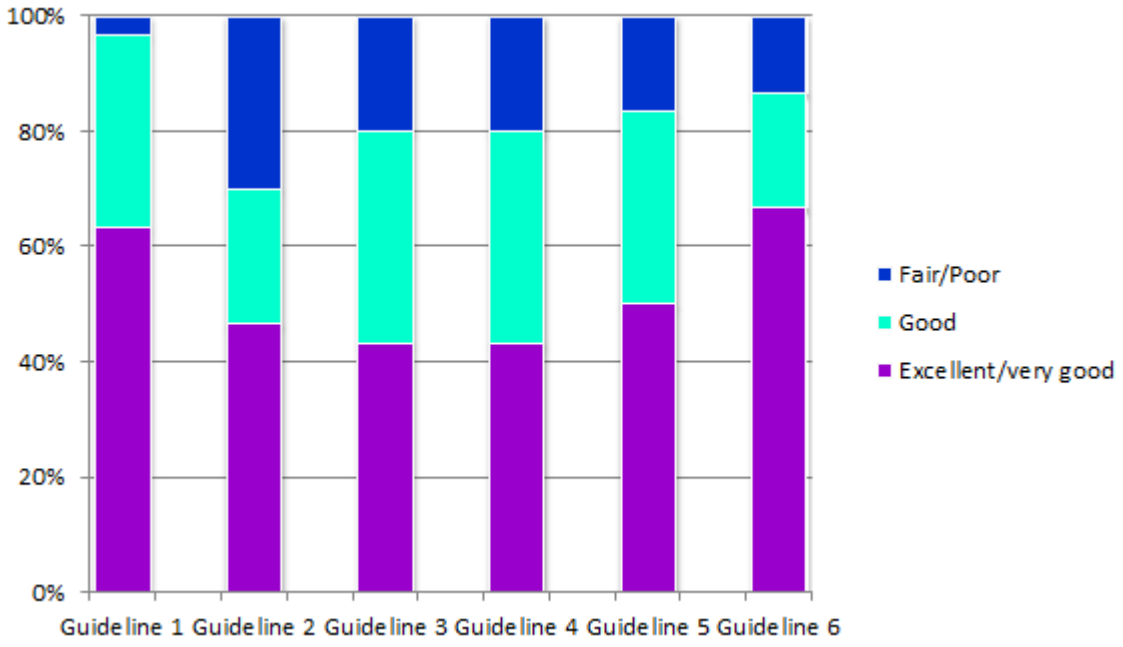

Figure 5.3 Ratings of the content/wording of each proposed guideline.
Note: Guideline 1: encouraging those doing no activity to do some; Guideline 2: daily activity; Guideline 3: volume for general health benefit; Guideline 4: higher volume for prevention of weight gain and some cancers); Guideline 5: muscle strengthening activities; Guideline 6: minimising sitting time.

Preamble

> *Regular physical activity reduces the risk of many adverse physical and psychosocial health outcomes. There is clear evidence that doing some activity is better than doing none at all and increasing amounts of activity provide increasing benefit.*

All respondents indicated that it was appropriate to include a preamble. Almost all (90%) thought the wording was appropriate.

In the written comments, several respondents indicated concerns with specific words. It was thought that "adverse" and "psychosocial" might not be understood by the *general* public. These respondents also indicated that they were unsure for whom this material was intended (ie informed audience vs general public).

Some respondents suggested that examples of specific health outcomes could be included in the statement.

Other individual comments were that: there may be health risks from high levels of activity; the value of high intensity activity; sedentary behaviour was not mentioned; activity is generally safe but inactive people with concerns can start with walking and consult a health professional; and that the sentence structure could be changed to improve readability, strength, and positive wording.

Guideline One

> *Scientific statement: The relationship between physical activity and health benefit is curvilinear. This means that the benefits increase with increasing amounts of physical activity, with 'diminishing returns' at the highest levels of activity.*
>
> *Guideline: Doing any regular physical activity is better than doing none. If you currently do no physical activity, start by doing some activity, and then build up to the recommended amount.*

There was a very high level of support for the appropriateness of introducing this new guideline, with 93% of respondents rating it as excellent/very good. The scientific statement was also strongly supported with 87% of respondents rating it as excellent/very good. Just under two thirds of respondents (67%) rated the content/wording as excellent/very good, and only one person rated it as fair/poor.

Written comments indicated that there were concerns with how to explain the concept of a "curvilinear relationship" in the scientific statement. Some respondents thought that "diminishing returns" was a negative statement, and that it might not be well understood, even by an informed audience. Individual suggestions were to state that benefits increase rapidly, most benefits would be seen in those who move from doing the least activity to doing more, that the increase in benefits becomes smaller at the highest levels of activity, and that some exercise is still beneficial. One researcher suggested that the scientific statement be qualified as "for most cases" given some contradictory evidence and to allow for any potential threshold effect at lower levels of activity. Another researcher suggested the relationship be described as "direct and curvilinear".

Some respondents were concerned with the guideline identifying "any *regular* activity", as this could apply to activities of low frequency (eg once per month) and any intensity. Individual comments on this guideline included suggestions to replace "some" activity with "a small amount", to specify a minimum amount of activity, to include "gradually" in the statement on building up to the recommended amount, and to replace "do no activity" with "doing little or insufficient activity".

Guideline Two

> *Scientific statement: There is no clear evidence on the optimal frequency of physical activity, but there is strong support for recommending that adults should accumulate their physical activity across the week. Being active on most, if not all, days each week, is likely to provide increased metabolic benefits.*
>
> *Guideline: Spread your activity through the week.*

Just over three quarters of respondents (77%) rated the accuracy of the scientific statement as excellent/good. Just under half (47%) rated the content/wording of the guideline as excellent/good, and 23% (n=9) rated the wording as fair/poor.

In the written comments, respondents questioned why the scientific statement identified only the *metabolic* benefits of being active on most days, as there were also benefits for eg strength, bone health, wellbeing, cardiovascular health etc. Several respondents commented that the term "metabolic" may not be well understood, and this emphasis was inconsistent with the overall focus on general health and wellbeing. One was concerned that the conclusion of "no clear evidence" in the scientific statement might be misinterpreted or not understood.

The written comments indicated that respondents strongly supported the concept of the guideline encouraging people to be active on multiple days, instead of eg one or two days. Many respondents suggested the guideline should refer to "every", "many" or "most" days; or "equally" through the week. Some respondents added a qualifier that

this was "preferably", "ideally" or "if possible". Two respondents indicated that a non-quantified descriptive statement (vs eg specifying a set number of days) would be difficult to operationalise for evaluative/research purposes.

Guideline Three

> *Scientific statement: The scientific data on the relationship between total volume (frequency x duration x intensity) of activity and health benefits are more convincing and consistent than those for frequency, duration or intensity of activity. Optimal benefits (ie in terms of effort required, for health gain) are gained in the range from around 500 to around 1000 MET.min/week of physical activity. 500 MET.min/week is equivalent to 150 minutes of moderate-intensity activity, or 75 minutes of vigorous activity, or any combination of intensity and duration that provides this amount of activity. 1000 MET.min/week is equivalent to 300 minutes of moderate intensity or 150 minutes of vigorous activity (or a combination).*
>
> *Guideline: Accumulate at least 150 minutes of moderate intensity physical activity (including brisk walking) or 75 minutes of vigorous activity, or an equivalent combination of moderate and vigorous activities, each week.*

Almost three quarters of the respondents (73%) rated the accuracy of the scientific statement as excellent/very good, and only two respondents rated it as fair/poor. The content/wording of the guideline was rated as excellent/very good by 43%, and as good by 37% of respondents.

Written comments indicated that respondents were concerned how people would translate the scientific statement and guideline into behaviour. Respondents were concerned that people would find it difficult to understand MET values and to determine the "equivalent combination of moderate and vigorous activities". Government-based respondents said this guideline was too wordy, too complicated, and needed to be revised so as to have a clear and simple message to disseminate to the general public. Suggestions were also made for examples of, or supporting documentation on, the meaning of the terms moderate and vigorous intensity activity. Some respondents

questioned why "including brisk walking" was specified, and if it was intended as an example. One researcher noted that other international guidelines indicate that activities need to be >10 minutes.

Several researchers questioned the expression of "optimal benefits in terms of effort required" in the scientific statement, and suggested that the wording needed revising so as to remove the inference of a cost-benefit evaluation.

Some respondents suggested changes to specific phrases (eg first sentence of scientific statement) or words (eg "gained", "accumulate", "equivalent", "optimal").

Guideline Four

> *Scientific statement: For most health outcomes, additional benefits occur with more physical activity. In particular, more activity is required for prevention of weight gain and some cancers. This higher amount of physical activity can be achieved through longer duration (more minutes) or greater frequency (more often) or doing activities of higher intensity.*
>
> *Guideline: For additional health benefits, and for prevention of weight gain and some cancers, accumulate 300 minutes of moderate intensity activity, or 150 minutes of vigorous, or an equivalent combination of moderate and vigorous activities, each week.*

Almost three quarters of the respondents (73%) rated the accuracy of the scientific statement as excellent/very good, and three respondents indicated it was fair/poor. The content/wording of the guideline was rated as excellent/very good by 43% of respondents, good by 37%, and fair/poor by 20% (n=6) of respondents.

Many of the comments reiterated what was said for guideline three. Respondents questioned whether people would be able to understand the volume of activity identified. Some comments from respondents in government positions indicated a concern that the role of diet/healthy eating was not acknowledged for prevention of weight gain.

Several respondents praised this guideline for identifying cancer prevention, clarifying the higher volume of activity needed for preventing weight gain, and giving more than a minimum standard of physical activity. Others found this additional guideline unclear, and wondered whether it was only beneficial for cancer and weight gain prevention. Some respondents wanted other health benefits, such as cardiovascular and bone health, to be acknowledged in the second part of this guideline; one respondent questioned whether there were psychosocial benefits.

Guideline Five

> *Scientific Statement: Resistance training (muscle strengthening) activities are important for metabolic, cardiovascular and musculoskeletal health (including prevention of falls), and for maintaining functional status and ability to conduct activities of daily living.*
>
> *Guideline: In addition, do muscle strengthening activities on at least 2 days each week.*

There was strong support for the appropriateness of introducing this guideline, with 87% of respondents rating it as excellent/very good.

The accuracy of the scientific statement was rated as excellent/very good by 80% of respondents, and only one rated it as fair/poor. The content/wording of the guideline was rated as excellent/very good by 50% of respondents, and good by a third of respondents (33%).

Many respondents commented that people would need examples of this type of activity. One respondent noted the possible confusion from using multiple terms ("resistance training", "muscle strengthening", "strength training"). Two respondents questioned the required duration of sessions.

Some respondents noted that it would be necessary to clarify whether this type of activity was in addition to (ie not included in) the physical activity described in the other guidelines. A few respondents suggested that this information could be included with

the other guideline so as to provide one statement on the recommended levels of physical activity per week. Some respondents suggested that some more specific benefits of this type of activity could be identified e.g., bone health, functional status, falls prevention and activities of daily living.

A few respondents found it contradictory that this guideline specified frequency when the scientific statement appeared to state that there was insufficient evidence to recommend a specific frequency of physical activity.

Guideline Six

> *Scientific Statement: Strong emerging evidence indicates that extended sitting time is associated with increased risk of diabetes and all-cause mortality. There is however insufficient evidence at this time to make a specific recommendation on the minimal or optimal duration of sitting.*
>
> *Guideline: Minimise the amount of time spent sitting. Break up long periods of sitting as often as possible.*

There was a very high level of support for introducing this guideline, with 93% of respondents rating the appropriateness as excellent/very good, and only one person rating it as fair/poor.

Just over two thirds of respondents (67%) rated the accuracy of the scientific statement and the content/wording of the guideline as excellent/very good, and 13% rated the content/wording as fair/poor.

Respondents were concerned with the descriptors of "strong" and "emerging" in the scientific statement, because, for example, this seemed contradictory, there is less evidence for diabetes than all-cause mortality, and there is a lack of evidence from intervention studies. There were mixed opinions between two of the researchers as to whether the health risks from prolonged sitting were independent of physical activity.

Although the limited amount of evidence was acknowledged, respondents in

government based positions asked if it was possible to identify more detailed information on eg how frequently sitting time should be interrupted, what duration of sitting time is considered adverse, and examples of how to break up sitting time. Some of these comments were precipitated by respondents having seen this type of information in the Draft Physical Activity Guidelines for Children and Adolescents, and their desire to align the recommendations between the two documents.

Some respondents suggested changes to specific words such as "all-cause mortality", "emerging" "minimal or optimal", "minimize", and "however".

Changes Made to the Draft Guidelines

Every comment made by the respondents was carefully considered by the consultants, and significant changes were made to the draft guidelines, as shown at the end of this section. In order to improve clarity, the order of the guidelines was changed, so that the guideline on frequency followed the one on volume of activity. In response to comments about people being able to interpret activity intensity, MET values, and other details, more information was added to the preamble and explanatory notes were added to guidelines three, four and five.

In general, there appeared to be more concern with guidelines three and four. The government based respondents wanted fewer words and a simpler message. Some of the researchers suggested that we had not really captured the concept of there being NO threshold of activity for health benefit but rather there is a range of activity levels, and a range of health benefits. In light of this, we decided to substantially modify the draft guidelines three and four into a single guideline on activity amount, with explanatory notes on the benefits associated with lower and higher levels. We moved the more straightforward 'frequency' guideline to follow this information.

Explanation and discussion of the changes made is provided in the next section, and the proposed new scientific statement and guidelines are shown in table form at the end of this part of the report.

DISCUSSION AND REVISIONS

Overall, there was approval of the proposed new guidelines, but with sufficient questions about guidelines three and four to warrant modification to these.

The **preamble** was acknowledged as being relevant and useful. Changes made in response to the comments included the removal of 'scientific' words, making the statement more positive, and providing explanations of the meaning of some of the key terms included in the guidelines.

The **scientific statements** were ratified by most respondents, though several policy officers/practitioners (non-researchers) acknowledged that they were not well informed of the current scientific evidence, and quite a few suggested that some of the words used in the statements might not be understood. It is therefore important to clarify that the scientific statements are written for informed readers with a basic understanding of terms commonly used in physical activity epidemiology. Acknowledging however that this understanding will vary, the revised scientific statements contain fewer 'technical' terms. Many of the questions asked by these respondents are answered in the scientific review section of this report, which was not seen during the consultation process.

In relation to the guidelines, there was significant support for the introduction of the three new guidelines (doing something is better than doing nothing, doing strengthening activities and reducing sitting time). There was also noteworthy support from key expert respondents for the introduction of a *range* of recommended *volume* of activity. There were, however, numerous suggestions for improving the *wording* of the new guidelines, and many of these were incorporated. While many health promotion materials are written for people with a reading age of 12,[1] these guidelines are written for adults with standard (high school) education. It will therefore be important to ensure that the 'messages' (see Part Three of this report) that accompany these guidelines (for example in any social marketing campaign) are tailored and meaningful to the target population.

In contrast with the revised guidelines for children and young people, the revised guidelines for adults are somewhat different from the previous ones. The previous adult guidelines were developed over 15 years ago, and the evidence has changed since then.

Guideline One

The main intent of this guideline is to encourage those who currently do no activity, to do some, as a first step towards achieving the amount recommended in Guideline two (below).

If these guidelines are accepted, they will be one of the first in the world to include a recommendation that people who do nothing should do something. (The Irish guidelines also make this point in their additional notes.[2]) This is important, because, in relation to Australian population surveys conducted over the last 15 years, about 15-20% of adult respondents say they did not do any walking for transport or recreation, or any moderate intensity or vigorous activity. The population health benefits of 'activating' the inactive are significant.[3]

Guideline Two

The first intent of Guideline two is to increase awareness that a *range* of activity levels can be beneficial for health, and that no single definitive amount of physical activity is ideal. The second intent is to encourage people to accumulate *more than* the previously recommended 150 minutes/week, especially in light of the urgent need to prevent population weight gain.

We have clarified in the preamble that physical activities which 'count' towards the new range include those in the *leisure* (including sports, exercise and recreational activities); *transport* (for example walking or cycling to get to or from places); and *occupational* (including paid and unpaid work like lifting, carrying or digging) domains. The intent here is that the new range of activity levels may not appear to be so daunting if it is realised that a range of activities can contribute to achieving it.

We acknowledge that the increase in the recommended change may be difficult to promote, and recommend that different ways of communicating this guideline are carefully tested with target audiences.

Several research respondents reminded us that, since dose-response relationships are

curvilinear, there is no objective threshold of activity for health benefits, which makes it difficult to defend the former '150 minutes' or '5 x 30' as a specific target amount, other than as a 'low end' or potentially achievable target. As one respondent said, "we don't have sufficient evidence of the curvilinear shape of the curve to state a specific amount".

There are some potential important advantages of identifying a range of activity instead of a specific single amount. One researcher respondent was very pleased that "people were not being given a minimum guideline", but rather a 'range' which could be achieved from a variety of different activities of differing intensities. Some respondents also noted that a range would allow for different individual capabilities.

The move to recommending a *range* of activity, rather than a single threshold, is novel. While the WHO, US and UK guidelines also suggest a range of activity for health benefits, their wording suggests that activity at the lower end of the range (ie 150 minutes of moderate intensity activity) is sufficient, and that activity at the upper end (ie 300 minutes of moderate intensity, or greater intensity) is optional, and for *additional* benefits. Our interpretation of the current evidence is that activity at the upper end of the range is *required* for the prevention of weight gain and for primary prevention of some cancers. Finding the right words to express that, for example, 150 minutes is recommended for some health outcomes, but that more (duration or intensity) will result in greater benefits, while at the same time conveying that more is *required* for some health outcomes, is challenging.

Another research respondent explained that, although this range (150-300 minutes, or equivalent) is frequently mentioned in the US Guidelines report, the actual Guideline is for 150 minutes.[4] However, in *"some of the presentations people have made about the American Guidelines, one of things that is commonly said is that the Guideline is a range, not a single specific point. So, I think I would prefer using the range."* Ireland is the only other country to recommend a range of activity. They used words that simplified the evidence to state "30-60 minutes of moderate-vigorous activity on 5 or more days each week".[2]

In light of the fact that some respondents were not familiar with the MET as a unit of measurement of effort or intensity, we have added a definition of the MET to the scientific statement for this guideline. We have also added explanatory notes to the guideline, to better explain the concept of mixing and summating activities of different intensity, and to emphasise that activity at the upper end of the range is required for some health outcomes.

The issue of whether we should recommend *vigorous* activity for additional health benefits, as is done in the New Zealand and Canadian guidelines,[5,6] was also raised by some respondents. While we acknowledge in our evidence review that there is an increasing body of evidence showing additional cardiovascular benefits of more vigorous activity, we are wary of emphasising these potential additional benefits, because, in the long term, if vigorous activity was adopted on a population level, there may be increased 'adverse effects' in terms of injury (see Part 1.5 of this report), and potentially (in association with injury) of increased joint problems. If vigorous activity was widely adopted and continued, we could imagine a scenario of aging Australians with better functioning hearts and lungs and stronger bones, but with more hip and knee replacements.

The issue of doing activity in bouts of at least ten minutes (as is suggested in several other sets of guidelines), was also raised by several respondents. In the evidence review we conclude that the evidence for ten minute bouts is not strong; 15 minute bouts may also be desirable, but the effects of five minute bouts have not been examined. We therefore decided not to include a recommendation about minimum duration.

Guideline Three

The main intent of guideline three is to encourage people to be active every day, rather than on only one or two days each week.

Our third guideline is the only one which now remains unchanged from that included in the 1999 Australian guidelines.[7] Indeed, the main recommendation in 1999 was that all adults should 'put together' at least 30 minutes on most, preferably all, days each week.

In essence, the new guidelines 2 and 3 do not vary greatly from this, given that 'putting together' could infer any of the combinations of activity that are suggested in the new Guideline 2. Our interpretation of the evidence on frequency of activity was that there are benefits from daily activity because of the physiological and metabolic adaptations that occur with activity. In contrast with Guidelines one and two, in the absence of definitive evidence, the evidence on which this guideline is based was rated as 'B'.[8]

Guideline Four

The main intent of Guideline four is to encourage people to include muscle strengthening in their physical activities.

The addition of muscle strengthening activity (now as Guideline Four) was seen as appropriate by most respondents. Although the evidence base underlying this recommendation was rated as 'A/B', (and hence weaker than for Guidelines One and Two) this new guideline is in accord with those of seven other countries (see Table 4), the majority of who concur with the frequency of 'at least 2 days per week'. We have added examples of muscle strengthening activities in the explanatory notes, in order to indicate that these do not only include gym-based resistance training programs.

Guideline Five

The main intent of Guideline five is to encourage people to sit less, and to break up prolonged sitting time. The latter point is particularly salient for people who may be required to sit for extended periods of time (eg for work or in long journeys).

We have purposely used the term "sitting" instead of "sedentary" so as to minimise potential confusion, as the term "sedentary" has been commonly used in key national reports and publications to describe those who do no physical activity or exercise. (See, for example, The Australian Bureau of Statistics reports on Physical Activity,[10] Sport and Physical Recreation,[11] the National Health Survey,[12] and the National Aboriginal and Torres Strait Islander Health Survey;[13] The National Public Health Partnership publication

"Getting Australia Active";[14] and the draft NHMRC Clinical Practice Guidelines for the Management of Overweight and Obesity.[15] The term "sitting" is, however, more explicit, and consistent with the focus of the research evidence reviewed.

The addition of a guideline on reducing sitting time was seen as appropriate. It was apparent however that those in government positions were interested to have more specific advice about sitting time (how much is ok/harmful, how often should breaks be, and for how long, etc), while the researchers were more circumspect about the strength of the evidence and the ability to provide specific recommendations. The UK guidelines are the only others to include a recommendation about reducing sitting time.[9] Their expert panel also considered that there was insufficient evidence on which to base more specific recommendations about duration of sitting and breaks.

In contrast with the evidence on physical activity and health, which has been accumulating for more than 60 years, the evidence on sedentary time and health has only begun to emerge in the last ten years. Although the evidence is growing rapidly, there is still substantial debate on whether the effects of too much sitting occur independently of the amount of regular physical activity. At this time we do not believe therefore that there is sufficient evidence on which to base a separate set of guidelines on sedentary behaviour for adults.

The proposed new guidelines are shown in Table 5.3.

Table 5.3: Proposed new Australian Physical Activity Guidelines for Adults aged 18-64 years.

PREAMBLE:

Regular physical activity has important benefits for physical and mental health. It reduces the risk of many health problems, such as cardiovascular disease, diabetes, anxiety, depression, musculoskeletal problems, some cancers and weight gain. There is clear evidence that doing some physical activity is better than doing none at all, and that increasing amounts of physical activity provide even more health benefits.

These guidelines are for all adults aged 18-64 years. Although physical activity is generally safe for everyone, physical and mental abilities should be considered when interpreting the guidelines. Those who are unaccustomed to activity are advised to start gently (for example, by walking), without over-exertion, and to gradually build up towards reaching recommended levels. Consult a health professional if unsure.

In the context of these guidelines, **physical activity** is defined as any bodily movement produced by one or more large muscle groups, for movement as part of: *leisure* (including sports, exercise and recreational activities); *transport* (for example walking or cycling to get to or from places); and *occupation* (including paid and unpaid work like lifting, carrying or digging). These activities should be carried out at **moderate to vigorous intensity.** *Moderate* intensity activities require some effort, but conversation is possible. Examples include brisk walking, swimming, social tennis, dancing etc. *Vigorous* activities make you breathe harder or puff and pant (depending on fitness). Examples include aerobics, jogging and many competitive sports.

Summary of the Scientific Evidence	Guideline	Explanatory Notes
ONE In most cases, the relationship between physical activity and health benefits is direct and curvilinear. The greatest benefits are seen in those who change from doing the least or no physical activity to doing more. The increase in health benefits per unit increase in physical activity becomes smaller at the highest levels of activity. Level of Evidence = A	*Doing any physical activity is better than doing none. If you currently do no physical activity, start by doing some, and gradually build up to the recommended amount.*	
TWO The scientific data on the relationship between total *volume* (frequency x duration x intensity) of physical activity and health benefits are more convincing and consistent than those for the separate effects of frequency, duration or intensity of physical activity. The suggested *range* of activity is from around 500 to around 1000 MET.min/week*. 500 MET.min/week is equivalent to 150 minutes of moderate-intensity activity, or 75 minutes of vigorous activity, or any combination of duration and intensity that provides this amount of activity. 1000 MET.min/week is equivalent to 300 minutes of moderate intensity or 150 minutes of vigorous activity (or a combination).	*Accumulate 150 to 300 minutes of moderate intensity physical activity or 75 to 150 minutes of vigorous intensity physical activity, or an equivalent combination of both moderate and vigorous activities, each week.*	The lower end of this range (which can be achieved by, for example, a 30 minute walk five times a week) will provide *substantial* health benefits (eg lower risk of cardiovascular disease, diabetes, musculoskeletal and mental health problems). More activity (for example, two 30 minute walks, or one 30 minute jog on five days each week) provides additional benefits. Physical activity at the upper end of this range is required for the prevention of weight gain and to reduce the risk of breast and colon cancer.

Summary of the Scientific Evidence	Guideline	Explanatory Notes
For most health outcomes, additional benefits occur with more physical activity. In particular, more activity is *required* for the prevention of weight gain and some cancers. This higher amount of physical activity can be achieved by longer duration (more minutes) or greater frequency (more often) or higher intensity (more effort). **** The MET** (metabolic equivalent) is the unit used to define activity intensity or effort, in multiples of resting metabolic rate. One MET is defined as energy expenditure at rest, usually equivalent to 3.5mL of oxygen uptake per kg of body weight per minute. 500 MET.min/week is equivalent to 150 minutes of physical activity at 3.33 MET (moderate intensity) or 75 minutes of physical activity at 6.66 MET (vigorous).* Level of Evidence = A		Any combination of moderate and/or vigorous intensity activities can be included, with each minute of vigorous physical activity 'counting' as two minutes of moderate intensity activity.
THREE Evidence relating to the optimal frequency of physical activity each week is equivocal. The repeated physiological and metabolic adaptations, and energy expenditure associated with daily physical activity, make it likely that frequent activity is more beneficial than activity on only one	*Be active on most, preferably all, days every week*	

Summary of the Scientific Evidence	Guideline	Explanatory Notes
or two days, each week. Level of Evidence = B		
FOUR Muscle strengthening activities are important for metabolic and musculoskeletal health (including maintaining bone density), and for maintaining functional status and ability to conduct activities of daily living in older age. There is limited evidence on the *optimal* frequency, duration or intensity of strength training, but there is some evidence of significant benefits from muscle strengthening activities twice weekly, on non-consecutive days. Level of Evidence = A/B	*Do muscle strengthening activities* on at least 2 days each week*	***** These include 'pushing' 'pulling' or 'lifting' activities, in which the muscles work against some form of resistance. The resistance can be provided by body weight (eg push-ups), hand-held weights (eg dumbbells), or pushing or pulling using machines as resistance.
FIVE Emerging evidence indicates that prolonged sitting time is associated with increased risk of premature death and a range of chronic health problems. There is insufficient evidence at this time to make a recommendation on the specific duration of sitting that is associated with poor health outcomes. There is emerging evidence to show that the negative effects of prolonged	*Minimise the amount of time spent in prolonged sitting. Break up long periods of sitting as often as possible.*	Breaks in sitting time need not involve moderate-vigorous activity. Standing-up, stretching and 'light' activities are beneficial.

Summary of the Scientific Evidence	Guideline	Explanatory Notes
sitting may occur even in those who meet the guidelines for moderate-vigorous activity. Level of Evidence = A/B		

REFERENCES: (Part 5)

1. Hawe, P, Degeling D, Hall J. Evaluating Health Promotion: A Health Worker's Guide. Sydney: MacLennan and Petty, 1990.

2. Department of Health and Children, Health Service Executive. The National Guidelines on Physical Activity for Ireland. Dublin, Ireland: Department of Health and Children and Health Service Executive; 2009. Accessed June 2012 from Get Ireland Active

3. Powell KE, Paluch AE, Blair SN. Physical activity for health: What kind? How much? How intense? On top of what? Annu Rev Public Health. 2011; 32: 349-365.

4. US Department of Health and Human Services. Physical Activity Guidelines for Americans Resources. At-a-Glance: A Fact Sheet for Professionals. Washington, USA, 2008. Accessed June 2012.

5. Sport and Recreation New Zealand. Guidelines for Promoting Physical Activity to Adults. Wellington, New Zealand: Sport and Recreation New Zealand; 2005.

6. Canadian Society for Exercise Physiology. 2011 Canadian Physical Activity Guidelines. Ottawa, Canada: Canadian Society for Exercise Physiology; 2011.

7. Department of Health and Ageing. National Physical Activity Guidelines for Australians. Canberra: Commonwealth Government of Australia, 1999.

8. (Australian) National Health and Medical Research Council. Additional Levels of Evidence and Grades for Recommendations for Developers of Guidelines. Canberra: National Health and Medical Research Council. Accessed June 2012.

9. Department of Health. UK Physical Activity Guidelines - Factsheets 1-4. London, UK. Accessed June 2012.

10. Australian Bureau of Statistics. Physical Activity in Australia: A Snapshot, 2007-08. ABS Cat no. 4835.0.55.001. Canberra: ABS, 2006.

11. Australian Bureau of Statistics. Sports and Physical Recreation: A Statistical Overview, Australia, 2011. ABS cat. no. 4156.0. Canberra: ABS, 2011.

12. Australian Bureau of Statistics. National Health Survey: Summary of Results, 2007-2008. ABS cat. no. 4364.0. Canberra: ABS, 2009.

13. Australian Bureau of Statistics. National Aboriginal and Torres Strait Islander Health Survey 2004–05. ABS cat. no. 4715.0. Canberra: ABS, 2006.

14. Bauman A, Bellew B, Vita P, Brown W, Owen N. Getting Australia active: towards better practice for the promotion of physical activity. National Public Health Partnership. Melbourne, Australia, 2002.

15. NHMRC Management of overweight and obesity in adults, adolescents and children. Clinical guidelines for primary health care professionals. Public consultation draft 29th March 2012,

and evidence summary. Accessed June 2012 from Public Consultations NHMRC Management of overweight and obesity in adults, adolescents and children.

NEXT STEPS

NEXT STEPS

The following issues are identified as being important next steps for these physical activity guidelines

PROMOTION OF THE NEW GUIDELINES

Following ratification of the revised guidelines it will be important to promote them to the Australian adult population. This will require the development of a public health messaging strategy that encourages awareness and adoption of the new guidelines. The messages should be tested with the target audience, and could be incorporated into a new or existing social marketing campaign, with use of a wide range of media. As stated in Part Three of this report, this step is often overlooked when new guidelines are developed.

In developing public communication messages to accompany these guidelines, key issues and challenges will be to promote:

- that 'some activity is better than none', without leaving people with the impression that 'any activity will do';
- the concept of a *range* of activity, with more activity providing greater benefits; but with a clear message that more activity is required for the prevention of weight gain;
- the concept of 'mixing and matching' a range of activities of different intensities;
- a wide range of examples of physical activities, and not to focus solely on structured 'exercise' as the only option.

MONITORING COMPLIANCE

Although the proposed new guidelines are different from the previous ones, it will be important to continue to monitor levels of compliance with guidelines among Australian adults. It is possible to estimate the proportion of adults whose physical activity levels fall in the range suggested by Guideline Two, using the National Health Survey that is currently in progress. It will also be useful to monitor compliance with the 'minimal' recommendation (150 minutes etc), as this will enable comparisons to be made with previous surveys. As the new National Health Survey also includes questions on strength training and sitting, it will also be possible to monitor compliance with the new Guidelines Four and Five.

RESEARCH NEEDS

This update of the scientific literature on physical activity and health revealed numerous issues that require clarification.

The issue of whether we should be promoting greater participation in vigorous activity is important. There is no doubt that vigorous activity promotes fitness and that this has benefits, especially for cardiovascular health. We do however need more prospective cohort study evidence on whether those who do regular vigorous activity (or high energy weight bearing activity) have more adverse long term health outcomes than those who, for example, 'only walk'. We also need to better understand the comparative benefits and adverse effects of moderate and vigorous activities on specific health outcomes.

We also need to know whether thinking about activity in terms of an overall 'volume' of moderate intensity and vigorous activity should be extended to include light intensity activities. Much more needs to be understood about light intensity activity and its overall contribution to health outcomes, and this is feasible now that objective monitoring of activity across the entire intensity spectrum is possible. We already know that light intensity activity can provide psychosocial benefits, and is probably better than sitting, but does 30 minutes of light activity at say, 2 METs, have the same health benefits as 15 minutes of moderate activity at 4 METs?

In relation to the new guidelines, we also need more research on the minimal duration or 'bout' of activity that will promote health, on the relative benefits of activity on 'most/all' and fewer days, and on the dose-response relationships between strength training and health outcomes, especially in relation to 'non-gym' based activities. In terms of sedentary behaviour, we need more research to support the development of guidelines on the duration of sitting time that is associated with adverse outcomes, and the required frequency and type of breaks in prolonged sitting time to reduce health risk.

There are also numerous areas of research relating to the promotion of these guidelines. For example, are punitive messages and campaigns (like the Grim Reaper campaign) more effective than positive messages in promoting physical activity? Is TV advertising more effective than mailed materials in promoting awareness of the guidelines and how should materials be tailored for different target groups?

This is not intended to be an exhaustive list. It is provided only as evidence of the fact that there is still much to be understood about physical activity, sedentary behaviour and health outcomes.

REVIEW OF THE GUIDELINES

Given that the evidence on physical activity, sitting time and health is accruing relatively quickly, it would be pertinent to review these new guidelines every five years, to ensure that the guidelines continue to be based on the most recent evidence.

APPENDICES

APPENDIX ONE

EXAMPLES OF COMMUNICATION TOOLS DEVELOPED FOR PHYSICAL ACTIVITY GUIDELINES FROM THE USA AND THE UK

1. THE USA

The most recent 2009 USA guidelines provide an example of how physical activity guidelines can be developed and communicated using a suite of communication tools which aim to provide the right level of detail to the intended audience. As a set of tools, the materials compliment and reinforce each other. A summary of these materials is provided below.

US Physical Activity Scientific Report

(760 pages, structured around reporting the science on health benefits by disease outcome as well as risks)

A précis of the scientific evidence is provided on page 5 of the report. Taken directly, it reads:

"Data from a large number of studies evaluating a wide variety of benefits in diverse populations generally support 30 to 60 minutes per day of moderate to vigorous intensity physical activity on 5 or more days of the week. For a number of benefits, such as lower risk for all-cause mortality, coronary heart disease, stroke, hypertension, and type 2 diabetes in adults and older adults, lower risk is consistently observed at 2.5 hours per week (equivalent to 30 minutes per day, 5 days per week) of moderate to vigorous intensity activity. The amount of moderate to vigorous intensity activity most consistently associated with significantly lower rates of colon and breast cancer and the prevention of unhealthy weight gain or significant weight loss by physical activity alone is in the range of 3 to 5 hours per week."

The summary continues to provide further details on the dose response relationship:

"It is possible to combine aerobic activities of different types and intensities into a single measure of amount of activity. For many studies, the amount of moderate and vigorous intensity activity associated with significantly lower rates of disease or improvements in biomarkers and fitness is in the range of 500 to 1,000 MET-minutes per week. An adult can achieve a target of 500 MET-minutes per week by walking at about 3.0 miles per hour for approximately 150 minutes per week (7.5 miles), walking faster at 4.0 miles per hour for 100 minutes (6.6 miles), or jogging or running at 6 miles per hour for about 50 minutes per week (5.0 miles). To achieve 1,000 MET-minutes per week, these amounts of activity would need to be doubled."

The summary also outlines the science on other types of activity and their benefits for specific health endpoints:

"Resistance or muscle-strengthening exercises are important for maintaining muscle and bone health, and these exercises enhance functional status and contribute to a reduction of falls in older adults. Most of the evidence supports a resistance activity program with the following characteristics: progressive muscle strengthening exercises that target all major muscle groups performed on 2 or more days per week. To enhance muscle strength, 8 to 12 repetitions of each exercise should be performed to volitional fatigue. One set is effective; however, limited evidence suggests that 2 or 3 sets may be more effective."

As a précis this provides an excellent short cut to the 760 page report, but it is entirely inappropriate for communication to audiences beyond those familiar with the scientific field and the historical developments and computations involved.

To communicate the important information to a professional audience the US developed a shorter report which might be regarded as a technical or professional report. This is just 76 pages long and contains the key information on the physical activity guidelines within a report aimed at how this information will be used to promote physical activity to adults and the wider community.

The report is called **2008 Physical Activity Guidelines for Americans, *Be Active, Healthy, and Happy!*** (13) On page vii within what might be regarded as the summary section of the

report the following is provided:

Key Guidelines for Adults

- All adults should avoid inactivity. Some physical activity is better than none, and adults who participate in any amount of physical activity gain some health benefits.
- For substantial health benefits, adults should do at least 150 minutes (2 hours and 30 minutes) a week of moderate-intensity, or 75 minutes (1 hour and 15 minutes) a week of vigorous-intensity aerobic physical activity, or an equivalent combination of moderate- and vigorous-intensity aerobic activity. Aerobic activity should be performed in episodes of at least 10 minutes, and preferably, it should be spread throughout the week.
- For additional and more extensive health benefits, adults should increase their aerobic physical activity to 300 minutes (5 hours) a week of moderate-intensity, or 150 minutes a week of vigorous-intensity aerobic physical activity, or an equivalent combination of moderate- and vigorous-intensity activity. Additional health benefits are gained by engaging in physical activity beyond this amount.
- Adults should also do muscle-strengthening activities that are moderate or high intensity and involve all major muscle groups on 2 or more days a week, as these activities provide additional health benefits.

The core substance of the 760 page report and its summary have been reduced to 4 dot points. Later on page 5 of the same report ***Be Active, Healthy, and Happy!*** is the following text:

"The Advisory Committee report provides the basis for dividing the amount of aerobic physical activity an adult gets every week into four categories: inactive, low, medium, and high (see table below). This classification is useful because these categories provide a rule of thumb of how total amount of physical activity is related to health benefits. Low amounts of activity provide some benefits; medium amounts provide substantial benefits; and high amounts provide even greater benefits.

Inactive is no activity beyond baseline activities of daily living.

Low activity is activity beyond baseline but fewer than 150 minutes (2 hours and 30 minutes) of moderate-intensity physical activity a week or the equivalent amount (75 minutes, or 1 hour and 15 minutes) of vigorous-intensity activity.

Medium activity is 150 minutes to 300 (5 hours) minutes of moderate-intensity activity a week (or 75 to 150 minutes of vigorous-intensity physical activity a week). In scientific terms, this range is approximately equivalent to 500 to 1,000 metabolic equivalent (MET) minutes a week.

High activity is more than the equivalent of 300 minutes of moderate-intensity physical activity a week. For more information, Appendix One provides a detailed explanation of MET-minutes, a unit useful for describing the energy expenditure of a specific physical activity."

SOURCE: Page 5. 2008 Physical Activity Guidelines for Americans (76 page report).

Fact Sheets

Although the 76 report is useful for the informed and interested professional, it is still not suitable for communication of the new USA physical activity guidelines to a wider audience. (For example one that might include the wider community as well as other professional groups who may not read the report). The set of fact sheets is aimed at such groups and the primary message shown within a box is replicated below:

How much physical activity do I need to do?

This chart tells you about the activities that are important for you to do. Do **both** aerobic activities and strengthening activities. Each offers important health benefits. And remember, some physical activity is better than none!

Aerobic Activities

If you choose activities at a **moderate** level, do at least **2 hours and 30 minutes** a week.

If you choose **vigorous** activities, do at least **1 hour and 15 minutes** a week.

- Slowly build up the amount of time you do physical activities. The more time you spend, the more health benefits you gain. Aim for twice the amount of activity in the box above.
- Do at least 10 minutes at a time.
- You can combine moderate and vigorous activities.

Muscle Strengthening Activities

Do these at least **2 days** a week.

- Inlcude all the major muscle groups such as legs, hips, back, chest stomach, shoulders, and arms.
- Exercises for each muscle group should be repeated 8 to 12 times per session.

SOURCE: USA 2009 Physical Activity Guidelines: FACT SHEET*

*extract of the table only, other information is provided on this 1-2 pager

Tool Kit

Another resource within the suite of supporting materials launched alongside the USA physical activity guidelines is a community focussed *tool kit* ***"Be Active Your Way: A Guide for Adults Making Physical Activity a Part of Your Life".*** This 26 page guide recommends both the amount of physical activity to be undertaken, as well as a framework of how individuals and families could implement this within their daily lives. On page 9 the following core information is provided:

"Planning your activity for the week.

Physical activity experts say that spreading aerobic activity out over at least 3 days a week is best. Also, do each activity for at least 10 minutes at a time. There are many ways to fit in **2 hours and 30 minutes** a week. For example, you can do 30 minutes of aerobic activity each day, for 5 days.

On the other 2 days, do activities to keep your muscles strong. Find ways that work well for you."

SOURCE: Be Active Your Way A Guide for Adults Making Physical Activity a Part of Your Life

All the materials are available on the US Physical Activity Guidelines website which itself is another tool for use by multiple audiences. No other country has produced such a comprehensive set of materials to support the national guidelines and had them available at the launch or shortly thereafter. It is too early to know if this approach has made a difference in the USA, but this will be difficult to judge, given no previous set of guidelines has been subject to any comprehensive evaluation.

2. THE UK

The second example of a set of scientific guidelines and their communication to a wider audience is from the recently completed work in the UK. In 2011 new physical activity guidelines were launched by the joint Chief Medical Officers of England, Scotland, Wales and Northern Ireland. In the CMO report, both in the Summary section (page 7) and in the main report (page 34), the guidelines are stated as follows:

Adults (19–64 years)

1. Adults should aim to be active daily. Over a week, activity should add up to at least 150 minutes (2½ hours) of moderate intensity activity in bouts of 10 minutes or more – one way to approach this is to do 30 minutes on at least 5 days a week.

2. Alternatively, comparable benefits can be achieved through 75 minutes of vigorous intensity activity spread across the week or a combination of moderate and vigorous intensity activity.

3. Adults should also undertake physical activity to improve muscle strength on at least two days a week.

4. All adults should minimise the amount of time spent being sedentary (sitting) for extended periods."

SOURCE: CMO Report 2011: page 7 and page 34

Fact Sheets

Of interest, this is exactly the same wording used in the Fact Sheets produced for dissemination to the wider community as well as professional groups that work with adults and that might use or be informed by the new guidelines. Reproduced below is the UK Fact Sheet and the 4 messages:

"1. Adults should aim to be active daily. Over a week, activity should add up to at least 150 minutes (2½ hours) of moderate intensity activity in bouts of 10 minutes or more – one way to approach this is to do 30 minutes on at least 5 days a week.

2. Alternatively, comparable benefits can be achieved through 75 minutes of vigorous intensity activity spread across the week or combinations of moderate and vigorous intensity activity.

3. Adults should also undertake physical activity to improve muscle strength on at least two days a week.

4. All adults should minimise the amount of time spent being sedentary (sitting) for extended periods.

Individual physical and mental capabilities should be considered when interpreting the guidelines"

SOURCE: UK Factsheet for Adults (19–64 years)

APPENDIX TWO

MATERIALS USED IN THE CONSULTATION PROCESS

EMAIL INVITATION TO PARTICIPATE IN THE CONSULTATION PROCESS.

Dear Colleague

The Australian Government Department of Health and Ageing has contracted us to review and update the scientific evidence on physical activity and health, and to recommend changes to the existing **Australian Physical Activity Guidelines for Adults** (18-64 years).

You have been identified as having expertise or as being a stakeholder in this area. As part of the consultation process, we are seeking **your feedback** on the draft summary of scientific findings and proposed new physical activity guidelines for adults.

If you would like to provide feedback on this draft document, we invite you to complete the **brief online survey** (10-15 minutes) and comment on the accuracy, appropriateness and content of the material provided. Please ensure that all material is kept **confidential**, and do not circulate it to anyone else.

Your feedback is requested by **Monday June 11, 2012 at 5pm.** I apologise for the short notice that is required to meet the timelines for this work.

Your involvement is greatly appreciated.

With best wishes

Wendy Brown, Adrian Bauman, Fiona Bull, Nicola Burton
(consultants)

Survey Link: Link to online survey
Any questions about the survey can be directed to Helen Elizabeth Brown on email h.brown1@uq.edu.au

Wendy J Brown
Professor of Physical Activity and Public Health
School of Human Movement Studies, University of Queensland
Blair Drive St Lucia QLD4072
Tel: +61 (0)7 3365 6446 Fax: +61 (0)7 3365 6887

ONLINE SURVEY USED IN THE CONSULTATION PROCESS

Proposed Recommendations for Physical Activity and Sedentary Behaviour for Australian Adults (18-64 years)

*The following questions ask your opinion on the **appropriateness, accuracy, content** and **wording** of the proposed recommendations.*

There is also space for you to provide any additional comments.

If you have any questions about this survey, please feel free to contact Helen Elizabeth Brown on h.brown1@uq.edu.au

There are 22 questions in this survey

PREAMBLE

The proposed preamble provides an overall statement on the benefits of physical activity.

Regular physical activity reduces the risk of many adverse physical and psychosocial health outcomes. There is clear evidence that doing some activity is better than doing none at all and increasing amounts of activity provide increasing benefit.

[1] Is it appropriate to include a preamble? Please choose **only one** of the following:

- ○ Yes
- ○ No

[2] Is the wording clear? Please choose **only one** of the following:

- ○ Yes
- ○ No

[3] Do you have any other comments on the preamble?

Please write your answer here: (space provided)

GUIDELINE ONE

Guideline One is a new guideline which encourages those who currently do no activity to do some.

Scientific statement:

The relationship between physical activity and health benefit is curvilinear. This means that the benefits increase with increasing amounts of physical activity, with 'diminishing returns' at the highest levels of activity.

Guideline One:

Doing any regular physical activity is better than doing none. If you currently do no physical activity, start by doing some activity, and then build up to the recommended amount.

[4] Please rate the following aspects of this guideline.

Please choose the appropriate response for each item:

	Excellent	Very good	Good	Fair	Poor
The accuracy of the scientific statement	○	○	○	○	○
The appropriateness of introducing this new guideline	○	○	○	○	○
The content/wording of the guideline	○	○	○	○	○

[5] Do you have any other comments about Guideline One?

Please write your answer here:

GUIDELINE TWO

Guideline TWO encourages people to do some physical activity every day.

Scientific statement

There is no clear evidence on the optimal frequency of physical activity, but there is strong support for recommending that adults should accumulate their physical activity across the week. Being active on most, if not all, days each week, is likely to provide increased metabolic benefits.

Guideline Two:

Spread your activity through the week.

[6] Please rate the following aspects of this guideline.

Please choose the appropriate response for each item:

	Excellent	Very good	Good	Fair	Poor
The accuracy of the scientific statement	○	○	○	○	○
The content/wording of the guideline	○	○	○	○	○

[7] Do you have any other comments about Guideline Two?

Please write your answer here:

GUIDELINES THREE AND FOUR

Guidelines Three and Four present a move towards encouraging a *range* of levels of physical activity, with emphasis first (Guideline Three) on general health benefit, then on a higher volume for of activity for prevention of weight gain and some cancers, in Guideline Four.

Scientific statement:

The scientific data on the relationship between total *volume* (frequency x duration x intensity) of activity and health benefits are more convincing and consistent than those for frequency, duration or intensity of activity.

Optimal benefits (i.e. in terms of effort required, for health gain) are gained in the range from around 500 to around 1000 MET.mins/week of physical activity. 500 MET.mins/week is equivalent to 150 minutes of moderate-intensity activity, or 75 minutes of vigorous activity, or any combination of intensity and duration that provides this amount of activity. 1000 MET.mins/week is equivalent to 300 minutes of moderate intensity or 150 minutes of vigorous activity (or a combination).

For most health outcomes, additional benefits occur with more physical activity. In particular, more activity is *required* for prevention of weight gain and some cancers. This higher amount of physical activity can be achieved through longer duration (more minutes) or greater frequency (more often) or doing activities of higher intensity.

Guideline Three:

Accumulate at least 150 minutes of moderate intensity physical activity (including brisk walking) or 75 minutes of vigorous activity, or an equivalent combination of moderate and vigorous activities, each week.

Guideline Four:

For additional health benefits, and for prevention of weight gain and some cancers, accumulate 300 minutes of moderate intensity activity or 150 minutes of vigorous, or an equivalent combination of moderate and vigorous activities, each week.

[8] Please rate the following aspects of Guideline Three.

Please choose the appropriate response for each item:

	Excellent	Very good	Good	Fair	Poor
The accuracy of the scientific statement	○	○	○	○	○
The content/wording of the guideline	○	○	○	○	○

[9] Do you have any other comments about Guideline Three?

Please write your answer here:

[10] Please rate the following aspects of Guideline Four.

Please choose the appropriate response for each item:

	Excellent	Very good	Good	Fair	Poor
The accuracy of the scientific statement	○	○	○	○	○
The content/wording of the guideline	○	○	○	○	○

[11] Do you have any other comments about Guideline Four?

Please write your answer here:

GUIDELINE FIVE

Guideline Five is about the need for muscle strengthening activities.

Scientific statement:
Resistance training (muscle strengthening) activities are important for metabolic, cardiovascular and musculoskeletal health (including prevention of falls), and for maintaining functional status and ability to conduct activities of daily living.

There are insufficient data on which to base a specific recommendation about the frequency of strength training, but significant benefits are associated with strength training at least twice a week.

Guideline Five:

In addition, do muscle strengthening activities on at least 2 days each week.

[12] Please rate the following aspects of this guideline.

Please choose the appropriate response for each item:

	Excellent	Very good	Good	Fair	Poor
The accuracy of the scientific statement	○	○	○	○	○
The appropriateness of introducing a guideline on strength training	○	○	○	○	○
The content/wording of the guideline	○	○	○	○	○

[13] Do you have any other comments about Guideline Five?

Please write your answer here:

GUIDELINE SIX

Guideline Six is about the need to minimise sitting time.

Scientific statement:

Strong emerging evidence indicates that extended sitting time is associated with increased risk of diabetes and all-cause mortality. There is however insufficient evidence at this time to make a specific recommendation on the minimal or optimal duration of sitting.

Guideline Six:

Minimise the amount of time spent sitting. Break up long periods of sitting as often as possible.

[14] Please rate the following aspects of this guideline. *

Please choose the appropriate response for each item:

	Excellent	Very good	Good	Fair	Poor
The accuracy of the scientific statement	○	○	○	○	○
The appropriateness of introducing a guideline on sitting	○	○	○	○	○
The content/wording of the guideline	○	○	○	○	○

[15] Do you have any other comments about Guideline Six?

Please write your answer here:

The following questions ask about you and your current work in relation to physical activity and sedentary behaviour.

[16] Are you ○ Female ○ Male

[17] What is your age? Please write your answer here: _____

[18] What is the highest educational qualification you have completed?
Please choose **only one** of the following:

- ○ School only
- ○ Post school certificate or diploma
- ○ University degree
- ○ Higher research degree

[19] What is the context of your employment?
Please choose **only one** of the following:

- ○ Local government
- ○ State government
- ○ Non-government organisation
- ○ University
- ○ Private industry
- ○ Other

[20] Where are you located?
Please choose **only one** of the following:

- ○ QLD
- ○ VIC
- ○ SA
- ○ NT
- ○ Outside Australia
- ○ NSW
- ○ TAS
- ○ WA
- ○ ACT[1]

[21] How would you describe the primary focus of your employment?

Please choose only one of the following:

- ○ Research/academic
- ○ Service provision/health promotion practice
- ○ Management
- ○ Policy
- ○ Other

Many thanks for taking the time to complete this survey. Your contribution to this project is greatly appreciated.

[1] Omitted in error from the actual survey. (ACT respondents entered NSW).