Physical activity and Aboriginal and Torres Strait Islander people in Australia

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Contents

Supervisor's Statement

As the primary supervisor of Rona Macniven's doctoral work, I certify that I consider her thesis to be suitable for examination.

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Declaration

This thesis is submitted to The University of Sydney, Australia, in fulfillment of the requirements for the degree of Doctor of Philosophy. The work presented in this thesis is, to the best of my knowledge and belief, original except as acknowledged in the text. I hereby declare that I have not previously submitted this material, either in full or in part, for a degree at this or any other institution.

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Authorship Attribution Statement

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In addition to the statements above, in cases where I am not the corresponding author of a published item (manuscripts presented in Appendices to this thesis), permission to include the published material has been granted by the corresponding author.

Appendix 1 Gubhaju L, Banks E, **Macniven R**, Joshy G, McNamara B, Bauman A, Eades S. Factors relating to participation in follow-up to the 45 and Up study in Aboriginal and non-Aboriginal individuals. BMC Medical Research Methodology 2016 16: 53.

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'Just a world that we all must share

It's not enough just to stand and stare

Is it only a dream that there'll be

No more turning away?'

Pink Floyd, 1987

Abstract

Background

Globally, non-communicable diseases (NCDs) such as cardiovascular disease and diabetes represent an issue of epidemic proportion, responsible for tens of millions of premature deaths annually. NCDs are also responsible for reducing quality of life and causing detrimental social and economic effects. Disparities across population groups are evident. In Australia, NCDs were a leading cause of the total burden of disease in 2011. Aboriginal and Torres Strait Islanders have a shorter life expectancy and poorer health risk factors and outcomes than non-Indigenous Australians. Much of this gap in life expectancy has been attributed to preventable NCDs. Physical activity is a key modifiable cause of the excess burden of disease and mortality. Among Aboriginal and Torres Strait Islander people, there is a lack of evidence around the associations between physical activity and health and demographic factors and the impact of strategies to increase physical activity, compared to evidence among mainstream populations.

Aims

This thesis aims to contribute to the evidence base around the association between physical activity and the health of Aboriginal and Torres Strait Islander people. The first aim is to examine cross-sectional associations between physical activity and a range of lifestyle, environmental and social factors among adults. Subsequently, the thesis identifies and describes physical activity patterns and influencing factors among adolescents. The third aim is to describe characteristics of physical activity programs targeting Aboriginal and Torres Strait Islander people. Lastly, the thesis aims to measure the effects of a community-based physical activity program.

Methods

The series of studies used a range of methods. The first study examined whether achievement of national

physical activity recommendations was associated with healthy lifestyle behaviours, neighbourhood environmental characteristics and social support among Aboriginal and non-Aboriginal adults in New South Wales (NSW) (**Chapter 2).** The second study examined cross-sectional demographic, social, psychosocial and health correlates of physical activity among Aboriginal and non-Aboriginal adolescents in NSW (**Chapter 3**). The third study examined age related declines in physical activity among Aboriginal and non-Aboriginal young people and their variation by season, setting and type among Aboriginal and non-Aboriginal children from between 2007/8 and 2011/12 (**Chapter 4**). The fourth study reviewed the scientific and grey literature for physical activity programs targeting Aboriginal and Torres Strait Islander people operating between 2012 and 2015, described their characteristics and engaged with program coordinators to verify sourced information (**Chapter 5**). The final study examined the perceived health and community impact of the Indigenous Marathon Program (IMP) in a remote Torres Strait island community, using questionnaire and semi-structured interview mixed methods (**Chapter 6**).

Results

In **Chapter 2,** a similar proportion of Aboriginal and non-Aboriginal adults achieved national physical activity recommendations and factors relating to achieving recommendations were similar in both groups. However, neighbourhood features and social support were less favourable among Aboriginal adults. Among Aboriginal and non-Aboriginal adolescents, physical activity levels were similarly low but some correlates differed by Aboriginality (**Chapter 3**). Aboriginal girls were less active than boys, as were those whose mothers were unemployed. In **Chapter 4,** serial physical activity declines were found in a population of Aboriginal and non-Aboriginal young people over five years, but not across all seasons, settings and types. **Chapter 5**, identifies 110 programs that aimed to increase physical activity for health or broader social outcomes. Around half were found to collect process or impact evaluation data but this is underrepresented in the scientific literature. In **Chapter 6**, perceived impacts of Indigenous Marathon Program were the adoption of running and broader healthy lifestyle factors in a remote community with a

high initial level of community readiness. Barriers to running were both personal, cultural and environmental.

Conclusion

The findings from this thesis make a novel contribution to building an evidence base of associations between physical activity and the health of Aboriginal and Torres Strait Islander people. A number of factors associated with physical activity in adults and children are unique to Aboriginal and Torres Strait Islanders populations; other factors are similar to those experienced by mainstream populations. This thesis also provides an inventory of physical activity programs for Aboriginal and Torres Strait Islander people, and examines one community program in detail with recommendations for future actions. It is vitally important that physical activity programs that aim to improve health or social outcomes can determine their value through evaluation.

Abbreviations

6 MWT	6 min walk test
ABS	Australian Bureau of Statistics
ACCHO	Aboriginal Community Control Health Organisation
AFL	Australian Football League
AIHW	Australian Institute of Health and Welfare
AMS	Aboriginal Medical Service
BMI	Body Mass Index
BP	Blood pressure
CI	Confidence interval
CVD	Cardiovascular disease
GP	General Practitioner
HbA1c	Glycosylated hemoglobin
IMP	Indigenous Marathon Program
MET	Metabolic equivalent
MRDPP	Many Rivers Diabetes Prevention Project
NCD	Non-communicable disease
NHMRC	National Health and Medical Research Council
NPA	Northern Peninsula Area
NSW	New South Wales
NT	Northern Territory
OR	Odds ratio
Qld	Queensland
SA	South Australia
SEEF	Social Economic and Environmental Factor; a sub-study of the 45 & Up Study

SD	Standard deviation
Tas	Tasmania
T2DM	type 2 diabetes mellitus
Vic	Victoria
WA	Western Australia
WC	Waist circumference
WHO	World Health Organization

Chapter 1

Introduction

1 Thesis overview

This thesis is about physical activity among Aboriginal and Torres Strait Islander people in Australia. The introductory chapter (**Chapter 1**) outlines the background and rationale for this research from a public health perspective. Firstly, the Aboriginal and Torres Strait Islander population, current health status, and the historical context of Aboriginal and Torres Strait Islander health are described. Next, physical activity is defined as a behavioural risk factor for non-communicable diseases and its benefits described. Background material on promotional strategies to increase population levels of physical activity is also provided. Subsequently, previous research on physical activity prevalence and descriptive epidemiology among Aboriginal and Torres Strait Islander people and program evaluation specific to this population group are outlined. Finally, the overall aims and objectives of this thesis are described and how these are addressed through the following thesis chapters which link together to form a program of research.

The following five chapters focus on original research on physical activity prevalence, correlates and interventions among Aboriginal and Torres Strait Islander populations. The next two chapters present new cross-sectional associations and trends between physical activity and other health and broader lifestyle factors among Aboriginal and Torres Strait Islander adults and children. **Chapter 2** examines physical activity, healthy lifestyle behaviours, neighbourhood environment characteristics and social support among adults. **Chapter 3** describes physical activity patterns and correlates among adolescents. **Chapter 4** explores age related declines in physical activity among Aboriginal and non-Aboriginal young people. The next two chapters focus on physical activity programs and their evaluation. **Chapter 5** presents an inventory of physical activity programs targeting Aboriginal and Torres Strait Islander people in Australia and describes their characteristics. **Chapter 6** examines health and community impacts in a pilot study of the Indigenous Marathon Program in a remote Torres Strait island community.

Finally, **Chapter 7** provides a summary of the main findings from this thesis and discusses these in the context of relevant literature on physical activity and Aboriginal and Torres Strait Islander health. The strengths and limitations of the findings are discussed, including how each study meets the National Health and Medical Research Council (NHMRC) principles of Improving the Health of Aboriginal and Torres Strait Islander People through Research (1). Future possible epidemiological and intervention evaluation research directions arising from this thesis are outlined.

A note on terminology:

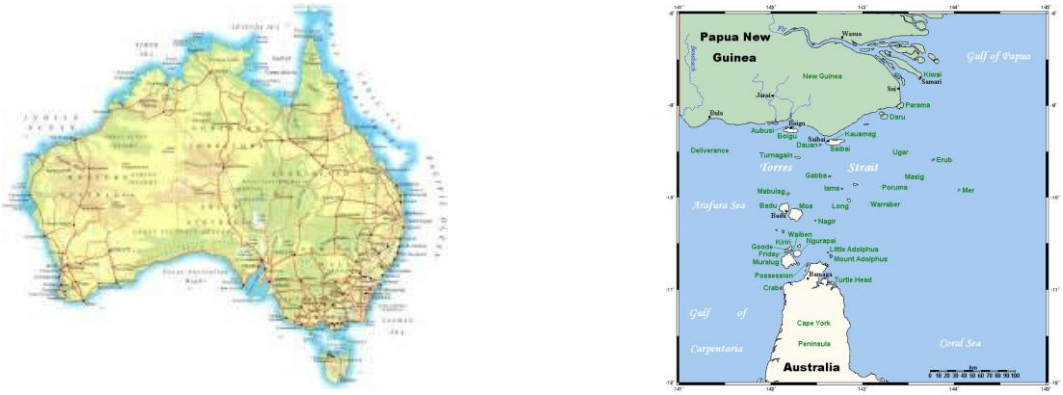
Australian Aboriginal and Torres Strait Islander people are often referred to as Indigenous Australians. For the purposes of this thesis, the term 'Aboriginal and Torres Strait Islander' will be used consistently except when referring to a study, publication, policy, program or entity that has itself used the term 'Indigenous'. The term 'Aboriginal' will be used when describing populations of Aboriginal people only or where the population of Aboriginal relative to Torres Strait Islander people is higher than for Australia as a whole. The term 'Torres Strait Islanders' will be used when describing populations of Torres Strait Islander people only. Where different studies within the thesis use different terminology (e.g. Indigenous and Aboriginal) but are being discussed collectively, the term 'Indigenous' will be used for consistency.

2 The health of Aboriginal and Torres Strait Islander people in Australia

2.1 Introduction

The Indigenous people of Australia comprise two groups: Aboriginal Australians and Torres Strait Islanders (2). Aboriginal Australians are indigenous to mainland Australia and Tasmania (Tas). The Torres Strait contains over 274 islands, 17 of which are inhabited, and is situated in north Queensland (Qld), between the tip of Cape York and Papua New Guinea. Torres Strait Islanders are distinct to Aboriginal Australians and are culturally and genetically Melanesian people.

Figure 1: Maps of Australia and the Torres Strait. Source: Wikipedia, cited 2017 (2)



Australian Census data estimates the number of Aboriginal and Torres Strait Islander people at 786,689 in 2011 or 3.3% of the total Australian population in 2016 (3). This is an increase from the 2011 Census when the estimated number was 699,736 (3% of the total Australian population). Of this 3.3%, 606,200 (90%) identified as being of Aboriginal origin only, 38,100 (6%) were of Torres Strait Islander origin only, and 25,600 (4%) were of both Aboriginal and Torres Strait Islander origin. Almost 80% of Aboriginal and Torres Strait Islander people live in regional and metropolitan areas (4, 5) and while just 14% live in very remote areas (with the remaining 6% in remote areas), they comprise 45% of people living in these areas. The largest populations reside in New South Wales (NSW) at 208,500 people, followed by Qld at 189,000 people and the Australian Capital Territory (ACT) has the smallest population of Aboriginal and Torres Strait Islander people, 6,200 people. The state/territory with the highest proportion of Aboriginal and Torres Strait Islander people is the Northern Territory (NT) at 30% of the total population of the territory. The median age of the Aboriginal and Torres Strait Islander population is 21.8 years, compared to 37.6 years for the non-Indigenous population.

The life expectancy of Aboriginal and Torres Strait Islander people is at least 10 years lower than non-Indigenous Australians (6). In 2008, a 25 year political commitment to Closing the Gap was made through the establishment of seven targets and their yearly reporting (6). However, only modest progress has been achieved over almost a decade. The ninth annual report shows that only one of the seven indicators, Year 12 attainment rates, is on target with an additional indicator, access to early childhood educational, potentially on track. Targets to close or reduce the gap on the remaining targets including infant mortality, education and employment and overall life expectancy are not being met (6).

2.2 Historical context

The current poor health status of Aboriginal and Torres Strait Islander people can be attributed to social inequalities experienced over time (7). This includes intergenerational trauma related to colonisation and subsequent dispossession, poor treatment, exploitation and cultural fragmentation (8). Severe declines in populations and introduced communicable diseases also had a substantial impact on the health and welfare of Australia's first inhabitants (9).

This thesis is about the physical activity of Aboriginal and Torres Strait Islander people. Traditional active hunter-gatherer lifestyles that had existed for tens of thousands of years were forever disrupted by the dispossession associated with European colonisation that commenced over 200 years ago (10). This dispossession continued to occur across Australia during the 19th and 20th centuries and as a consequence, physical activity became a separate Westernised concept (11). While these health and social factors are historical in origin, they continue to have an influence today where health behaviours like physical activity are viewed as an individual pastime for individual benefit, rather than for collective, culturally relevant family or community benefit (12).

2.3 Factors contributing to Aboriginal and Torres Strait Islander health

A wide range of factors have contributed to the health of Aboriginal and Torres Strait Islander people. Indigenous views of health are interpreted differently to those of Western society; more holistically, compared to the mere absence of disease or presence of good physical health and encompassing life, land, environment, physical body, community, relationships and customary law (13). Aboriginal and Torres Strait Islander models of health consider social and spiritual factors to be main causes of illness (14). Factors contributing to Aboriginal and Torres Strait Islander health and the disparities that exist when compared to the non-Indigenous population can be attributed to a combination of general social determinants, as well as Indigenous-specific elements (15).

Marmot describes how broad approaches targeting social determinants of health including housing, education and access to health care are necessary to improve the health of Indigenous Australians (16). He suggests social disparities experienced by Aboriginal and Torres Strait Islander people are due to two factors. The first factor is broad social disadvantage experienced by low socio-economic individuals in mainstream society, which he has also investigated extensively (17). The second factor is the marginalised relationship of Indigenous Australians to mainstream society. This marginalisation creates additional barriers to achieving the six domains of social determinants necessary for good health, as outlined in Box 1.

Box 1: Social determinants recommendations from the Marmot Review (18)

1. Early child development
2. Education and skills development
3. Employment and working conditions
4. Minimum income for healthy living
5. Sustainable communities
6. A social-determinants approach to prevention

However, these two distinct factors are inter-connected as Aboriginal and Torres Strait Islander people are over-represented among low socio-economic groups and fare worse than non-Indigenous Australians across the three key measures of education, employment and income (6, 19). Specifically, they experience lower levels of educational attainment and income and higher unemployment. These disparities exist despite socioeconomic outcomes for Aboriginal and Torres Strait Islander people varying dramatically across Australia (3) and it is likely that these three indicators will need to be tackled together in order to achieve improvements across any indicator.

This over-representation among low socioeconomic groups has occurred due to the combination of historical, social as well as cultural determinants of health experienced by Aboriginal and Torres Strait Islander people (15). Colonial policies that forced the removal of people from their ancestral lands and interfered with the continuation of local languages resulted in negative health and wellbeing impact given the loss of the traditional, holistic economy considered essential to health (20). In additional to loss of language and connection to the land, environmental deprivation, and spiritual, emotional, and mental disconnectedness are additional cultural determinants that have affected health since colonisation (15).

Racism has major negative impacts on the health of Aboriginal and Torres Strait Islander people and is a further impediment to effective health care but could be improved by addressing structural determinants of health inequities (21).

2.4 Non-communicable diseases and their modifiable risk factors

Much of this gap in life expectancy between Aboriginal and Torres Strait Islander people and the rest of the Australian population has been attributed to preventable NCDs (22) including cardiovascular disease, type 2 diabetes mellitus (T2DM), kidney disease and cancer by the AIHW. Rates of these NCDs are considerably higher among Aboriginal and Torres Strait Islander people relative to the Australian population as a whole. Evidence from large, representative samples in both NSW and Victoria (Vic) have established that the social determinants of health described above are strongly in turn associated with NCD disparities.

Data from the 2008 Victorian Population Health Survey (23) found higher levels of self-rated 'fair' or 'poor' health, cancer, depression and anxiety, and asthma among Aboriginal respondents compared to non-Aboriginal respondents. In this cross-sectional study, Aboriginal Victorians (n=339) had a higher prevalence of psychosocial risk factors, lower SES, lower social capital and a higher prevalence of lifestyle risk factors. Cultural experiences have also been identified as contributing to the gap in diabetes rates between Aboriginal and non-Aboriginal people in NSW. While differences in BMI and education accounted for much of the gap, as well as onset at younger age, psychological distress from family removal appeared to contribute to the increased risk in the Aboriginal population. (24).

The 45 & Up Study is the largest cohort study in the southern hemisphere of over 250,000 mid-older age adults at baseline residing in NSW (25). This population sample included 1985 Aboriginal (and/or Torres Strait Islander) participants which is comparatively large for epidemiological studies of Aboriginal health. It therefore allowed for the quantification of a number of health factors and comparisons between Aboriginal and non-Aboriginal participants where such data has not previously existed. The 45 & Up study demonstrated a higher diagnosis of medical conditions among Aboriginal, compared to non-Aboriginal, participants with the strongest associations for T2DM (OR=2.1, 95% CI 1.8-2.4), depression (OR=1.6, 95% CI 1.4-1.8) and stroke (OR=1.8, 95% CI=1.4-2.3) (26). Other indicators associated with disadvantage were also higher among Aboriginal participants: smoking (2.4, 2.0-2.8); obesity (2.1, 1.8-2.5); having care-giving responsibilities (1.8, 1.5-2.2); major physical disability (2.6, 2.2-3.1); severe physical functional limitation (2.9, 2.4-3.4) and very high levels of psychological distress (2.4, 2.0-3.0).

Disparities in the social determinants of health were also observed; after age-and sex-adjustment, Aboriginal participants had lower levels of formal educational qualifications (OR = 6.2, 95% CI 5.3-7.3), lower income (higher odds < $20,000/year versus $70,000/year (5.8, 5.0-6.9)) and higher levels of unemployment (3.7, 2.9-4.6). Socioeconomic factors including income and education could not fully explain the health differences between Aboriginal and non-Aboriginal adults.

In the Torres Strait, lifestyle-related chronic disease and risk factor prevalence was examined among 592 adults from 9 communities (27). There were high rates of overweight (30%), obesity (51%), abdominal obesity (70%) and T2DM (26%), hypercholesterolaemia (33%), albuminuria (28%), hypertension (32%) and smoking (45%). Only 8.5% of men and 6.5% of women were free of any cardiovascular risk factors.

Among Aboriginal and Torres Islander children, rates of T2DM are higher than that of non-Indigenous children. Prevalence data is limited (28) but exists for some Australian states. In a prospective population-based incidence study in NSW, 22% of 128 incident cases of T2DM were of Indigenous Australians (incidence rate ratio, 6.1; 95% CI, 3.9–9.7; P < 0.001) (29). In WA, state level hospital diabetes unit data showed an increase in type 2 diabetes in children and adolescents between 1990 and 2002 with particularly high rates among Indigenous children where 23 of 43 patients were of Indigenous origin (30). In response to these higher rates among Indigenous compared to non-Indigenous children, physical activity has been a specific recommended lifestyle modification strategy in the prevention of T2DM (31).

In the 2011 Australian Burden of Disease Study (32), the disease groups causing the most burden among Indigenous Australians were mental and substance use disorders, injuries, cardiovascular diseases, cancer and respiratory diseases. Overall, the total burden of disease experienced by Indigenous Australians was 2.3 times higher than the rate among non-Indigenous Australians, using the disability-adjusted-life-year or DALY measure. Chronic diseases accounted for almost two-thirds (64%) of the total disease burden and were responsible for 70% of the gap in disease burden between Indigenous and non-Indigenous Australians. Specifically, cardiovascular diseases accounted for 19% of the gap, mental & substance use disorders accounted for 14% of the gap and cancer for 9% of the gap. Differences across the four jurisdictions that were sampled were reported where the NT and WA had higher rates of Indigenous burden of disease than NSW and Qld. There were inequalities in the burden of disease according to remoteness where remote and very remote areas had higher rates than non-remote areas. The study calculated that over a third of the overall disease burden experienced by Indigenous Australians could be prevented by removing exposure to risk factors such as tobacco and alcohol use, high body mass, physical inactivity and high BP. Since the previous report using data from 2003, there was a 5% reduction in the

rate of total burden of disease among Indigenous people; that is the number of years of healthy life lost per person. This reduction was attributed to decreases in the rate of the fatal burden (11%) and by preventing or delaying deaths from particular diseases or injuries, including cardiovascular diseases. However, during this time there was a 4% increase in the rate of non-fatal burden, which is the impact of living with poor health. A key reason for this non-fatal burden increase was increases in people living with chronic diseases. Physical inactivity was identified as the 4th leading contributing risk factor to the burden of disease among Aboriginal and Torres Strait Islander people, accounting for 6% of the total burden (32). Each of the categories of NCDs described above can be prevented by participation in regular physical activity, which can also assist in the management of these NCDs (33).

The Burden of Disease Study acknowledged that social determinants cannot be adequately described within the Burden of Disease framework due to the complexity and multi-directional nature of the relationships between the social determinants of health and health status. Other estimates of the exact contribution of social determinants on the burden of disease among Aboriginal and Torres Strait Islander people, however, are thought to range from between one third and one half (34, 35). A further cause of the health gap between Aboriginal and Torres Strait Islander people and non-Indigenous Australians is poorer access to health services (36) and inadequate government funding for specific health services that are more accessible and acceptable to Indigenous people (37).

3 Physical activity, sport and health

This section describes the health and broader benefits of physical activity and sport, using evidence from epidemiological and intervention studies.

3.1 Definitions

Physical activity is defined as '*any skeletal body movement resulting in energy expenditure*' (38).

Exercise which can be described as '*a subset of physical activity that is planned, structured, and repetitive and has as a final or an intermediate objective the improvement or maintenance of physical fitness*' (38).

Sport is a specific organized form of physical activity or exercise and has been defined as '*all forms of physical activity which, through casual or organised participation, aim at expressing or improving physical fitness and mental well-being, forming social relationships or obtaining results in competition at all levels*' (39).

Energy expenditure arising from physical activity is typically quantified using metabolic equivalents (MET) values where one MET is the energy level expended from sitting quietly (40). Three physical activity intensity categories have been established: light (>1.5-<3 METs); moderate (3-<6 METs); and vigorous (≥6 METs). Examples of some common activities are walking (3 METs (2.5 mph, firm surface)), household chores (2 METs) and jogging, general (7 METs) (40). These MET levels apply to the adult population. A specific compendium of energy expenditures has also been developed for youth aged 6-18 years (41). It contains over 200 common activities of youth and their associated MET intensity levels, 35% of which are unique to the youth compendium.

3.2 Benefits of physical activity

There are numerous physical and mental health benefits of regular physical activity participation. Along with smoking, physical activity is considered one of the key modifiable risk factors for NCDs. Epidemiological evidence has established clear benefits between physical activity and health. Worldwide recent data estimate that physical inactivity contributes to 6% of the burden of disease from coronary heart disease, 7% of T2DM, 10% of breast cancer, and 10% of colon cancer (33). There is also strong evidence that physical activity is associated with reduced rates of all-cause mortality, high BP, stroke, metabolic syndrome, depression and falling. Further, regular physical activity participation is linked to increased cardiorespiratory and muscular fitness, improved bone health and increased functional health

and cognitive function (33) (42). Through its role in energy expenditure, physical activity also makes an important contribution to the prevention and management of overweight and obesity (43) which are additional risk factors for NCDs (44).

The benefits of physical activity have also been established for aspects of mental health. There is clear cross-sectional evidence linking higher physical activity levels to reduced rates of depression (45) and physical activity is known to be an effective intervention in the treatment of depression (46). Longitudinal evidence has shown, bidirectionaly, that depression leads to subsequent reduced rates of physical activity (47) and a recent review concluded that physical activity reduces the risk of future depression (48). Emerging cross-sectional evidence has demonstrated positive associations between physical inactivity and anxiety (49) and physical activity and happiness (50), using data from large, international populations.

For children, similar benefits from physical activity participation in improving a similar range of health indicators including cardiorespiratory and muscular fitness, bone health, and cardiovascular and metabolic health biomarkers are evident (51, 52). There is also evidence of a relationship between fitness and academic achievement in children (53). Physical activity in childhood is believed to track into adulthood (54) therefore establishing regular physical activity participation among young people is important for future adult health. Regarding mental health, a review of reviews concluded that there is some evidence of the beneficial effect of physical activity in reducing anxiety and improving self-esteem among children as well as some evidence of improved cognitive performance and academic achievement (55).

3.3 Burden of physical inactivity

The 2013 Global Burden of Disease Study ranked physical inactivity as the 5th highest risk factor among the adult population, responsible for 5% of the total disease and ill health burden (56). Physical inactivity causes 9% of premature mortality, or more than 5.3 million of the 57 million deaths worldwide in 2008 (57) as well as the morbidity estimates described above (33). The economic burden of physical inactivity is also a major concern as it is estimated to have cost health-care systems worldwide $53.8 billion during 2013 (58). In response, the WHO Global Action Plan for the Prevention and Control of NCDs 2013-2020 has set national targets of 10% reduction in physical inactivity by 2025 (59).

The Australian 2011 Burden of Disease Study ranked physical inactivity as the 5th highest risk factor among the adult population, responsible for 5% of the total disease and ill health burden (60). Much of this burden results from preventable, non-communicable diseases (NCDs) such as CVD, T2DM and

cancer (61). Action to reduce the prevalence of NCDs is an urgent priority as over 36 million people die from NCDs annually, which equates to 63% of deaths globally, including over 14 million premature deaths of adults between the ages of 30 and 70 years (61).

3.4 Physical activity measurement

The accuracy of physical activity measurement in epidemiology, surveillance, correlates & determinants and evaluation is important to establish the benefits of physical activity (62). Physical activity is typically measured through self-report or objective measures. Self-report measures are often described as 'subjective' as they ask an individual to report their perspective or behaviour of interest. The measurement properties of both these approaches should be established through determining their reliability and validity.

Self-report measures are widely used and typically ask respondents to recall their physical activity over a specified time period (63). Since 2000, the Active Australia Survey has been used consistently to measure the (self-reported) physical activity of adults through multiple domains (e.g. leisure, transport), in both government data collection and academic studies (64). A study measured the agreement of the Active Australia survey in relation to three other questionnaires: the short International Physical Activity Questionnaire (IPAQ) (65); the physical activity items in the U.S. Behavioral Risk Factor Surveillance System; and the (Australian) National Health Survey used by the ABS (66). There was a high percent agreement scores for classifying adults as 'active', 'insufficiently active' or 'sedentary' consistently across the four surveys, e.g. 79% agreement between the Active Australia survey and the IPAQ (67). This study also measured reliability of the four measures; the kappa score for Active Australia was 0.52 which was classified as acceptable. These scores can be considered acceptable as the measurement of physical activity may vary over time due to actual variation in activity, rather than measurement issues (169).

The physical activity of children has been measured in many countries through the reliable and valid Health Behaviour of School Children (HBSC) survey which measures the frequency and duration of out of school activity only (68). Test-retest reliability agreement at two time points had a percent agreement between 67% and 85% which can be considered acceptable and at least partial criterion validity against fitness was established. The Adolescent Physical Activity Recall Questionnaire asks this population group about their organised and non-organised activity in multiple domains and has also demonstrated acceptable to good reliability and acceptable validity. The percent agreement scores ranged from 67% to 90%, kappa scores ranged from 0.25-0.74 and validity correlations ranged from 0.14-0.39 (69).

There are both advantages and disadvantages of self-report measures. Advantages include the low cost, ease and speed of administration of this method. Disadvantages include varying levels of reliability and validity and other variations related to gender and level of activity measured (70). Objective ways to measure physical activity have also been commonly used in research studies; typically pedometers (71) and accelerometers (72). While objective measures often have better reliability and validity than self-report measures (73), there is debate around their suitability in large surveillance studies (74). Selecting an appropriate physical activity measure depends on a range of factors including characteristics and preferences of the study population and costs and other logistical issues.

3.5 Physical activity recommendations

Specific recommended levels of physical activity have been developed as guidance for populations regarding the amount of physical activity required for health benefits (75). Global physical activity recommendations have been developed by the WHO for three age groups: 5–17 years old; 18–64 years old; and 65 years old and above (42). In brief, children and young people aged 5–17 years old are advised to accumulate at least 60 minutes of moderate to vigorous-intensity physical activity daily. Adults (aged 18–64 years old; and 65 years old and above) should do at least 150 minutes of moderate-intensity aerobic physical activity, or at least 75 minutes of vigorous-intensity aerobic physical activity, or an equivalent combination of moderate- and vigorous-intensity activity throughout the week.

In Australia, there are specific national government recommended levels of physical activity for health benefits, for both adults and children. These recommendations are also commonly described as guidelines and the two terms are used by the government interchangeably.

Australia's Physical Activity & Sedentary Behaviour Guidelines for Adults (18-64 years) (76) are outlined in Box 2:

Box 2: Australia's Physical Activity & Sedentary Behaviour Guidelines for Adults

Physical Activity Guidelines

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.

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

Accumulate 150 to 300 minutes (2 ½ to 5 hours) of moderate intensity physical activity or 75 to 150 minutes (1 ¼ to 2 ½ hours) of vigorous intensity physical activity, or an equivalent combination of both moderate and vigorous activities, each week.

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

Sedentary Behaviour Guidelines

Minimise the amount of time spent in prolonged sitting.

Break up long periods of sitting as often as possible.

Australia's Physical Activity & Sedentary Behaviour Guidelines for Children 5-12 years (77) and for young people 13-18 years (78) provide the same advice and are outlined in Box 3:

Box 3: Australia's Physical Activity & Sedentary Behaviour Guidelines for Children 5-12 years and for young people 13-18 years

Physical Activity

For health benefits, accumulate at least 60 minutes of moderate to vigorous intensity physical activity every day.

Physical activity should include a variety of aerobic activities, including some vigorous intensity activity.

On at least three days per week, engage in activities that strengthen muscle and bone.

To achieve additional health benefits, engage in more activity – up to several hours per day.

Sedentary Behaviour

To reduce health risks, minimise the time they spend being sedentary every day. To achieve this:

Limit use of electronic media for entertainment (e.g. television, seated electronic games and computer use) to no more than two hours a day – lower levels are associated with reduced health risks;

Break up long periods of sitting as often as possible.

There are also detailed Physical Activity Recommendations for Older Australians (65 years and older) (79) and National Physical Activity Recommendations for Children 0-5 years (80).

3.5 Physical activity prevalence

Using a methodology consistent with the WHO Global Health Observatory (81) The 2016 Lancet Physical Activity Series calculated the worldwide prevalence of physical *inactivity* among adults at 23.3%, using data from 146 countries. This methodology defined physical inactivity as not achieving 150 minutes of moderate-intensity activity or 75 minutes of vigorous-intensity activity per week, or an equivalent combination, regardless of the weekly frequency, consistent with not meeting global recommendations. Of these 146 countries, 137 had higher physical inactivity rates among women compared to men (82).

In Australia, 2014/15 data from the ABS (83) found that 55.5% of adults achieved the national physical activity recommendations of 150-300 minutes of moderate or 75-150 minutes of vigorous physical activity, or an equivalent combination of both, per week. There were higher rates among males than females (57.7% versus 53.3%). Only one in four (24.9%) adults aged 65 years and over did at least 30 minutes of exercise on five or more days in the previous week (83). The most recent data for children from 2011/12 reveals only 19% of children aged 5-17 years were achieving the national physical activity recommendations for this age group of at least an hour a day of MVPA (66). Physical activity declines during adolescence (84) and there is emerging evidence that this decline commences at younger ages (85).

3.6 Physical activity promotion

The WHO Global Action Plan for the Prevention and Control of NCDs 2013-2020 (59) provides a number of policy options for promoting physical activity. These include the provision of built and natural environments to support physical activity in schools, universities, workplaces, clinics and hospitals, and in the wider community, especially through active transport. A further option is to support and encourage physical activity for all ages and abilities. In 2010, the Toronto Charter for Physical Activity was launched to advocate for increased physical activity promotion by governments and other relevant agencies. The Charter outlines the direct health benefits and co benefits of investing in policies and programs to increase levels of physical activity. An accompaniment to the Charter was a document on Investments that Work for Physical Activity (86), outlined in Box 4:

Box 4: 7 Best Investments for Physical Activity

1. 'Whole-of-school' programs;
2. Transport policies and systems that prioritise walking, cycling and public transport;
3. Urban design regulations and infrastructure that provides for equitable and safe access for recreational physical activity, and recreational and transport-related walking and cycling across the life course;
4. Physical activity and NCD prevention integrated into primary health care systems;
5. Public education, including mass media to raise awareness and change social norms on physical activity;
6. Community-wide programs involving multiple settings and sectors and that mobilize and integrate community engagement and resources;
7. Sports systems and programs that promote 'sport for all' and encourage participation across the life span.

The evaluation of initiatives aimed at increasing physical activity, to generate evidence effective and cost-effective actions is also recommended.

One of the main policy responses to the deleterious effects of physical inactivity has been to deliver interventions to increase physical activity levels for health benefits (57). Physical activity interventions have demonstrated effectiveness across a range of settings and delivery modes (87). These include the workplace (88) and health settings (89) although there is insufficient evidence in support of broad community-based interventions (90). Increasingly, there is also evidence of favorable effects of interventions delivered through website and remote-based platforms (91). However, while physical activity interventions often demonstrate short term efficacy, such as the immediate post-intervention period or after a short follow-up (e.g. 12 weeks), sustained population level behaviour change can be hard to elucidate (90).

For children, high level review evidence of the effects of school-based programs in increasing physical activity and fitness have demonstrated only a small impact (92). Physical activity levels during physical education classes are typically an insufficient means of achieving physical activity recommendations (93). There is also some encouraging evidence of the role of physical activity and sport programs as alternative educational programs for disaffected youth (94) and in crime prevention (95). However, there have also been criticisms of the aspirational claims made around the role of sport in achieving broader social

outcomes, in the absence of empirical evidence (96). As with adult interventions, achieving long term behaviour change among child populations that also tracks into adulthood is challenging (54). Reviews of intervention studies often conclude that high quality study designs are rare and impact the establishment of intervention effectiveness, in both adult and child population (97).

3.7 Physical activity correlates and determinants

Physical activity participation is associated with many socio-demographic factors and behaviours. The identification of these associations is important as they provide potential avenues through which to increase physical activity. Bauman et al. have defined the terms relating to cross-sectional associations as 'correlates' and relational factors for exposures identified in longitudinal studies as 'determinants' (98).

Among adults, there are many individual-level factors correlated with physical activity such as age, gender and socioeconomic status. Older adults are less active than younger adults (99), females are less active than males (82) and those experiencing social disadvantage across indicators of income and education are less active than their more advantaged counterparts (100). Self-efficacy or confidence to be active is correlated with actual activity levels as is an individual's past physical activity (99). Beyond these individual-level correlates, physical activity is determined by a wide range of factors across the ecological spectrum (101). Ecological models of physical activity correlates typically comprise aspects of the social and physical environment, policy and global levels as well as their interactions with individual-level factors (102). Environmental correlates of transport-related activity are walkability and street connectivity and total physical activity is correlated with recreation facilities and locations, transportation environment, and aesthetics (103). In a recent review published in the Lancet, a number of (longitudinal) determinants of physical activity were identified (102) from previous reviews. These were health status and self-efficacy, past physical activity in adulthood, intention to be active, (low) stress levels and planning. Physical and psychological outcome realisations determined maintenance, but not initiation, of physical activity.

Correlates and determinants of physical activity among children differ somewhat to those of adults. In a review of 60 studies of correlates among children aged 4-12 years, published in 2007, gender (male), self-efficacy, parental physical activity (among boys), and parental support were positively associated with physical activity (104). In the same review, among adolescents aged 13-18 years, physical activity was also positively associated with being male, parental education and self-efficacy as well as attitude, goal orientation/motivation, physical education/school sports, family influences, and friend support. In a

review of the neighbourhood environment and physical activity among youth published in 2011, correlates among children were walkability, traffic speed/volume, access/proximity to recreation facilities, land-use mix, and residential density. Correlates among adolescents were land-use mix and residential density.

In a review published in 2011 of 30 studies of (longitudinal) determinants of physical activity (105), intention to be active was found to be a determinant of children's physical activity. Determinants of higher activity among adolescents were being an older adolescent, of white ethnicity and planning to be active. The Lancet review of previous reviews (102) also established a number of determinants, self-efficacy and previous physical activity among children and adolescents and social support for physical activity among adolescents only.

Most of this evidence comes from studies undertaken in high income countries; relatively less is known about physical activity correlates and determinants among people from low and middle income countries (82, 102) or from disadvantaged population groups such as Indigenous people.

4 Physical activity and Aboriginal and Torres Strait Islander people

This section describes the literature to date on physical activity among Aboriginal and Torres Strait Islander people across three categories: prevalence and descriptive epidemiology and correlational associations where they exist; intervention and evaluation research; and other studies on physical activity and sport, including qualitative research. It is prefaced with a description of the historical and current context of physical activity among Aboriginal and Torres Strait Islander people and the physical activity of Indigenous people in New Zealand, Canada and the U.S.

4.1 Historical and current context

Historically, physical activity in the lives of Aboriginal and Torres Strait Islander people occurred as active hunter-gatherer lifestyles in Australia during the tens of thousands of years prior to European colonisation (10) and in other countries with Indigenous populations such as New Zealand (106) and Canada (107). Daily physical activity was necessary to find renewable food and resources, sustain the spiritual connection to country, and maintain familial and cultural practices (11). However, this traditional lifestyle was permanently disrupted with colonisation which first occurred in NSW and progressively displaced Aboriginal and Torres Strait Islander people and took over land for agriculture that was previously used for natural resource management (10) (108). Subsequently, physical activity became viewed by Aboriginal and Torres Strait Islander people as a separated, Westernised concept rather than a traditional activity (11) and increasingly sedentary lifestyles became common. This occurred at different time periods in different locations across Australia over the last 200 years and has resulted in different understanding of physical activity among Aboriginal and Torres Strait Islander people compared to the non-Indigenous perspective as a separate, measurable concept (12). Cultural perspectives therefore need to be carefully considered with regard to the current context of physical activity among Aboriginal and Torres Strait Islander people. In both historical and current times, physical activity and sport have played an important role in the lives of Aboriginal and Torres Strait Islander people (109) (110).

Documented evidence of the historical importance of physical and sporting activities in the form of Traditional Indigenous Games (TIG) for cultural, social and historical experiences of Indigenous communities exists and is described by Edwards (111). He uses the definition of those which include all aspects of traditional and contemporary play cultures associated with Aboriginal and Torres Strait Islander cultures and identifiable communities, and are generally accepted as an adequate reflection of their cultural heritage and social identity. However, he concludes that few pre-colonial traditional games are still played, and therefore information about them is limited. Despite this, it is established that the

modern game of AFL may have some of its roots in the traditional Aboriginal ball game of *Marn Grook* (112).

In the 2011 Australian Burden of Disease Study, physical inactivity was identified as the 4th leading contributing risk factor to the burden of disease among Aboriginal and Torres Strait Islander people (32), accounting for 6% of the burden with only smoking (12%), alcohol use and high body mass (both 8%) ranked higher. Data for Australia overall identified physical inactivity one place lower as the 5th highest risk factor, responsible for 5% of the total disease and ill health burden. In the corresponding previous report using data from 2003 (113), physical inactivity was identified as the 3rd leading contributing risk factor to the burden of disease among Aboriginal and Torres Strait Islander people and the 4th contributing risk factor in Australia overall. In 2003, physical inactivity was responsible for 7% of the total Indigenous burden, behind only smoking and high blood pressure.

Physical activity prevalence data for the Aboriginal and Torres Strait Islander population is described in the section below. Despite the well-established benefits of physical activity in reducing the risk of NCDs (32), the evidence base specific to Aboriginal and Torres Strait Islander populations is relatively underdeveloped. However, epidemiological evidence of the benefits of physical activity among low and middle income countries has shown that benefits do not differ across population groups (114). Nor do these benefits differ to those that have been demonstrated among high income country populations. Therefore, specific physiological benefits of physical activity do not necessarily require investigation among population groups such as Aboriginal and Torres Strait Islander people. Yet while there is a considerable body of literature about the determinants and correlates of physical activity among mainstream populations, little is known that is specific to Aboriginal and Torres Strait Islander people and whether these may differ. There is also a lack of empirical evidence of the effectiveness of interventions which promote physical activity to Aboriginal and Torres Strait Islander people and recommendations of effective strategies to increase physical activity among this population group.

4.2 Physical activity prevalence and descriptive epidemiology

Data on the physical activity of Aboriginal and Torres Strait Islander people has been collected in population level surveys as well as epidemiological studies and smaller studies of specific populations.

4.2.1 Population-level data

The ABS has published data on the physical activity levels of Aboriginal and Torres Strait Islander adults and children (115). Data from the ABS demonstrates that Aboriginal and Torres Strait Islander children are typically more physically active than non-Indigenous children but the opposite is found for adults. This is an interesting paradox and cannot be currently explained by data from the ABS or other sources but could relate to steeper declines among adolescence which are well-established (116). Historical, social and/or cultural reasons may account for why these declines may be more pronounced among Aboriginal and Torres Strait Islander people.

Thirty-eight percent of 1170 Aboriginal and Torres Strait Islander adult participants were sufficiently active for health in 2012-13, doing at least 150 minutes of physical activity in five or more sessions over a seven day period in *non-remote* areas, defined as Major cities, Inner and Outer regional Australia (4). Overall, adults spent around one third the time on physical activity compared with children aged 5-17 years at 39 mins/day; 21 mins of which was walking for transport. Compared to non-Indigenous adults, after adjusting for age differences, they were less likely to be sufficiently active for health (rate ratio 0.8), less likely to be participating in any physical activity (rate ratio 0.9) and spent less time on sedentary behaviour for work, leisure, and travel (rate ratio 0.9). In a pedometer sub-study of 403 participants, adults recorded an average of 6,963 steps per day, with one in six (17%) meeting the recommended threshold of 10,000 steps (71) or more. In *remote* areas, defined as Remote and Very Remote (4), data were collected on the day before the interview only. Data from 3608 adults found 55% achieved sufficient physical activity for health.

Whelan & Wright (117) examined the associations between health services use and lifestyle choices of Indigenous and non-Indigenous Australians using self-report data from the ABS 2004 National Health Survey (118) and the 2004 National Aboriginal and Torres Strait Islander Health Survey (119). Analyses of data from 17,449 adults were undertaken: 2830 *non-remote* Indigenous adults; 1779 *remote* Indigenous adults; and 12,840 non-Indigenous adults. After adjustment for demographic, socio-economic and long term health conditions, they found that Indigenous Australians were more likely to make poorer lifestyle choices but also more likely to use health services than non-Indigenous Australians. *Non-remote* Indigenous were 5.7% less likely to undertake moderate exercise than the non-Indigenous and *Remote* Indigenous were 4.7% less likely to undertake moderate exercise than the *non-remote* Indigenous.

ABS Data from 2207 children aged 5-17 years in *non-remote* areas shows that almost one in two (48%) met the national physical activity recommendations (77, 78) with more than one in three (35%) of non-

Indigenous children reaching this level. In a pedometer sub-study, 125 participants recorded an average of 9,593 steps per day, with a quarter of children (25%) achieving the 12,000 steps threshold per day (120), on average. Data from children aged 2-4 was collected in *non-remote* areas from only 145 participants. This age group spent an average of 6.6 hours per day being physically active and more time outdoors than non-Indigenous children aged 2-4 years (3.5 hours compared to 2.8 hours). Data from 1489 children aged over 5 years in *remote* (4) areas showed that 86% of aged 5-14 year olds and 66% of 15-17 year olds did more than 60 minutes of physical activity (equating to the national recommendations) on the day before the interview. Data on non-Indigenous children in *remote* areas was not available for comparison.

Analyses of baseline data from the 45 & Up Study (25) found lower levels of 'sufficient physical exercise', defined as at least 150 min of physical activity in 5 or more sessions a week, among Aboriginal participants (64%) compared to non-Indigenous participants (75%). After adjusting for the socio-demographic factors of age, sex, income and education the adult Aboriginal participants also had a higher odds ratio of insufficient physical exercise (OR=1.4, 95% CI 1.3-1.6) relative to the non-Indigenous participants (26).

These data from the ABS and 45 & Up Study provide useful information on the physical activity of Aboriginal and Torres Strait Islander people from large, population representative samples. Associations between physical activity and other socio-demographic and health variables were not examined in the baseline analyses of the 45 & Up data (26). To date, the ABS has provided comparisons of physical activity levels by age and BMI only. In the non-remote adult sample, 31% of those who achieved the physical activity recommendations were obese, compared to obesity levels of 50% of those who did not achieve the recommendations. Time spent walking for transport reduced with increasing age. In the remote adult sample, physical activity decreased with increasing age and 65% of underweight and normal weight adults achieved the physical activity recommendation compared to only 51% of overweight and obese adults. Beyond these two data sources, little is known about the cross-sectional or longitudinal population level associations between physical activity and other socio-demographic and health variables among Aboriginal and Torres Strait Islander people.

4.2.2 Other adult studies

In 1998-2000, Li et al measured 7-day recall of physical activities of at least a moderate intensity and a 30 minute duration (121) as part of a broader health screening service in 1580 Aboriginal and 944 Torres Strait Islander people from 26 communities in north Qld (122). Physical activity levels were low among both populations; 20.0% of Aboriginal and 29.5% of Torres Strait Islander participants were active

enough according to WHO criteria doing moderate to vigorous physical activity for more than 30 minutes/day for 5 days in the week prior to the survey.

Another study in the Torres Strait published in 2002 examined CVD risk factors among 592 adults between 1993-97, which represented 50% of all eligible Torres Strait Islander people in the nine communities sampled (27). Participants were asked about their usual physical activity practices and were defined as being physically active if they achieved any physical activity vigorous enough to increase breathing rate at least three times a week for at least 20 minutes each time. This measure has been validated (123) and equated to meeting the physical activity recommendations at the time the study was conducted (75). Low levels of regular physical activity were reported for 48.7% of the overall sample and for almost half of the sample in all age and sex categories with the exception of young (15-34 year old) men who were significantly more likely to be active than were older men or younger women ($p<0.001$).

A study by Taylor et al. examined levels of physical activity and depression among 183 T2DM adult patients across five remote islands in the eastern Torres Strait region. Each additional hour of exercise, measured through 7-day recall of daily MVPA, was associated with a 0.34 decrease in depression score, measured through the Patient Health Questionnaire (PHQ)-9 ($\beta = –0.34$, 95% CI: –0.57–0.11, $P = 0.004$). Each one hour increase in screen time was associated with a 0.11 increase in depression score ($\beta = 0.11$, 95% CI: 0.07–0.16, $P < 0.001$) (124). However, these studies only assessed associations with depression so their causal significance should be treated with caution.

4.2.3 Other childhood studies

Physical activity and sedentary behaviour and their correlation with overweight/obesity was examined in 245 Aboriginal and 7607 non-Aboriginal children aged 5-16 years using data from the 2010 NSW Schools Physical Activity and Nutrition Survey (SPANS) (125). SPANS is a representative cross-sectional population surveillance survey which required children to self-report their physical activity through the NSW Population Child Health Survey (for Grades K/2/4 (126)) and the Adolescent Physical Activity Recall Survey (APARQ; for Grades 6/8/10 (69)). Their cardiorespiratory fitness was assessed by a 20-metre shuttle run test, their sedentary behaviour through the Adolescent Sedentary Activity Questionnaire and BMI was objectively measured. There were no statistically significant differences in the proportion of Aboriginal (45.0% for the younger, and 61.4% for the older, children) and non-Aboriginal children meeting the physical activity recommendations. There were also similarities in their fitness levels where 65.5% of Aboriginal children were adequately fit. However, Aboriginal children were more likely to exceed screen time recommendations on weekdays (but not weekends) compared to non-

Aboriginal children at 62.8% (OR 1.78 (1.32–2.39) after adjusting for sex, grade and SES.

In 2003, Valery et al. investigated cross-sectional physical activity patterns and obesity levels in 277 school-aged children (5-16 years old) in four Torres Strait islands (127) by asking how many days they did physical activity in the last week. BMI was derived from height and weight measures, indicating that almost half of the youth were overweight/obese (46%). In the last week, 47% and 53% had done physical activity on 0-3 and 4-7 days, respectively. This differed according to weight status in analyses adjusted for age, sex, physical activity and boarding school status where the overweight/obese youth were less likely to be inactive (OR = 2.50, 95% CI 1.44-4.34). Sixty one percent of the normal weight youth were active on 4-7 days compared to only 43% of the overweight/obese youth. Primary school aged children reported more days of activity than high school children ($p<0.001$) and girls reported fewer days of activity than boys.

Dalton et al. examined cross-sectional associations between self-reported sport participation and health outcomes among 639 15-19 year olds using data from the 2012 Mission Australia Youth Survey (128). Those who participated in sport were 3.5 times more likely to report good general health and 1.6 times more likely to have no probable serious mental illness. The authors advocate for the development of grassroots, evidence-based, well resourced, culturally sensitive, inclusive and community-led initiatives with input from youth.

4.2.4 Summary

Taken together, these studies depict physical activity prevalence among Aboriginal and Torres Strait Islander groups across Australia but vary widely in their methods, measures and populations. Physical activity levels of Aboriginal and Torres Strait Islander adults tend to be *lower* than that of non-Indigenous adults but physical activity levels of Aboriginal and Torres Strait Islander children tend to be *higher* than that of non-Indigenous children. Few studies document associations, either cross-sectional or longitudinal, with socio-demographic and health outcomes and causal inference cannot be established. So, there are substantial gaps in the literature of the epidemiology of physical activity participation among Aboriginal and Torres Strait Islander people. However, some overall conclusions from this literature can be made. Firstly, similar to mainstream populations, there is enough evidence to conclude that physical inactivity is associated with poor health outcomes, particularly chronic disease. Secondly, Aboriginal and Torres Strait Islander adults appear to be less active than non-Indigenous Australian adults but the reverse may be true for children.

4.3 Intervention and evaluation research

This section describes studies of physical activity interventions among Aboriginal and Torres Strait Islander people and their evaluation. Reviews and primary studies of physical activity and both health and social outcomes are described as well as other studies including investigations of barriers and enablers to physical activity. These studies have taken place in a variety of settings including the community, schools and health care, consistent with the settings based approach outlined in the Ottawa Charter for Health Promotion (129).

Modern day applications of TIG have shown mixed success. Parker et al. demonstrated TIG community organisation implementation and usage in two south-east Qld communities (130). Dinan Thompson studied the views of 12 grade 5-6 students who engaged in TIG through the curriculum and at a carnival in Far North Qld (131), specifically their understandings of TIG, perceptions of participating and cultural significance. The students described playing the games and participating in the carnival as a positive experience that resulted in enhanced cultural knowledge and cultural significance as a community social practice. Another study in Townsville, North Qld conducted a cluster randomised trial to investigate the effectiveness of TIG resources to improve physical activity and cultural connectedness among 167 primary school students (21.6% Indigenous) aged 9-12 years from six schools (132). Before and after the three month intervention period, students were asked about their type and frequency of physical activity and school activity questions on physical activity engaged in during breaks, through the validated Active-Ate Student Questionnaire (133). Cultural connectedness was defined as elements of social capital: shared vision, opportunity, gatherings and respect. However, there were no statistically significant improvements found in the two intervention or the two control groups in terms of physical activity levels or cultural connectedness.

4.3.1 Review evidence - interventions

Overall, little is known about the effectiveness of physical activity interventions for Aboriginal people. However, a number of reviews of the literature have been conducted, each of which are reviewed below.

A review by Shilton & Brown in 2004 (134) identified only one intervention study published in peer-reviewed literature since 1999 (135). A further study on the benefits of opening swimming pools in remote communities was also included (136). Additional initiatives operating at the time of the review were described but these did not present specific results.

A systematic review by Pressick et al. of Indigenous adults in Australia, Canada and New Zealand included three studies of Australian Aboriginal adults which examined the effectiveness of a subset of physical activity, group-based sport and exercise programs, published in 2015 (137). The review found that programs were effective in producing short to intermediate term health outcomes. The review included the Looma study (135) described previously and the results of two 12-week exercise programs (138) (139). These studies were classified as being of moderate quality using the McMasters University Guidelines and Appraisal Forms for Critical Review for Quantitative Research (140).

A third systematic review by Sushames et al., published in 2017, also focussed on Indigenous adults in Australia, Canada and New Zealand and included nine studies from Australia. Using the Quality Assessment Tool for Quantitative Studies (141), the overall quality of the Australian studies was poor in one study (135), moderate in nine (138, 139, 142-147) and none were classified as strong. Regarding population representativeness, eight studies were classified as weak due to not being representative of the target population and only one study (147) was classified as strong. Study sample sizes among the Australian studies ranged from n=10 to n=416. This review found no clear evidence that physical activity interventions significantly increased activity levels (measured through a mixture of self-report and objective measures) but did find positive effects from objectively measured fitness tests and health outcomes (148). These overall significant improvements in fitness, but not physical activity, are unusual and could be due to methodological inaccuracies in the self-report measures and unknown validity of these measures in Indigenous populations. Yet given the direct association between physical activity and fitness, if can be inferred that the studies demonstrating increases in fitness would usually lead to (or be associated with) increases in physical activity (149).

Details of the 10 intervention studies included in these three reviews and their findings are summarised in Table 1. Beneficial outcomes were found for key metabolic and health indicators such as reductions in weight and biomarkers. However, only four studies measured physical activity or fitness outcomes. Eight studies used pre-post designs and two used RCT or cluster RCT designs. While the latter designs are considered optimal for intervention studies (150) study designs should consider community views and preferences therefore alternative designs may be more feasible (1). One study was published in 1984 and another in 1999 but four were published within the last four years. Most of these ten studies examined the effects of structured physical activity programs among clinical populations of individuals with chronic disease or at risk of chronic disease, with sample sizes of less than 100. These are population sub-groups who benefit from physical activity, but studies of these sub-groups do not provide representative, population-wide intervention evidence. This leaves a gap in the literature of evidence of the effects of

community level interventions to increase physical activity among Aboriginal and Torres Strait Islander people.

Table 1: Summary of studies included in reviews of physical activity interventions among Aboriginal and Torres Strait Islander adults

Study title	**Year ***	**Review inclusion**	**Design**	**Participants**	**Intervention**	**Main findings****
Effectiveness of a community-directed 'healthy lifestyle' program in a remote Australian aboriginal community (135)	2000	Shilton & Brown, Pressick et al., Sushames et al.	Pre-post	N=49 (high-risk cohort)	Physical activity and diet program	↑ 2 year *physical activity*, associated with subsequent improvements in plasma glucose and triglycerides
Benefits of swimming pools in two remote Aboriginal communities in Western Australia: intervention study (136)	2003	Shilton & Brown	Pre-post	N=162 children aged < 17 years	Opening of community swimming pools	↓ prevalence of skin and ear infections at three 6-monthly intervals
Pragmatic randomised trial of a 12-week exercise and nutrition program for Aboriginal and Torres Strait Islander women: clinical results immediate post and 3 months follow-up (138)	2012	Pressick et al., Sushames et al.	RCT (waitlist control)	N=51 females (49 matched controls)	Structured exercise and nutrition program	↓ weight, BMI of -1.65 kg and -0.66 kg/m2 respectively (post-intervention T2) and -2.50 kg and -1.03 kg/m2 respectively (after 3 months T3). ↓ systolic and diastolic BP of -1.24 mmHg and -2.46 mmHg respectively at T2 and -4.09 mmHg and -2.17 mmHg respectively at T3.
A 12-week sports-based exercise programme for inactive Indigenous Australian men improved clinical risk factors associated with type 2 diabetes mellitus (139)	2015	Pressick et al., Sushames et al.	RCT	N=16 males (10 controls)	Sports-based exercise	↑ insulin sensitivity and ↓ insulin resistance, leptin, BMI, waist circumference and waist to hip ratio, ↑ in *fitness* (peak oxygen consumption)

Study title	Year	Review inclusion	Design	Participants	Intervention	Main findings*
Short term efficacy of a lifestyle intervention programme on cardiovascular health outcome in overweight Indigenous Australians with and without type 2 diabetes mellitus. The healthy lifestyle programme (HELP) (144)	2007	Sushames et al.	Pre-post	N=101 (middle –aged, overweight)	Physical activity and diet program	↓ WC (3.1 cm) and diastolic blood pressure (4.6 mmHg), HbA1C, total cholesterol, HDL cholesterol and triglycerides. non-significant ↑ *physical activity* (pedometer step count) at 6 months
Tasmanian Aborigines step up to health: evaluation of a cardiopulmonary rehabilitation and secondary prevention program (143)	2014	Sushames et al.	Pre-post	N=72 (chronic heart or respiratory disease or at high risk)	Cardiovascular and pulmonary rehabilitation program	mean ↑ in 6-min walk distance (55.7m, 95% CI 37.8 to 73.7), incremental shuttle walk (106.2m, 95% CI 79.1 to 133.2), as well as ↓ weight, WC, quality of life, dyspnoea, fatigue
Marked improvement in carbohydrate and lipid metabolism in diabetic Australian Aborigines after temporary reversion to traditional lifestyle (142)	1984	Sushames et al.	Pre-post	N=10 (diabetics)	Hunter/ gatherer lifestyle (7 weeks)	↑ *physical activity*, ↓ weight, BMI, glucose and triglyceride
Abdominal obesity reduction in indigenous men (145)	1999	Sushames et al.	Pre-post	N=47 (middle aged men)	Lifestyle messaging	↓ weight (3.3 kg; 3.5%), WC (4.0cm; 3.5%), fat mass (10.8%) at 12-months

Study title	Year	Review inclusion	Design	Participants	Intervention	Main findings*
Build it and they will come: outcomes from a successful cardiac rehabilitation program at an Aboriginal Medical Service (146)	2013	Sushames et al.	Pre-post	N=28	Cardiac rehabilitation program (8 weeks)	↓ BMI (34.0 ± 5.1 v. 33.3 ± 5.2 kg m^{-2}; P<0.05), WC (113 ± 14 v. 109 ± 13 cm; P<0.01, BP (135/78 ± 20/12 v. 120/72 ± 16/5 mmHg; P<0.05), ↑ 6-min walk distance (296 ± 115 v. 345 ± 135m
An Aboriginal-driven program to prevent, control and manage nutrition-related "lifestyle" diseases including diabetes (147)	2006	Sushames et al.	Pre-post	N=416	Regular exercise, sport and active recreation participation promotion	↑ *physical activity* (measurement tool and magnitude of change unspecifed)

* denotes year published

** statistical significance at p<0.05 unless otherwise stated

4.3.2 Review evidence – other physical activity associations

Additional reviews of physical activity among Aboriginal and Torres Strait Islander people have been conducted that have examined non-intervention studies, each of which are described below.

A systematic review published in 2016 included 12 studies that examined evidence of health and wellbeing being associated with swimming pools in remote communities (151). Study populations were predominantly children. The review found associations between access to swimming pools and a reduction in skin infections but benefits to ear and eye health remain unclear. The relationship between community swimming pools and physical activity participation has not been empirically investigated. Burgess et al. conducted a broader, narrative review of perspectives from previous health, social science and ecology literature to explore the health potential of Indigenous natural resource management activities in remote areas of northern Australia. Evidence linked natural resource management inherently to increased physical activities such as hunting and active conservation (142).

A literature review of programs that targeted environmental influences on Indigenous health was undertaken by Johnston et al. in 2011 (152) and included several programs that involved a component of infrastructure for physical activity. This review took an ecological approach given how colonisation has negatively affected the physical and social environment among Aboriginal and Torres Strait Islander people. Included programs were festivals incorporating sporting events as a component of health programs in a diabetes prevention study by Cargo et al. (153), the Looma study by Rowley et al. (135) and a tobacco intervention by Ivers et al. (154). The establishment of regular sports teams or walking groups were also reported by Cargo et al (153) and Reilly et al. (155). In a longitudinal process that examined the extent to which an ecological approach was integrated into an Aboriginal community-based chronic disease prevention program, Cargo et al. (153) found a community commitment to prevention. Reilly et al. conducted a pilot study of environmental factors of an Aboriginal health promotion in regional Victoria that aimed to improve nutrition and physical activity and was found to have adopted an ecological perspective (155). The review also described the swimming pool study by Lehmann et al. (136).

A further systematic review examined physical activity as a risk factor in a more holistic investigation of chronic disease prevention and management among Indigenous Australians (156). This review included one study that examined physical activity which was actually a previous review by Clifford et al. which described and critiqued methodological aspects of interventions targeting risk factors including physical inactivity (157). This review by Clifford et al. included three studies relating to physical activity by Chan

et al. (144), Egger et al., (145) Rowley et al. (135) that have been described previously. Clifford concluded the importance of more rigorous evaluations of interventions targeting risk factors including physical activity and the establishment of reliability and validity of measures to quantify their effect.

Nelson et al. (158) used a social–ecological model to review the literature about Indigenous Australians and physical activity. The paper concludes that Indigenous perspectives are critical to understanding socioecological models and their value in understanding and promoting issues relating to physical activity engagement. Factors at three levels are described: 'structural macro-social' such as culturally relevant physical activities like camping and hunting; 'structural environment' such as barriers and facilitators like safety and adverse climates; 'social connections' such as family and community focussed physical activity beyond engagement for individual benefit. Individual level characteristics were also identified as psychosocial (physical activity as an aid to manage stress), socio-economic (how sport could help overcome issues) and behavioural (physical activity as a diversionary strategy).

Overall, these of these five reviews demonstrate a number of established ways to increasing physical activity among Aboriginal and Torres Strait Islander adults including walking programs, sports programs and programs that incorporated aspects of the natural environment. The importance of collective, community activity and incorporating Indigenous perspectives was also a key message from these reviews. A limitation is their strict inclusion criteria which resulted in conclusions that were based on only a small number of studies. Many overlapped in their focus and the studies which were subsequently identified. Each recommended that future high quality studies should be undertaken. In recent years, however, there has been a proliferation of studies on physical activity and sport participation among both adults and children which were not included in these previous reviews. These studies have used either quantitative or qualitative methods and are described below. No reviews of physical activity among Aboriginal and Torres Strait Islander children currently exist.

4.3.3 Other studies: physical activity and health outcomes

Two physical activity interventions, in adult populations, have examined a range of health outcomes and perceptions of physical activity programs that are not captured in the reviews described above as they examined factors that were broader than main outcome measures. These studies are valuable in providing additional understanding of the context of these programs/interventions and their overall effectiveness beyond their main outcomes.

A brief report describes a health and wellbeing program for women of all ages which began in 2010 and includes a physical activity component, on the south coast of NSW (159). Physical activity sessions are personalized to participants and incorporate a varied, seasonal program of cardiovascular and strength activities. Views from participants describe the acceptability of the program and anecdotal reports of increased energy rates and improvements in biomarkers following participation.

The study by Canuto et al. described in Table 1 (138) that compared the effectiveness of an urban women's structured exercise and nutrition program also examined factors influencing program attendance (160). Through a mixed methods process evaluation, qualitative interview data indicated the women chose to participate for health reasons, either to improve their health generally or in specific response to an existing medical condition. A further study on participant views of the program found it was generally well received and enjoyable (161), in addition to the main trial findings demonstrating reductions in weight, BMI and blood pressure at 3-month follow-up (138). Barriers to participation were more commonly described in low attendees who cited illness, family and work commitments as well as logistic constraints such as impacting on their ability to attend.

4.3.4 Other studies: physical activity, sport and social outcomes

A larger number of studies have examined the effects of physical activity intervention on social outcomes. Given a more holistic focus around the importance of family and community among Aboriginal and Torres Strait Islander people, social outcomes derived from physical activity may hold more relevance than measures of an individual's health (12). There is also evidence from studies conducted in mainstream populations that physical activity and sport programs can achieve broader social benefits through education attainment (53) and crime prevention (162). These studies have predominately been conducted in child or young adult populations.

Dinan Thompson et al. (163) conducted interviews with children, parents, teachers and stakeholders to examine the impact of the AFL Kickstart program in four communities in Cape York in Far North Qld over a 12 month period during 2004-5. The Kickstart program targets boys up to age 16 years and girls up to age 13 years and requires participants to attend school, refrain from substance abuse, bullying and violence and focuses on AFL skill development. This evaluation examined its effectiveness in enhancing lifeskills such as school attendance, respect, social and moral values. Improvement in the education, attitudes and lifestyle choices of Indigenous youth in the selected Cape York communities occurred, despite mixed meanings surrounding the interpretation of "lifeskills". The program described physical activity participation as a diversionary tactic to reduce boredom and vulnerability to drug use and

violence but no data on these outcomes were presented.

The Deadly Choices health education program, a seven week program delivered once a week was evaluated by Malseed et al (164) through pre and post intervention questionnaire completed by 65 intervention and 16 control group students in grades 7-12 (ages 11-18 years) in urban Qld. The physical activity component of Deadly Choices focused on participation, increasing self-efficacy and teamwork. Traditional Indigenous games were included as activities and sessions were facilitated by young Indigenous healthy lifestyle workers who were considered role models to the children. The authors state that the questionnaire was based on a previous program evaluation questionnaire and has been pilot tested prior to the current study but no information is provided on the questions used or their validity. Significant improvements were demonstrated by the intervention group for most of the overall knowledge, attitudes and self-efficacy regarding leadership, chronic disease and risk factors questions. There were also increases in physical activity frequency ($P \leq 0.001$) in the intervention group. However, there were no differences over time for either group regarding the percentage of children who were 'very active at school', 'very active at weekends' or who used active modes of transport to school.

Peralta et al (165) investigated the effect of a 10 week community and school sport program 34 students in Grades 7-10 in urban NSW on their life skills and physical activity levels within program sessions as well as program acceptability. Acceptability of the program was determined through interviews with 18 participants and 6 key stakeholders. Systematic observations of program indicated that students were engaged in MVPA for 58% of lesson time but pre-post measures of participants' life skills showed no change ($p = 0.93$).

A brief report by Neesham & Garnham describes how the Clontarf Foundation promotes education, life-skills and employment prospects through Australian Rules Football (166). The Clontarf Foundation operates academies across Australia with the aim to improve the education, discipline, life skills, self-esteem and employment prospects of young Aboriginal Torres Strait Islander men and equipping them to participate meaningfully in society. This article describes the activities of the academies within the focus areas of education, leadership, employment, healthy lifestyles, life skills and football across 53 schools during 2012 engaging 2850 Indigenous youth annually. Formal evaluation of the program has not been undertaken to date.

Peralta & Cinelli undertook a qualitative evaluation of an Australian Aboriginal controlled-community organisation's sports-based program in a remote community in the NT with around 200 residents (167).

Through semi-structured and focus group interviews with 11 school students and 13 stakeholders, they examined how the program influenced participants' knowledge, educational engagement, social and cultural well-being and the extent of its support from the community and school. The paper identified that the program was having an influence on youth educational and social development. It was also influencing, to a lesser extent, the cultural health needs of the community through improved school attendance, increased knowledge of sports and activities and feelings of well-being and pride and was generally supported by participants.

Rumbalara Football and Netball Club is an Aboriginal community sports club in regional Vic. which has competed in local leagues since 1997. The club also runs health promotion programs to increase physical activity and improve diet, promote engagement of young people in education, and facilitate employment opportunities Doyle et al. (168) discuss the role of the club in promoting Indigenous wellbeing. Broadly, they describe how the club can promote community health and through sport participation, by other club activities, and as a social gathering place for families. For Aboriginal people it takes on more significance than just a sporting venue. It is viewed as a place for Aboriginal holistic wellbeing involving cultural strength, identity, pride, and beliefs.

In another study of a sport club, Thorpe et al (169) aimed to understand the impact of an Aboriginal community sporting team that was established in the 1970s, the Fitzroy Stars Football Club, through qualitative interviews and focus groups with 14 past and present players. Specifically, the study examined the impact of the club's environment on the social, emotional and physical wellbeing of young Aboriginal men, and to identify barriers and motivators for participation. Themes emerged around community connection, cultural values and identity, health, values, racism and discrimination. Social connections were considered complex and Aboriginal community networks in sports settings considered strong. Social reasons for participation were given equal importance as individual health reasons where social and community connection was found to be an important way to strengthen and maintain cultural values and identity. Barriers and motivators relating to participation were found to be complex and interrelated, for example racism. Other barriers included community explanations and conflict, and other commitments. Other motivators included history and pride, keeping fit and having a stress outlet. The study concluded that the Aboriginal sports teams have the *potential* to have a profound impact on Aboriginal health through fostering a safe and culturally strengthening environment and specific positive social community hub.

Aboriginal and Torres Strait Islander people have been typified as natural, gifted sportsmen and women. There have been examples of great sporting prowess by athletes at the elite level in sports such as AFL (170) and athletics (171) although achievements have been somewhat overshadowed by racism (172). Sport programs have been a recommended means of improving social outcomes among Aboriginal and Torres Strait Islander people since the Royal Commission into Aboriginal Deaths in Custody in the late 1980s (173). Yet there have been attempts to extrapolate the potential of these achievements of individuals to apply to all Aboriginal and Torres Strait Islander people and sport has been promoted as a broad panacea for a number of social issues such as anti-social behaviour, health and education (174). Overall, the studies described in this section provide some useful evidence of how this has been some of these outcomes have been realised. However, more robust identification and evaluation of physical activity and sport programs that claim to improve these broader social outcomes among Aboriginal and Torres Strait Islander people is required.

4.4 Non-intervention studies on physical activity and sport among Aboriginal and Torres Strait Islander people

4.4.1 Measurement

This section outlines how physical activity has been measured in Aboriginal and Torres Strait Islander populations and the establishment of self-report and objective measurement tools.

An investigation to identify potential health and social outcomes from sport and recreation programs in Indigenous communities in Australia was conducted in the early 2000s (175). A three-stage process was utilised: firstly, a literature review identified potentially relevant indicators; secondly, discussions with key members of three NT communities identified community expectations and experiences of sport and recreation programs; and thirdly, consultation with relevant stakeholders determined the potential usefulness and appropriateness of these identified indicators. Three types of indicators were proposed: 1) program viability and sustainability indicators; 2) participation indicators; and 3) outcome indicators. Eleven program viability and sustainability indicators measured aspects of program functioning, succession planning, adequacy of facilities and equipment and access to these facilities and equipment. Participation indicators provided a summary of community participation in sport and recreation programs and physical activity, including the specific participation of target groups. Outcome indicators were categorised into two groups. The first group included indicators on crime rates and school attendance. The second group included indicators around local sport and recreation employment, health clinic attendances, family violence, alcohol and drug related offences and self-harm. There has been little previous research

conducted among Aboriginal and Torres Strait Islander populations in relation to this second group of outcome measures and as such were particularly recommended for further research and development.

The next two studies conducted during the 2000s demonstrate the validity of modified versions of two established self-report physical activity tools for Aboriginal and Torres Strait Islander young people. Trost et al. (176) determined the concurrent validity of modified version of the established previous day physical activity recall (PDPAR-24) instrument in 63 Aboriginal and Torres Strait Islander and 59 non-Indigenous adolescents from five schools in urban Qld. The adolescents completed the PDPAR-24 after wearing a pedometer on the previous day. The established PDPAR instrument was modified by changing the recall time period from 3:30-11:30 p.m. on the previous day to the previous 24 hours, starting at 9:00 a.m. on the day of survey administration, excluding the time period between midnight and 5:00 a.m. The list of activities was modified to include activities specific to the Australian context including sports such as AFL, both rugby codes, cricket, netball, boogie boarding and surfing. Validity coefficients (rho) ranged from 0.29 to 0.34 ($p < 0.05$) and correlations among the Aboriginal and Torres Strait Islander people were equal to or greater than those observed for the non-Indigenous students. Gwynn et al. validated a self-report measure of physical activity in 84 Aboriginal and Torres Strait Islander and 146 non-Indigenous rural children aged 10-12 years in NSW and described their physical activity participation (177). The measure, Many Rivers Physical Activity Recall Questionnaire (MRPARQ), was a modified version of the APARQ (69) described above which has been used extensively in population level surveys in NSW and in studies of adolescents. MRPARQ was modified by using large font text to assist survey completion and using headings for key parts of the week such as ‘after school’ and ‘weekends’. A sub-group of participants (n=86) wore an accelerometer for seven consecutive days which gave modest to poor Pearson and Intra Class correlation coefficients of 0.31 and 0.16, respectively, for Aboriginal and Torres Strait Islander children, and 0.38 and 0.31, respectively, for non-Indigenous children. Self-reported MVPA was 162-172 minutes/day from the MRPARQ, and 125 minutes by accelerometer for the Aboriginal and Torres Strait Islander children who were more active than the non-Indigenous children who did 123-149 minutes (MRPARQ) and 107 minutes (accelerometer).

Sushames et al. (178) tested the utility of field based measures to assess Indigenous Australians' functional fitness and sedentary time through an observational study of a convenience sample of 61 Indigenous and 35 non-Indigenous adults. Functional exercise capacity was measured through the 6 MWT and sedentary time over seven days were measured using both accelerometers and the Past-day Adults' Sedentary Time (PAST) questionnaire (179). Participants also provided ratings on their experiences of the ease of complying with study protocols. Functional exercise capacity was lower in

Indigenous Australians (p<0.001), and independently associated with increased age, higher BMI, and being Indigenous, where 45% of variability in the 6 MWT distance was explained by these variables. The relationship between accelerometer and self-report measures of sedentary behaviour was significant (p<0.001) but only explained 17% of the total variation in sedentary behaviour.

In summary, few measures of physical activity have been developed specifically for Aboriginal and Torres Strait Islander populations. However, those that have been developed have reasonable properties for physical activity measurement (65) and can be utilised in future research. In addition, measures validated for whole-of-population use, such as those employed by the ABS and in other population studies (26, 115), can be used in Aboriginal and Torres Strait Islander populations. Community consultation regarding the suitability of any proposed measures for use in community research is ethically necessary (1), as well as possible further testing of proposed measures within target populations and communities to establish validity.

4.4.2 Descriptive studies

Two additional descriptive studies have examined aspects of physical activity and sport among Aboriginal and Torres Strait Islander people. These studies are relevant to this thesis given their focus on physical activity and help to inform the state of the current literature.

Marshall et al. examined knowledge of the Physical Activity Guidelines (PAG) and the preferred sources of physical activity assistance or advice among 194 Indigenous adults in urban Qld (180). The study examined the current PAG at the time it was conducted, which were the physical activity guidelines published in 1999 (181) but did not differ substantially to those published in 2014 (76). Self-reported questionnaires asked how participants rated their physical activity levels compared to their peers and asked their extent of agreement with five PAG statements and indicated their preferred sources of assistance or advice. Knowledge levels around the PAG were similar to that of non-Indigenous adults (182) and 39% of participants reported that they were 'more/much more active' than their peers. Most participants demonstrated excellent knowledge of the current PAG, with between 88% and 92% correctly agreeing with the main statements ('*Generally being more active good for health'* and '*Brisk walk half an hour daily good for health*', respectively). A greater proportion (79%) of participants over 44 years identified that '*blocks of 10 minutes of activity are OK*' compared to younger participants (aged 18-44 years: 60%; X2=6.23; p= .04). Higher educated participants were more likely to agree that '*brisk walking for half an hour most days was good for health*' compared to less educated participants (96% vs. 85%; X2=8.08; p= .02). For men, GPs and health professionals (62%) were the preferred source of physical

activity advice and for women it was “a group to be active with” (60%).

A study published in 2014 examined the agreement between GPs and 141 patients on their health risk factor status of smoking, alcohol consumption and physical inactivity (183). The prevalence of physical inactivity, defined as not achieving 30 minutes of physical activity on most days of the week, was similarly high as reported by patients (79%) and GPs (87%). However, agreement between patients and GPs was poor (Kappa -0.15 (95% CI -0.25, -0.05; $p<0.0667$). Comparative data on agreement between patients and GPs regarding physical activity status is not available.

Both of these studies are useful in providing information on knowledge and preferred sources of physical activity information among Aboriginal and Torres Strait Islander adults. In both studies, the population and statistical analyses used provide valid data although the findings cannot be assumed to be valid for all Aboriginal and Torres Strait Islander populations. Both studies are also examples in the literature that have examined outcomes relating to the Australian physical activity guidelines (or recommendations); their use of this established outcome measure is commendable.

4.4.3 Barriers and enablers to physical activity and sport

A number of studies of barriers to and enablers of physical activity and sport among adult and child Aboriginal and Torres Strait Islander populations in urban, regional and remote areas have been conducted, typically through qualitative studies.

A brief report by Edwards et al. describes barriers and enablers to physical activity among 15 young people aged 12-16 years in regional WA, using photovoice techniques (184). Environmental barriers related to transport to facilities, poor amenities and aesthetics and improvements such as shade, grass, water fountains and play equipment were suggested as enablers. Shame or embarrassment around participation, a lack of knowledge around physical activity options, cost of participation and drugs, alcohol and smoking were also given as barriers. The report concluded that barriers to physical activity participation among young people were not fully understood.

In a study published in 2000, Thompson et al. (12) observed the social and cultural context of risk and prevention of diabetes in relation to physical activity (and food) through interviews with 57 urban Indigenous adults in Melbourne. Participants categorised physical activity as three types: optional leisure-time exercise; everyday necessary activities; and individual-level sport. Individual-level physical activity participation was negatively regarded as shameful and disconnected to the community. An exception to

this was in the management of acute illness. However, physical activity participation was viewed as acceptable within the context of the family and community.

Hunt et al. (185) explored the meaning of, barriers to, and potential physical activity promotional strategies in focus groups involving 96 urban Indigenous adults in Qld. Participants had a clear understanding of the relationship between physical activity and health and typically participated in walking, domestic chores and specific sports like football, boxing and netball. Barriers included a perception of being judged by others when in public spaces, affordability and accessibility. Motivators were family engagement, fun activities, being a role model to young people and group-based activities.

Stronach et al. conducted exploratory qualitative research with 22 urban and rural Indigenous women aged 18-74 years from Redfern, NSW and Flinders Island, Tas with the aim of gaining better contextual and cultural understanding of the issues involved (186). The methodology of *Dadirri* was employed, which proceeds inductively by gathering information through quiet observation and deep listening, building knowledge through sensitivity and awareness, and developing understanding by contemplation and reflection (187). Through individual or group interviews, the women were asked to describe their participation levels in physical activities for recreation, exercise, or sport consistent with the methodology from the ABS survey on Participation in Sport and Physical Recreation (188). Experiences of sport and physical activity were considered complex, across individual, family & community and external/societal factors. While participation levels in organised sport were low, physical activity was identified as an important part of cultural and community activities in a non-organised manner. Participants wanted to be active role models for their families, especially for children and appreciated that physical activity and sport can both improve health and potentially reduce risk taking behaviours among youth.

Through qualitative research with women and girls from 21 families living in remote communities in the Torres Strait and Northern Peninsula Area, Qld, Macdonald et al (189) explored their thoughts on physical activity as a lifestyle "choice". The barriers to and enablers of being active were also explored. Three consistent themes emerged: "shame" arising from the public nature of engaging in physical activity; gender-specific choices to be active alongside other gender-specific tasks; and the deferral of responsibility for organising activities to the state and agencies. These themes were not consistent with Western health policies typically focused on individual responsibility, however high rates of diabetes (190) in the region were affecting views of the women and girls around the importance of individual activity.

Qualitative semi-structured interviews by Thompson et al. (191) explored and described local perspectives, experiences and meanings of physical activity from 23 purposively selected adult community members in two remote NT communities. These data were supplemented by local art and author observations. Physical activity involvement was strongly embedded in the natural environment. Participants described physical activities as being associated with natural and cultural resource management, customary spaces, hunting, seasonal timing and traditional education as creating and protecting health, including through diversionary activities. These activities were considered both culturally appropriate ways of improving health through physical activity as well as ways to build and maintain relationships, wealth, resources and the environment and through education and employment. Organised exercise programs like walking groups were only considered for adoption by those with existing chronic diseases, rather than as an everyday way of life.

Nelson (192) conducted focus groups with 14 urban Indigenous young people aged 11-13 years, aiming to challenge the commonly held assumptions about sport as a panacea for social issues that are described in section 4.2.3. Diverse, multiple, shifting and complex identities were expressed by participants in their described experiences of the place and meaning of sport and physical activity in their lives. Sport and physical activity were viewed as a way to connect with friends, family and community. The young people both engaged in, and resisted, dominant Western discourses regarding representations of Indigenous people in sport. Nelson et al. also examined their perceived risks around physical activity and health (193). The young people in this study did not perceive themselves as 'at-risk' of ill-health despite the recognition of 'unhealthy' choices or a family history of chronic illness. They appeared to negotiate risk based on both their knowledge of public health messages and their trust in themselves and those around them.

In the Torres Strait and Northern Peninsula Area of Qld, Abbott et al. (194) used a cross-sectional survey to explore practices of, and perceived barriers to, physical activity among 367 school children aged 9-16 years. Over 40% reported that they did not participate in physical activity on a daily basis but no age or gender differences were found. The major barriers related to the hot and wet climate, insufficient time, lack of equipment and child specific activities and low self-perception of sporting ability. Shyness was also a factor and was associated with wearing sports clothes as a barrier among high school girls ($P = 0.01$). The importance of talking with family members about being physically active was apparent. Structural and family based strategies were recommended to engage young people in physical activity as well as delivering skill and confidence building activities and non-competitive options.

Barriers to and enablers of the provision of sporting opportunities in remote Cape York communities were investigated by Meldrum & Dinan Thomson (195) through interviews with four sporting organisations that operate 'fly-in-fly-out' services. There were perceptions that community members were happy for their children to be involved with sport programs but did not wish to become engaged themselves. The training of Torres Strait Islander people through the translation of mainstream coaching material by one organisation was considered a desirable outcome. Sustainability of program provision was a challenge but deemed vital and considered achievable through the capacity building of coaches and volunteers. Other barriers were costs, travel, facilities and seasonal restrictions (during the wet season).

Taken together, while these 10 studies on barriers to and enablers of physical activity among Aboriginal and Torres Strait Islander people are diverse in their sample characteristics and geographic location, a number of common findings are apparent. Firstly, barriers to and enablers of participation in sport and physical activity appear to be complex and inter-related. Secondly, specific cultural barriers such as fear of embarrassment or 'Shame' are evident. Thirdly, some barriers and enablers are similar among Aboriginal and Torres Strait Islander people and non-Indigenous populations such as motivation, poor weather and perceived time constraints. A limitation of these studies is that none have incorporated quantitative data to corroborate their qualitative findings.

5. Thesis aims and objectives

This thesis comprises a series of studies which form a body of research about physical activity among Aboriginal and Torres Strait Islander people.

Overall, this thesis aims to contribute to the evidence base about the determinants of physical activity among Aboriginal and Torres Strait Islander people and developing strategies to increase physical activity for health and broader benefits. The first objective is to examine cross-sectional associations between physical activity and a range of lifestyle, environmental and social factors among adults through secondary analysis of epidemiological data. The second objective is to describe physical activity patterns and influencing factors among adolescents; through one cross-sectional study and one repeated cross-sectional study; both are secondary analyses of existing data sources. The third objective is to identify and describe characteristics of physical activity programs targeting Aboriginal and Torres Strait Islander people, using primary data sources. The fourth aim is to conduct a pilot evaluation of one of these physical activity programs, towards developing feasible interventions for this population group, again through collecting primary data.

The initial three chapters present original published research from cross-sectional and repeat cross-sectional studies. **Chapter 2** presents original research examining whether achievement of national physical activity recommendations was associated with healthy lifestyle behaviours, neighbourhood environmental characteristics and social support among Aboriginal and non-Aboriginal adults in NSW. This study used data from a sub-study of the 45 and Up Study, the Social, Environmental and Economic Factor (SEEF) study.

The second study presents cross-sectional demographic, social and psychosocial and health correlates of physical activity among Aboriginal and non-Aboriginal adolescents aged 13-17 years in rural and metropolitan NSW (**Chapter 3**). The study describes physical activity patterns and influencing factors, comparing Aboriginal and non-Aboriginal adolescents.

The third study presents original research from a repeat cross-sectional study. This study examines age related declines in physical activity among Aboriginal and non-Aboriginal young people and their variation by season, setting and type among Aboriginal and non-Aboriginal children from between 2007/8 and 2011/12 (**Chapter 4**).

The fourth study identified and reviewed the published and online scientific and grey literature for physical activity programs targeting Aboriginal and Torres Strait Islander people operating between 2012 and 2015. It presents original research describing their characteristics (**Chapter 5**).

The next chapter presents original research from a pilot study which examines the health and community impacts of one of the programs identified in Chapter 5, the Indigenous Marathon Program (IMP), in a remote Torres Strait Island community (**Chapter 6**).

The final chapter summarises the main findings from this thesis and discusses their context within the broader relevant literature on Aboriginal and Torres Strait Islander physical activity and health (**Chapter 7**).

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Chapter 2

Physical activity, healthy lifestyle behaviors, neighborhood environment characteristics and social support among Australian Aboriginal and non-Aboriginal adults.

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Chapter 1 identified that physical activity participation is important for the health of Aboriginal and Torres Strait Islander adults and children and that various correlates of physical activity participation have been established in mainstream populations. However, little is known about physical activity levels or the associations between physical activity, health and other factors correlated with health among either adult or child Aboriginal and Torres Strait Islander populations.

Chapter 2 contributes to the evidence base around the associations between physical activity and health of Aboriginal and Torres Strait Islander people by determining achievement of physical activity recommendations and whether these were associated with healthy lifestyle behaviours, neighbourhood environmental characteristics and social support. In this Chapter, I conducted secondary analysis of cross-sectional data collected as part of a sub-study of the 45 and Up Study, the Social, Environmental and Economic Factor (SEEF) study. The 45 and Up study is the largest epidemiological study in the southern hemisphere and the SEEF study collected data on physical activity and healthy lifestyle behaviours, neighbourhood environmental characteristics and social support variables in NSW adults aged 45 years and over. The sample size of Aboriginal adults in the SEEF sub-study was large enough to examine associations between physical activity and these variables of interest and whether these differed to associations among a comparative population of non-Aboriginal adults.

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Physical activity, healthy lifestyle behaviors, neighborhood environment characteristics and social support among Australian Aboriginal and non-Aboriginal adults

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ABSTRACT

Physical inactivity is the third leading cause of the burden of disease for Australian Aboriginal adults. The neighborhood environment and social support are known to influence physical activity (PA) participation. This study examined these factors in relation to achieving PA recommendations in Aboriginal and non-Aboriginal Australians. Cross-sectional data from the 2010 Social, Economic, and Environmental Factor (SEEF) Study in New South Wales, Australia were used to estimate adjusted odds ratios (OR) for Aboriginal versus non-Aboriginal participants for PA-related attributes, including achieving PA recommendations. ORs for achieving PA recommendations were estimated in both groups. Overall, 63.1% of Aboriginal (n = 314) and 65.4% of non-Aboriginal (n = 59,175) participants met PA recommendations. Odds of healthy sleep duration were lower, and receiving GP advice to be active was higher, among Aboriginal versus non-Aboriginal participants. Aboriginal respondents had higher odds of reporting that the crime rate made it unsafe to walk and that local public transport was inaccessible. They had higher odds of disagreeing they have local shops, footpaths or free/low cost recreation facilities. PA correlates were similar in both groups. The factors relating to PA were similar in Aboriginal and non-Aboriginal people. Neighborhood and social features were less PA-favorable for Aboriginal participants suggesting multiple possible avenues for increasing PA in this older population group.

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Introduction

Physical inactivity is the third leading cause of the burden of disease for Australian Aboriginal and Torres Strait Islander* adults (Vos et al., 2007). In 2011–2, only 46% of Aboriginal people aged 18 years and over living in non-remote areas achieved the minimum recommendation of 150 min of moderate intensity physical activity per week (Australian Bureau of Statistics (ABS), 2013a); 10% less likely to meet recommendations than their non-Aboriginal counterparts (Australian Bureau of Statistics (ABS), 2014a). Physical activity confers numerous health benefits including reducing the risk of non-communicable diseases such as cardiovascular disease, diabetes, hypertension, obesity and some cancers (World Health Organization, 2009). It can also contribute to the prevention and treatment of many mental health and age-related disorders (Steinmo et al., 2014; Norton et al., 2014).

Australia's Physical Activity & Sedentary Behavior Guidelines for Adults (18–64 years) recommend the accumulation of 150 to 300 min of moderate intensity physical activity or 75 to 150 min of vigorous intensity physical activity, or an equivalent combination of both moderate and vigorous activities, each week (MVPA). They also recommend reducing the amount of time spent sitting and breaking up periods of prolonged sitting. Sitting time has emerged as a risk factor for chronic disease and mortality, independent of physical activity (Chau et al., 2013). Time spent watching television (TV) is often used as a measurement indicator for sedentary behavior (Clark et al., 2009).

In the general population, physical activity levels are lower among older adults, females, disadvantaged populations and rural residents (Australian Bureau of Statistics (ABS), 2013a) (Australian Institute of Health and Welfare, 2008). Aspects of the neighborhood built environment are known to have a strong influence on physical activity participation, particularly walking and cycling (Saelens et al., 2003). Higher street connectivity and the presence of neighborhood destinations (such as shops) are associated with more frequent walking for transport

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(Koohsari et al., 2014). A review identified a positive relationship between parks and recreation settings and physical activity participation (Abercrombie et al., 2008). Fear of crime has also been found to lead to a decrease in time spent walking (Foster et al., 2014).

* *The term 'Aboriginal' will be used to refer to participants of Aboriginal and/or Torres Strait Islander origin, in keeping with advice from the Aboriginal Health and Medical Research Council.*

Identifying the factors associated with physical activity is important in devising strategies to increase levels of physical activity among Aboriginal people. There is little evidence regarding environmental correlates of physical activity among Aboriginal Australians. Internationally, a study of Native American elders found that being closer to interesting places was a facilitator to walking (Sawchuk et al., 2011). However, another Native American study found undesirable aspects of the built environment such as a lack of destinations for walking or public open space as barriers to walking for recreation and transport (Mathews et al., 2010). The majority of Aboriginal Australians live in urban locations (Australian Bureau of Statistics (ABS), 2011). Therefore, these aspects of the neighborhood built environment may serve to influence their levels of physical activity. However, the impact of specific historical factors such as colonisation and displacement may be a determinant of the types and quality of neighborhoods where Aboriginal Australians currently reside. To our knowledge no study has yet examined the evidence of the influence of the neighborhood built environment on physical activity levels among Australian Aboriginal people.

Social support of family and friends has been identified as a positive correlate of physical activity across various population groups, including ethnic minorities and women (Harvey and Alexander, 2012; Wilcox et al., 2009), and specifically Native American women (Henderson and Ainsworth, 2003). However, cultural traditions of Aboriginal Australians such as kinship place great importance on family and community values. Family engagement and group activities have been found to be strong motivators of physical activity participation among Aboriginal Australians (Hunt et al., 2008). We hypothesize that social support would be associated with physical activity among Aboriginal adults.

The aim of this study was to investigate the sociodemographic factors, attributes of the neighborhood built environment and social support associated with achieving the national physical activity recommendations among Aboriginal and non-Aboriginal participants of a large Australian cohort study.

Methods

Participant recruitment

The Sax Institute's 45 and Up Study is a large-scale population-based cohort study of men and women aged 45 years and older residing in New South Wales (NSW), Australia (Collaborators, 2008). Participants were randomly sampled through the Medicare database, with oversampling in rural areas and among older adults (Collaborators, 2008). Baseline self-administered postal questionnaires were distributed between 1 January 2006 and 31 December 2008. Joining the study involved completing the baseline questionnaire and providing written consent. The Social, Economic, and Environmental Factor (SEEF) study is a subsequent sub-study of the 45 and Up Study which aims to identify how social, economic and environmental factors influence the health and wellbeing of middle aged and older Australians. In 2010 the SEEF questionnaire was distributed by mail to the first 100,000 participants to join the 45 and Up Study. A total of 60,404 participants returned a completed questionnaire and a signed consent form (response rate = 60.4%).

The 45 and Up Study was granted ethical approval by the University of New South Wales Human Research Ethics Committee (Reference 050,035). The SEEF Study was granted ethical approval by the University of Sydney Human Research Ethics Committee (Ref no.: 10–2009/12,187). Ethical approval for the current study was also granted by the Aboriginal Health and Medical Research Council of New South Wales (reference 912/13).

Measures

Pilot testing of the SEEF questionnaire (n = 128) resulted in overall acceptable test–retest reliability intra-class coefficients (ICC) ranging from 0.33 to 0.84 and Cronbach's alpha coefficients ranging from 0.23 to 0.96. Aboriginal status was self-identified in the 45 and Up Study with the following question: 'Are you of Aboriginal or Torres Strait Islander Origin? and response options of: 1) No — non-Aboriginal; 2) Yes — Aboriginal; and 3) Yes — Torres Strait Islander. Participants were able to identify as both Aboriginal and Torres Strait Islander. Very few participants indicated they were exclusively of Torres Strait Islander origin (n = 19) and for the purposes of these analyses this variable was dichotomised into non-Aboriginal and Aboriginal and/or Torres Strait Islander, with the latter category referred to as 'Aboriginal'.

Physical activity

The main outcome variable, achieving the national physical activity recommendations, was calculated based on the Active Australia Survey (AIHW, 2003) which measures minutes of walking and other moderate and vigorous leisure-time physical activity in the past week, and has acceptable reliability (Brown et al., 2004a) and validity (Timperio et al., 2003). The SEEF questionnaire included questions about the frequency and duration of their time spent doing walking, moderate and vigorous activities in the past week. Two different thresholds of at least 150 min per week and at least 300 min per week of MVPA were used, based on the upper and lower thresholds of the range advised in the national guidelines (Australian Government Department of Health, 2013).

Socio-demographic variables

Sociodemographic variables (age, sex and annual household income) were derived from the SEEF questionnaire. Educational qualifications were derived from the baseline 45 & Up Study questionnaire and dichotomised as (None/school/intermediate/High School Certificate (HSC); trade/apprenticeship/certificate/diploma/university). The Accessibility Remoteness Index of Australia Plus (ARIA+) score (AIHW, 2004) and the measure of Socio-Economic Indices for Areas (SEIFA), the Index of Relative Socio-economic Disadvantage (IRSD) (Australian Bureau of Statistics (ABS), 2013b) were derived for each participant's postcode of residence at the time of recruitment to the 45 and Up Study, as recorded by Medicare Australia. These variables were dichotomised as: ARIA (Major City/Inner/Outer Regional; Remote/Very Remote) and SEIFA (Most disadvantaged quintiles 1, 2; Least disadvantaged quintiles 3, 4, 5). Other socio-economic variables were also dichotomised: sex (male; female); age (45–59 years; ≥60 years); income (<$39,999; ≥$40,000).

Neighborhood built environment and social support variables

The SEEF questionnaire included six neighborhood built environment questions adapted from the Physical Activity Neighborhood Environment Survey (PANES) (Sallis et al., 2010). These questions asked about access to shops/services, public transit and recreation facilities, presence of sidewalks and personal safety from crime (day and night). Responses option were dichotomised as: disagree (strongly disagree and somewhat disagree) and agree (strongly agree and somewhat agree). The two questions related to levels of crime were reverse scored. Cronbach's alpha coefficients and test-rests reliability ICCs were 0.64

and 0.56, respectively, for the two crime questions and 0.81 and 0.84 for the other neighborhood environment questions, respectively.

Social and neighborhood connections were assessed using eight questions. Dichotomised 'yes/no' responses were sought for survey items about whether the respondent visits neighbors or family outside their local area, can give or receive help from friends and neighbors, is likely to see people they know in their local area, can trust most people in their neighborhood; and if the area has a reputation for being safe. Three further questions from the Duke Social Support Scale (Goodger et al., 1999) asked the respondent how many times per week they spend: time with friends or family they do not live with (dichotomised as 0–3, ≥4); at meetings of social clubs, religious/other groups (dichotomised as 0, ≥1); and how many people outside home, within 1 h of travel they can depend on or feel very close to (dichotomised as 0–3; ≥4).

Healthy lifestyle behaviors

Respondents were also asked whether they had been told by their General Practitioner (GP) to be more physically active in past 12 months (yes/no). Dichotomisation of hours per day spent in sedentary behaviors was based on cut points established from current evidence for unhealthy levels of sitting at 8+ hours (Chau et al., 2013) and high levels of television viewing at 2+ hours (Hu et al., 2001). Hours per day spent sleeping were classified as healthy (7–9 h) or at risk (5–7 h or 9+ hours) Cappuccio, D'Elia (Cappuccio et al., 2010).

Analyses

Data analysis was carried out using SPSS version 21.0. Chi-squared tests were used to compare the sociodemographic profile of Aboriginal and non-Aboriginal participants. Odds ratios (ORs) and 95% confidence intervals (CIs) for Aboriginal versus non-Aboriginal participants for physical activity, sedentary behavior and sleep, neighborhood built environment and social support variables were estimated using forced entry binary logistic regression models, adjusting (where appropriate) for age and sex (Model 1). Models were further adjusted for remoteness of residence (Model 2) and education level (Model 3).

Similar models examined the factors associated with meeting the physical activity recommendations, separately in Aboriginal and non-Aboriginal participants. Effect modification of the relationship between each sociodemographic, behavioral, neighborhood built environment and social support factor and achieving the recommended physical activity levels by Aboriginal status was also examined using interaction tests.

Results

Participants without a valid age or date of entry into the study or a valid response to the question on Aboriginal origin (n = 910) were excluded from the analysis. Of the 60,404 respondents to the SEEF study a total of 59,489 (314 Aboriginal; 59,175 non-Aboriginal) participants were included in the analyses (98.5%).

Compared to non-Aboriginal participants, Aboriginal adults were more likely to be younger, have lower levels of educational qualifications and income and live in a disadvantaged area. Aboriginal participants were less likely to live in a major city and be married/living with a partner (all p ≤ 0.001) (Table 1).

Table 1
Socio-demographic characteristics of Aboriginal and non-Aboriginal participants of the 2010 SEEF study, New South Wales, Australia.

	Aboriginal (N = 314)%	Non-Aboriginal (N = 59,175)%	p value
Sex			
Male	40.4	46.4	0.034
Female	59.6	53.6	
Age			
45–59	63.4	47.1	< 0.001
60+ years	36.6	52.9	
Education			
None/school/intermediate/HSC	52.9	40.3	< 0.001
Trade/apprenticeship/certificate/diploma/uni	47.1	59.7	
Marital status			
Single/divorced/separated/widowed	31.8	24.0	0.001
Married/living with partner	68.2	76.0	
Income			
<$20,000–$39,000	55.7	40.3	< 0.001
$40,000+	44.3	59.7	
Remoteness (ARIA+)			
Major City	29.2	43.4	< 0.001
Inner/outer regional/remote/very remote	70.8	56.6	
SEIFA			
Most disadvantaged quintiles 1, 2	57.3	40.1	< 0.001
Least disadvantaged quintiles 3, 4, 5	42.7	59.9	

Physical activity and healthy lifestyle behaviors

Table 2 presents the proportion of participants meeting the upper threshold of the physical activity recommendations of >300mins/week, which was high in both Aboriginal (63.1%) and non-Aboriginal respondents (65.4%). A greater propotion of respondents met the lower threshold of the physical activity recommendations of >150mins/week (data not shown; 76.9% in Aboriginal and 80.4% in non-Aboriginal respondents, respectively p = 0.144). The odds of achieving the upper threshold of the physical activity recommendations did not differ according to Aboriginality, after adjustment for age, sex and ARIA/education. Aboriginal and non-Aboriginal participants did not differ significantly in terms of measures of sedentary behavior. Aboriginal participants had higher odds of being told to be more physically active by their GP in the past 12 months than non-Aboriginal participants in each model (age and sex adjusted OR = 1.90, 95% CI 1.50-2.40; Table 2). Compared to non-Aboriginal participants, Aboriginal participants also had a higher odds of unhealthy sleep duration in each model.

Neighborhood built environment and social support variables

Adjusting for age and sex, Aboriginal respondents had a higher odds of disagreeing that there were *local shops within easy walking distance of home*; *public transport within a 10–15 min walk from home*; *footpaths on most of the streets in neighborhood* or that the *neighborhood has free or low cost recreation facilities* AND HIGHER ODDS OF AGREEING or that the *crime rate makes it unsafe to walk* at both *day* and *night*; compared to non-Aboriginal respondents (Table 2). Adjustment for ARIA attenuated the association with accessibility to local shops, recreation facilities and footpaths. Aboriginal respondents had higher odds of indicating that they do not *go outside local area to visit family*, cannot *get help from friends when need it*; DO NOT agree *most people in neighborhood can be trusted* or DO NOT AGREE that their *area has a reputation for being a safe place*, compared to non-Aboriginal respondents. In the model adjusted for ARIA, Aboriginal respondents had a higher odds of reporting they cannot *ask neighbor to help care for someone*, compared to non-Aboriginal respondents.

Aboriginal participants had higher odds of *spending no time in the last week at meetings of social clubs or other group meetings* (compared to 1+) or having 0–3 *people outside home that they can depend on* (compared to 4+) compared to non-Aboriginal participants. Other neighborhood built environment, neighborhood connections and social support variable responses were similar among Aboriginal and non-Aboriginal participants.

Table 2
Physical activity (PA), healthy lifestyle behaviors, neighborhood characteristics and social support among Aboriginal and non-Aboriginal participants of the 2010 SEEF study, New South Wales, Australia.

	Aboriginal N = 314%	Non-Aboriginal N = 59,175%	Odds Ratios for Aboriginal vs non-Aboriginal participants (reference group)		
			Model 1 adjusted for age, sex	Model 2 adjusted for age, sex and remoteness of residence	Model 3 adjusted for age, sex and education
PA, healthy lifestyle behaviors					
Meets PA recommendations >300 min/week (no)	36.9	34.6	1.15 (0.89–1.47)	1.18 (0.92–1.51)	1.14 (0.89–1.47)
8+ hours per day spent sitting	36.4	36.0	1.06 (0.79–1.40)	1.13 (0.85–1.51)	1.08 (0.81–1.43)
2+ hours per day spent watching TV	57.2	56.3	1.07 (0.80–1.44)	1.04 (0.77–1.40)	0.99 (0.73–1.34)
5–7/9+ hours per day spent sleeping	34.7	20.8	2.10* (1.66–2.68)	2.11* (1.66–2.69)	2.03* (1.60–2.59)
Told by GP to be more active, past 12 months	35.6	22.3	1.90* (1.50–2.40)	1.95* (1.54–2.48)	1.81* (1.43–2.30)
Neighborhood built environment					
Local shops within easy walking distance of home (disagree)	59.0	53.5	1.26* (1.01–1.59)	1.12 (0.89–1.42)	1.28* (1.01–1.61)
Public transport within 10-15 min walk from home (disagree)	38.2	26.7	1.67* (1.32–2.10)	1.33* (1.03–1.71)	1.63* (1.29–2.06)
Footpaths on most streets in neighborhood (disagree)	54.2	43.9	1.51* (1.21–1.89)	1.24 (0.97–1.58)	1.49* (1.19–1.87)
Neighborhood has free/low cost recreation facilities (disagree)	35.4	26.2	1.49* (1.18–1.88)	1.25 (0.98–1.60)	1.40* (1.10–1.78)
Crime rate makes it unsafe to walk: NIGHT (agree)	33.7	26.6	1.53* (1.20–1.95)	1.58* (1.24–2.01)	1.44* (1.13–1.84)
Crime rate makes it unsafe to walk: DAY (agree)	13.0	4.6	3.31* (2.36–4.63)	3.41* (2.43–4.77)	3.09* (2.20–4.33)
Neighborhood connections					
Go outside local area to visit family (no)	20.5	15.0	1.53* (1.16–2.03)	1.59* (1.21–2.11)	1.45* (1.10–1.93)
Can get help from friends when need it (no)	11.1	6.0	1.88* (1.31–2.69)	1.92* (1.34–2.75)	1.77* (1.23–2.56)
Can ask neighbor to help care for someone (no)	49.8	42.8	1.23 (0.98–1.54)	1.26* (1.00–1.58)	1.23 (0.98–1.55)
Visited neighbor in past week (no)	47.7	45.2	1.00 (0.80–1.26)	1.04 (0.83–1.31)	1.02 (0.81–1.23)
Likely to run into friends and acquaintances locally (no)	12.3	13.7	0.85 (0.60–1.19)	0.97 (0.69–1.37)	0.89 (0.63–1.26)
Done favor for sick neighbor in past 6 months (no)	50.6	54.7	0.80 (0.63–1.00)	0.83 (0.66–1.04)	0.82 (0.65–1.02)
Agree most people in neighborhood can be trusted (no)	22.0	12.1	1.89* (1.43–2.49)	1.99* (1.51–2.62)	1.84* (1.39–2.43)
Area has reputation for being a safe place (no)	16.3	8.4	2.02* (1.48–2.74)	2.18* (1.60–2.97)	1.96* (1.44–2.68)
Social support					
0–3 vs 4+ Times last week with friends, family (do not live with)	59.0	59.0	0.96 (0.76–1.21)	0.97 (0.77–1.22)	0.94 (0.75–1.19)
0 vs 1 Times last week at social clubs, other groups meetings	55.4	44.7	1.40* (1.11–1.78)	1.41* (1.11–1.78)	1.36* (1.07–1.72)
0–3 vs 4+ People outside home, within 1 h travel can depend on	44.1	36.5	1.35* (1.08–1.70)	1.35* (1.08–1.70)	1.31* (1.04–1.64)

Model 1: adjusted for age, sex.
Model 2: adjusted for age, sex and ARIA where appropriate.
Model 3: adjusted for age, sex and education where appropriate
* Statistical significance $p < 0.05$.

Correlates of meeting physical activity recommendations among Aboriginal and non-Aboriginal participants

Non-Aboriginal participants had a higher odds of meeting the physical activity recommendations if they were female, younger (<60 years), married/living with a partner, living in a major city, more educated and earning more income (≥$40,000; Table 3). Although associations were statistically significant among the non-Aboriginal participants only, the OR and 95% CI among the Aboriginal participants were consistent with those for non-Aboriginal participants and tests for statistical interaction according to Aboriginality were not significant. Repeating the models using the lower threshold of the 150 mins/week physical activity recommendations did not materially alter the findings regarding these associations (data not shown).

In both Aboriginal and non-Aboriginal groups, those who were told to be more physically active by their GP in the past 12 months had a lower odds of meeting the physical activity recommendations (OR = 0.35, 95% CI 0.20-0.60 and OR = 0.46, 95% CI 0.44-0.48, respectively; Table 3). Compared to those who sat for more than eight hours a day, only the non-Aboriginal respondents who spent less than eight hours a day sitting had a higher odds of meeting the physical activity recommendations (OR = 1.75, 95% CI 1.67-1.83). Similarly, non-Aborginal respondents with four or more *people outside home that they can depend on* also had a higher odds of meeting the physical activity recommendations compared to those with fewer social contacts (OR = 1.37, 95% CI 1.32-1.42).

In the non-Aboriginal group, those who disagreed that: they have easily accessible public transport, local footpaths and crime rate made it unsafe to go out (day or night) had a higher odds of meeting the physical activity recommendations. Those who answered 'yes' to the seven questions relating to support from family, friends and neighbors and those who perceived their neighborhood as a safe place had a higher odds of meeting the physical activity recommendations. Participants who disagreed that there are *local shops within easy walking distance of home* had a lower odds of meeting the physical activity recommendations. Those who *spent more time* (*≥4* vs *0–3*) *in the last week with friends, family they do not live with* or *any time at social clubs, other groups meetings* had a higher odds of meeting the physical activity recommendations. Further adjustment for remoteness of residence did not materially alter the findings. After adjusting for education, the odds of meeting physical activity recommendations increased for those who spent less than eight hours a day sitting (OR = 1.86, 95% CI 1.00-3.45) and also for those with four or more *people outside home that they can depend on* and physical activity (OR = 1.69, 95% CI 1.01-2.83) increased (Supplementary Table).

The relationship of each of the sociodemographic, behavioral, neighborhood built environment and social support factors to meeting the physical activity recommendations did not vary significantly according to Aboriginality (p[interaction] ≥ 0.1).

Discussion

A large proportion of Aboriginal and non-Aboriginal participants met the upper threshold of the recommended levels of physical activity. Socio-demographic factors relating to higher levels of PA included female sex, younger age, higher educational qualifications, higher income, being married/partnered and residing in non-major city areas. Factors associated with achieving physical activity guidelines were similar

Table 3
Socio-demographic, behavioral, neighborhood and social support correlates of meeting physical activity recommendations of >300 min/week in the, adjusted for age and sex.

	Aboriginal N = 314		Non-Aboriginal N = 59,175	
	% meet PA	Odds ratios	% meet PA	Odds ratios
Socio-demographic				
Sex				
Male	62.6	1.00	64.1	1.00
Female	63.4	1.03 (0.62–1.71)	66.4	1.08* (1.04–1.12)
Age				
45–59	66.5	1.00	67.4	1.00
60+ years	55.8	0.64 (0.38–1.08)	54.4	0.84* (0.81–0.87)
Education				
None/school/intermediate/HSC	60.6	1.00	62.5	1.00
Trade/apprenticeship/certificate/diploma/uni	64.6	1.11 (0.67–1.86)	67.4	1.24* (1.19–1.29)
Marital status				
Single/divorced/separated/widowed	60.8	1.00	60.8	1.00
Married/living with partner	66.7	1.05 (0.60–1.84)	66.7	1.29* (1.24–1.35)
Income				
<$20,000–$39,000	55.7	1.00	63.0	1.00
$40,000+	68.6	1.55 (0.88–2.76)	67.8	1.22* (1.12–1.27)
Remoteness (ARIA+)				
Major city	59.0	1.00	63.8	1.00
Inner/outer regional/remote/very remote	64.6	1.24 (0.72–2.15)	66.6	1.13* (1.09–1.17)
SEIFA				
Most disadvantaged quintiles 1, 2	63.3	1.00	65.2	1.00
Least disadvantaged quintiles 3, 4, 5	62.7	0.99 (0.60–1.64)	65.4	1.01 (0.97–1.05)
Healthy lifestyle behaviors				
Hours per day spent sitting				
Unhealthy 8+ hours	50.0	1.00	55.8	1.00
Healthy <8 h	64.8	1.81 (0.98–3.35)	68.1	1.75* (1.67–1.83)
Hours per day spent watching TV				
High 2+ hours	63.6	1.00	64.9	1.00
Low ≤2 h	60.0	0.84 (0.43–1.62)	67.9	1.11* (1.06–1.17)
Hours per day spent sleeping				
Unhealthy 5–7/9+ hours	62.9	1.00	60.8	1.00
Healthy 7–9 h	64.5	1.05 (0.61–1.79)	67.1	1.30* (1.25–1.36)
Told by GP to be more active, past 12 months				
No	71.8	1.00	69.7	1.00
Yes	46.7	0.35* (0.20–0.59)	51.3	0.46* (0.44–0.48)
Neighborhood built environment				
Local shops within easy walking distance of home				
Agree	66.0	1.00	66.9	1.00
Disagree	61.8	0.83 (0.49–1.39)	64.4	0.90* (0.87–0.93)
Public transport within 10–15 min walk from home				
Agree	64.8	1.00	64.9	1.00
Disagree	61.4	0.84 (0.50–1.43)	67.2	1.11* (1.06–1.15)
Footpaths on most of streets in neighborhood				
Agree	64.4	1.00	64.0	1.00
Disagree	62.8	0.91 (0.55–1.51)	67.4	1.15* (1.11–1.20)
Neighborhood has free or low cost recreation facilities				
Agree	64.1	1.00	65.7	1.00
Disagree	62.5	0.93 (0.55–1.57)	65.0	0.96 (0.92–1.00)
Crime rate makes it unsafe to walk: NIGHT				
Agree	55.3	1.00	60.0	1.00
Disagree	67.0	1.60 (0.93–2.75)	67.4	1.37* (1.32–1.43)
Crime rate makes it unsafe to walk: DAY				
Agree	57.6	1.00	54.7	1.00
Disagree	63.5	1.18 (0.56–2.50)	66.0	1.59* (1.46–1.73)
Neighborhood connections				
Go outside local area to visit family				
No	62.7	1.00	57.7	1.00
Yes	63.9	1.09 (0.60–2.01)	66.7	1.46* (1.38–1.53)
Can get help from friends when need it				
No	59.3	1.00	55.6	1.00
Yes	64.7	1.26 (0.56–2.85)	66.1	1.58* (1.46–1.70)
Could ask neighbor to help care for someone				
No	59.8	1.00	63.2	1.00
Yes	68.3	1.57 (0.93–2.66)	67.5	1.25* (1.20–1.29)
Visited neighbor in past week				
No	59.0	1.00	61.8	1.00
Yes	68.2	1.53 (0.92–2.54)	68.6	1.39* (1.34–1.45)
Likely to run into friends and acquaintances locally				
No	63.9	1.00	58.4	1.00
Yes	63.4	0.96 (0.46–2.01)	66.6	1.44* (1.37–1.52)

(continued on next page)

Table 3 (*continued*)

	Aboriginal N = 314		Non-Aboriginal N = 59,175	
	% meet PA	Odds ratios	% meet PA	Odds ratios
Done favor for sick neighbor in past 6 months				
No	60.4	1.00	62.8	1.00
Yes	66.9	1.47 (0.87–2.48)	68.8	1.33* (1.28–1.38)
Agree most people in neighborhood can be trusted				
No	56.1	1.00	60.9	1.00
Yes	65.2	1.49 (0.82–2.74)	66.2	1.29* (1.22–1.37)
Area has reputation as a safe place				
No	60.0	1.00	60.4	1.00
Yes	65.1	1.20 (0.60–2.42)	66.0	1.30* (1.22–1.38)
Social support				
Times last week with friends, family (do not live with)				
0–3	63.2	1.00	62.0	1.00
4+	64.9	1.05 (0.63–1.76)	70.8	1.51* (1.46–1.57)
Times last week at social clubs, other groups meetings				
0	59.3	1.00	62.4	1.00
1+	68.4	1.61 (0.95–2.73)	68.1	1.33* (1.28–1.38)
People outside home, within 1 h travel can depend on				
0–3	57.9	1.00	61.0	1.00
4+	68.2	1.62 (0.97–2.71)	68.1	1.37* (1.32–1.42)

Test of interaction by Aboriginality of sociodemographic, behavioral, neighborhood built environment and social support variables and meeting the physical activity recommendations were not statistically significant.

* Statistical significance $p < 0.05$.

between Aboriginal and non-Aboriginal participants. Neighborhood conditions such as low crime rate and greater social interaction/social support were associated with achieving the physical activity recommendations. Despite less favorable neighborhood environments, the proportion of Aboriginal participants achieving the recommended physical activity recommendations was similar to the proportion of non-Aboriginal participants.

Given these high proportions and the tendency for physical activity to be over reported when measured through self report (Brown et al., 2004b), we focused on the results of the modeling of the upper threshold of the recommendations. While these high levels of physical activity are encouraging, particularly among the Aborginal participants, they may in part be due to a 'healthy cohort effect' where participants in studies tend to be healthier than the overall population from which they are sampled (Struijk et al., 2015).

The socio-demographic, neighborhood built environment and social support correlates of physical activity are largely consistent with existing literature (Saelens et al., 2003; Foster et al., 2014) in both Aboriginal and non-Aboriginal participants in our sample. An exception to this was our finding that females were more active than males. Males are typically more active than females in Australia (Australian Bureau of Statistics (ABS), 2013a) and internationally (Guthold et al., 2008). However, in specific population sub groups, including ethnic minorities and middle to older aged adults, females tend to be more active than males or rates are similar (Hawkins et al., 2009; Martin et al., 2014). Our findings appear to reflect these differences according to gender and across the life-course, both in the Aboriginal and non-Aboriginal sub groups.

Factors that influence physical activity can be explained through the socio-ecological model which takes account of both individual and social environmental aspects (McLeroy et al., 1988). The model has been adapted to include specific factors influencing physical activity participation among Aboriginal Australians, such as colonisation (structural macro-social factor), feeling unsafe in a physical environment (structural environmental factor) and family and community connections (social connections) (Nelson et al., 2010). While our findings highlight that Aborginal people experience less desirable neighborhood environments, as well as lower indicators of social support, similar levels of physical activity are achieved. This may be due to a cultural emphasis on, or acceptability of, physical activity and sport among Aboriginal people (Thorpe et al., 2014). Other influencing factors could include a level of resilience among the Aboriginal sample in our study where despite less than ideal conditions for health, reasonable health outcomes can be achieved. Evidence of links between resilience and Aboriginal health are emerging but appears to be positively associated with a strong traditional culture (Currie et al., 2013); therefore emphasising cultural connections is important. Other determinants of physical activity in Aboriginal populations may not yet be known or understood. Further, analyses of cohort studies including Aboriginal people, or qualitiative exploratory research may elucidate greater insights.

Aboriginal participants were more likely to have unfavorable neighborhoods compared to non-Aboriginal participants. However, following adjustment for remoteness of residence, some of these associations were attenuated which could be attributed to Aborginal Australians being more likely to live in rural/remote areas than non-Aboriginal Australians (Australian Bureau of Statistics (ABS), 2011). The use of the adapted PANES, which was established to measure physical activity and neighborhood environment aspects in urban populations only (Sallis et al., 2010), may also in part explain these findings. The development and validation of a corresponding measure for non-urban neighborhoods is important for future investigation. Further, some of the findings where the direction of association differered between participant groups, such as distance from public transport and presence of footpaths, could be due to the use of the PANES in a cohort where ARIA differed according to Aboriginality. Regardless, these findings indicate that for the majority of neighborhood built environment attributes, Aboriginal participants were more likely to experience or perceive a less satisfactory position, even after accounting for education, a commonly used indicator of (dis)advantage.

Hence, these data show that features of the neighborhood environment are associated with physical activity levels and that Aboriginal people report less physical activity favorable neighborhood attributes. The findings suggest that addressing features of the neighborhood and environment, such as walkability, crime and amenities could specifically improve physical activity levels. They also provide general support for policy based on the social determinants of health, where financial resources and the everyday conditions in which people live and work, such as the neighborhood environment, are targeted to reduce inequalities that influence health (Friel and Marmot, 2011). Recent evidence highlights the role of neighborhood walkability and safety in mediating the association between education level and physical activity (Pratt et al., 2015) suggesting specific modifiable neighborhood features.

This study found that those participants who were told to be more active by their GPs were those who were less likely to be achieving the physical activity recommendations suggesting that both Aboriginal and non-Aboriginal people are receiving the appropriate health advice. The effectiveness of GP advice to patients to be more physically active is well established (Orrow et al., 2012), but widespread implementation of such advice remains a public health challenge. A recent national survey demonstrated less than a fifth of participants had received advice from their GP to be active in the past year, but similar to our study, advice was more commonly given to those with poorer health (Short et al., 2015). Further exploration of GP advice to be physical active longitudinally would help understand how this strategy can be best utilised and establish whether the provision of such advice leads to behavior change over time. Specific training, protocols and resource provision for GPs may prove effective measures.

Among non-Aboriginal people, those who spent less than eight hours a day sitting were significantly more likely to meet the physical activity recommendations. A similar, but non-significant, finding was also evident in Aboriginal people. This is consistent with the evidence for the health risks of lengthy time periods spent sitting that has been established in recent years in mainstream populations (Bennie et al., 2013) and across sex and race groups in the U.S. (Staiano et al., 2014). Little is known of sitting time prevalence and associated health risks among Australian Aboriginal people although recent ABS data found Aboriginal adults in non-remote areas spent an average of 5.3 h per day in sedentary behavior, which was less than their non-Aboriginal counterparts (Australian Bureau of Statistics (ABS), 2014b). These findings provide emerging evidence of the association between physical activity and sitting time which should be examined in future epidemiological studies of health behaviors in Aboriginal populations.

This study showed that social support was correlated with achieving the physical activity recommendations. Having four or more people outside home to depend on was significantly associated with meeting the physical activity recommendations. Social support is an established correlate of physical activity in the general population (Nieminen et al., 2013) and given the holistic context of Aboriginal health, where physical, mental, social and spiritual aspects are interconnected, it could possibly have a stronger influence. However, given that we also found Aboriginal people were less likely to have four or more people outside home to depend on, as well as being less likely to spend time in the past week at social clubs; this seems to reflect an overall lower level of social connect within this Aboriginal sample. Yet it should be noted that the Duke Social Support Scale used in this study focuses on social contacts outside the home, which may not capture social support within the household or family; such household and family support may be of greater importance to Aboriginal people (Williamson et al., 2010).

Strengths of the present study include the large sample of almost 60,000 middle-older age adults and a relatively large sample of Aboriginal participants followed up in a cohort study. The SEEF study captures data on many indictors of the neighborhood built environment and social support together in a study of this magnitude. It provides data for the first time of these behavioral, social and environmental characteristics together within a specific Australian Aboriginal population group and one of the first of any Indigenous populations internationally. The findings should be acknowledged within several limitations including the self-reported, cross-sectional nature of the study and the small number of Aboriginal, relative to non-Aboriginal, respondents. This led to a larger number of significant associations in the non-Aboriginal population. However, testing of interaction effects revealed no differences between the two groups. Therefore, the non-significant findings in Aboriginal people where the direction of associations and magnitude of ORs matched that of the non-Aboriginal participants can be attributed in part to the smaller Aboriginal sample size. However, with several hundred Aboriginal participants, this study is large relative to many other Aboriginal studies. Further, there may have been sample bias reflecting participants with higher levels of literacy and education level than the general population, particularly among Aboriginal people who experience higher levels of disadvantage. In light of these strengths and limitations, it is important not to over-interpret non-significant findings in this context, and to not infer causality from the observed associations.

Conclusions

Despite unfavorable neighborhoods and reduced social support, Aboriginal participants in this cohort were as likely to be achieving the physical activity recommendations compared to non-Aboriginal participants. Factors associated with achieving the recommendations were similar between Aboriginal and non-Aboriginal participants and included younger age, higher education, higher income, greater social support and more favorable neighborhood conditions such as perceived low crime rates. Given that significant disparities in the neighborhood built environment and social support were found among Aboriginal compared to non-Aboriginal people; this is an important area for future research and public health policy and programs.

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.pmedr.2016.01.006.

Conflict of interest

The authors declare that there are no conflicts of interests.

Transparency document

The Transparency document associated with this article can be found, in online version.

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Chapter 3

Correlates of physical activity among Indigenous and non-Indigenous adolescents

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Chapter 2 established physical activity levels among Aboriginal and Torres Strait Islander adults aged 45 years and over and whether these were associated with known correlates of physical activity among mainstream populations, using cross-sectional data. These correlates were healthy lifestyle behaviours, neighbourhood environmental characteristics and social support.

Chapter 3 contributes to the evidence base around the associations between physical activity and health of Aboriginal and Torres Strait Islander people by examining cross-sectional demographic, social, psychosocial and health correlates of physical activity among Aboriginal and non-Aboriginal young people in NSW. The study was a secondary analysis of existing physical activity data that had already been collected during 2009/10 as part of a broader study on resilience and health among young people across NSW. The secondary analysis was conducted during 2014.

Correlates of physical activity among Australian Indigenous and non-Indigenous adolescents

Rona Macniven,[1] Shane Hearn,[2] Anne Grunseit,[1] Justin Richards,[1] Don Nutbeam,[1] Adrian Bauman[1]

Abstract

Objective: Physical inactivity is an important modifiable cause of the excess burden of disease among Indigenous Australians. We describe physical activity patterns and influencing factors, comparing Indigenous and non-Indigenous adolescents.

Methods: Indigenous (n=359) and non-Indigenous (n=637) adolescents aged 13-17 years from disadvantaged New South Wales regions completed a health and lifestyle survey. Socio-demographic, social, psychosocial and health correlates of out of school physical activity (high vs. low) among the whole sample, and stratified by Indigenous status were examined.

Results: Only 21% of Indigenous and 28% of non-Indigenous adolescents achieved higher levels of physical activity. Overall, higher levels were associated with being male; sports team membership; lower levels of TV viewing time and having an employed mother. Indigenous girls were less active than boys (OR=0.36; 85%CI=0.24-0.54), as were those whose mothers were unemployed (OR=0.66; 95%CI=0.40-1.09). Among non-Indigenous adolescents, high levels of physical activity were associated with sports team membership (OR=2.28; 95%CI=1.39-3.74) and community involvement (OR=1.46; 95%CI=1.04-2.06).

Conclusions: Physical activity levels were similarly low among disadvantaged Indigenous and non-Indigenous adolescents. Some influencing factors existed across the whole sample; others in stratification by Indigenous status.

Implications for public health: Early and targeted, supportive approaches are necessary. Some apply to disadvantaged adolescents broadly; others are Indigenous or non-Indigenous specific.

Key words: physical activity, Indigenous, adolescence

The health status and life expectancy of people of Australian Aboriginal and Torres Strait Islander (Indigenous) descent are considerably lower than their non-Indigenous counterparts in Australia.[1,2] National data also reveal a gap in life expectancy between the highest and lowest socioeconomic groups of four and two years among males and females, respectively, among the general adult population.[3] Physical inactivity is an important contributor to the burden of disease, and for Indigenous Australians accounts for 6% of the total burden in 2011.[4] This is similar to the 5% of the total burden of disease and ill-health attributed to physical inactivity among the overall Australian population.[5]

In Australia and internationally, at least an hour per day of moderate to vigorous physical activity (MVPA) is recommended for young people.[6] A greater proportion of Indigenous children from non-remote areas aged 5-17 years are achieving these recommendations than non-Indigenous children (48% vs. 35%).[7] However, at age 18+ years, less than half of Indigenous people (46%) meet the less intensive minimum recommendations for adults of 150 minutes of MVPA per week;[8] after adjusting for age differences between the two groups, this level was lower than non-Indigenous adults.[9] Lower levels of physical activity are also evident among low socioeconomic groups within developed countries.[10]

Being physically active during adolescence is associated with a number of modifiable and non-modifiable factors. Males are more active than females and the higher activity levels observed among younger children decline during adolescence.[11] As well as these individual correlates, a number of family, socio-demographic and behavioural characteristics including higher affluence and lower levels of TV viewing are associated with higher physical activity.[12] Participation in organised sport is also associated with being more physically active overall.[13] There are also consistent associations between sport and psychosocial health such as improved self-esteem, social interaction and fewer depressive symptoms.[14] These correlates represent critical targets for initiatives to increase activity yet only a small number of studies have focused on disadvantaged young people and fewer still among Indigenous populations. These are both groups in which both increased rates of risk factors and low rates of physical activity have been documented.

While physical education in schools is an important contributor to activity levels in school-aged children,[15] participation outside of school hours is vital to achieve optimal levels of physical activity for health benefits.[16] Further, declines in out-of-school physical activity are particularly pronounced during adolescence[17] and into adulthood,[18] identifying a key time period in which to establish patterns and habits that can be continued into adulthood.

This study describes and compares factors associated with physical activity in the out-of-school setting reported among a large community sample of Indigenous and non-

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Indigenous Australian adolescents living in disadvantaged areas. It explores associations between demographic, health and lifestyle factors and participation in physical activity, by Indigenous status.

Methods

Population and sampling

Participants were Indigenous and non-Indigenous adolescents aged 13 to 17 years enrolled in the public school system in NSW in 2010. All public high schools in NSW with an Indigenous enrolment greater than 5% were considered for inclusion in the study, as determined by the NSW Department of Education and Training (DET). Due to time and logistical constraints, the sampling frame was narrowed to 23 schools with the highest Indigenous enrolment located within 800 km of Sydney. Initial contact with schools was made via each school's generic email address, followed by a telephone call to the Principal one week later. Thirteen schools agreed to take part. Reasons for non-participation included a lack of time and a perceived burden from participating in research. Once participation of a school was confirmed, a date and time were scheduled to administer the surveys and a package sent to the principal in advance containing information for participants and consent forms. School staff were provided with an outline of the study and collected consent forms from students. An Indigenous researcher (SH) travelled to each school to administer surveys either in a classroom or in a common area such as a school hall. All adolescents aged 13–17 years at each participating school were invited to complete the survey. Information on student absenteeism on the day of data collection was sought from each school.

Survey instrument

A 54-item questionnaire, the Health and Lifestyle of NSW School Students Survey was developed primarily to measure resilience and lifestyle behaviours among adolescents and piloted with 28 subjects aged 13-17 years (25 of Indigenous descent). Test-retest reliability over a 10 day period was acceptable with Spearman rank order coefficients showing most test-retest correlations >0.6.[19] Pilot study participants also attended a focus group and provided feedback and suggestions to improve the face validity and readability of the questionnaire.

The questionnaire covered a range of established socio-demographic factors, physical health behaviours and mental health measures from various population studies conducted previously with diverse populations of adolescents.[20-22] Physical activity was of interest, given known declines during adolescence[18] and the relationships between physical activity and both chronic disease[23] and mental health in this age group.[24]

Measures

MVPA was measured according to reported frequency and duration. The frequency question asked "Outside school hours: How often do you usually exercise in your free time, so much that you get out of breath or sweat?" with response categories: every day; 4-6 times a week; 2-3 times a week; once a week; once a month or less. The duration question asked "Outside school hours: How many hours do you usually exercise in your free time, so much that you get out of breath or sweat?" with response categories: 7 or more hours a week; about 4-6 hours a week; about 2-3 hours a week; about 1 hour a week; about ½ hour a week; none. These questions have been used previously with diverse and disadvantaged adolescent health surveys and have acceptable measurement properties.[25] Consistent with the methods established by the validation study, the response categories 'every day' or '4-6 times a week' were recoded as 'highly active by frequency' and '7 or more hours a week' and 'about 4-6 hours a week' were recoded as 'highly active by duration'. Responses were further categorised by whether or not respondents were both highly active by frequency *and* duration, "higher levels of physical activity" representing a level most closely approximating meeting recommendations of at least 60 minutes MVPA per day.[6]

Socio-demographic variables were dichotomised as self-reported Indigenous status (Indigenous vs. non Indigenous), gender (male vs. female), region (urban vs. rural) and age based on the known timing of declines in physical activity (13-14yrs vs. 15-17yrs).[26] Social indicators were dual parent household (yes vs. no), has sibling (yes vs. no), father and mother employment, respectively (yes; no; unknown), been bullied this term (yes vs. no), bullied others this term (yes vs. no) and community involvement (strongly & moderately involved vs. a little & not involved). Psychosocial variables were also dichotomised based on distribution such that each category contained approximately equal numbers. Categories were: feeling happy/ok (happy & ok vs. not very & not at all happy); feeling lonely (very often & rather often vs. sometimes & never); feeling confident (always, often, sometimes vs. rarely & never); and feeling depressed in the last six months (not depressed vs. depressed in any setting). Health behaviours included were: ever smoked (yes vs. no); and ever been drunk (yes vs. no); sports team membership (yes vs. no); TV viewing time, dichotomised to approximate current sedentary behaviour recommendations (>3hrs/day vs. <3hrs/day).[27]

Statistical analyses

Pearson's chi-square tests assessed bivariate relationships between demographic and behavioural variables with achieving high (versus low) levels of physical activity in the whole sample and stratified by Indigenous status. Subsequently, three (whole sample, Indigenous only, non-Indigenous only) multivariate logistic regression models were run to calculate the odds of achieving higher levels of physical activity, with age, gender and variables which were significant ($p \leq 0.05$) in the bivariate analyses as the independent variables. Data analyses were carried out using SPSS version 17.0 and Stata version 11.1 and all inferential tests were adjusted for clustering within school using Stata's *svy* commands (StataCorp, College Station, Texas, US).

Ethics

Ethical clearance was obtained from the researchers' University Ethics Committee and a Government Department.

Results

In six of the 13 schools, absenteeism rates on the day of the survey ranged from 6.5% to 22.2%. The proportion of absentees in these schools did not differ by Indigenous status (17.4% vs. 13.9%; 95%CI=-0.1-7.2).[19] Survey completion response rates were 50% and 46% among Indigenous and non-Indigenous students, respectively, based on school enrolment numbers. In the remaining schools, corresponding response rates were also similar for Indigenous and non-Indigenous students. Each of the 13 participating schools were in areas in the lowest two quintiles, and half were in the most disadvantaged decile, of Census data on Socio-Economic Indexes for Areas (SEIFA) and the Index of Relative

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Social Disadvantage (IRSD).[28] A total of 996 adolescents completed the questionnaire (60% response rate among students at school on the survey day), 359 (36%) of whom reported they were of Indigenous descent. Respondents were aged between 13 and 17 years, with almost half aged 14 years (47.3%). Fifty-one percent of respondents were male but Indigenous males were underrepresented at 46.5% of the total male sample whereas Indigenous females represented a high proportion of total female respondents at 53.5%. Rates of single parent families were higher in the Indigenous compared to non-Indigenous adolescents (32.7% vs. 26%, p>.001).[19] Only just over a quarter (26%) of the total sample achieved higher levels of physical activity. The proportion of adolescents achieving this level in relation to demographic, social, psychosocial and health variables in the whole sample, and stratified by Indigenous status are presented in Table 1.

Whether a respondent achieved higher levels of physical activity varied significantly by Indigenous status; 21% (95%CI=17-25%) of Indigenous adolescents met the recommendations, compared with 28% (95%CI=25–31%) of non-Indigenous adolescents (p=0.01 in unadjusted analyses). Across all three groups, higher levels of physical activity were observed for girls aged 13-14 years compared to those aged 15-17 years (21.3% vs. 18.4% for the total sample; data not shown), whereas physical activity levels were higher among boys in the older versus younger age group.

In terms of other correlates, among the whole sample, eight variables were significantly associated with achieving higher levels of physical activity in the bivariate analyses. Being male, maternal employment, involvement in community, sometimes/never feeling lonely, feeling confident, ever having been drunk, sports team membership and watching less than three hours of TV daily were associated with being more physically active. Five variables were significantly associated with higher levels of physical activity among the Indigenous sub-sample: being male; maternal employment; paternal employment often/always feeling confident; and community involvement. For non-Indigenous respondents, sports team membership, lower TV viewing time per day, feeling confident and community involvement were significantly associated with higher levels of physical activity.

Table 1: Percentages achieving high levels of physical activity[d,e] and bivariate relationships across demographic variables in whole sample, Indigenous and non-Indigenous adolescents.[a,c]

Variable[b]		N	Total sample (n=996)		Indigenous (n=359)		Non-Indigenous (n=637)	
			%	*p* value	%	*p* value	%	*p* value
Socio-demographic factors								
Age	13-14 years	652	24.4	0.183	21.0	0.763	26.5	0.264
	15-17 years	337	28.7		22.1		31.8	
Gender	Male	512	31.0	0.001	29.6	<0.001	31.2	0.113
	Female	419	20.5		14.3		24.8	
Region	Urban	415	26.3	0.811	21.4	0.996	28.8	0.790
	Rural	588	25.5		21.4		27.8	
Social influences								
Dual parent household	Yes	653	26.3	0.710	20.1	0.389	29.0	0.745
	No	339	24.9		22.7		27.0	
Has sibling	Yes	810	25.8	0.872	20.1	0.628	29.0	0.524
	No	125	25.0		23.8		25.6	
Father employed[f]	Yes	725	27.6	0.073	25.5	0.014	28.3	0.967
	No	118	18.8		13.2		28.3	
	Unknown	160	22.5		16.5		27.8	
Mother employed[f]	Yes	624	29.9	0.015	26.9	0.041	30.9	0.229
	No	275	18.6		14.0		22.4	
	Unknown	104	19.2		17.1		20.6	
Been bullied this term	Yes	426	25.3	0.685	18.9	0.321	27.9	0.808
	No	562	26.3		22.9		28.6	
Bullied others this term	Yes	477	26.0	0.963	21.4	0.968	28.9	0.738
	No	499	25.8		21.6		27.6	
Involvement in community	Yes	303	33.3	<0.001	26.3	0.040	37.7	<0.001
	No	656	22.6		19.0		24.3	
Psychosocial influences								
Feeling happy/ok	Happy/ok	880	26.4	0.128	21.9	0.251	28.8	0.335
	Not very/not at all happy	113	20.4		16.7		23.2	
Feeling lonely	Never	854	29.8	0.040	24.1	0.085	33.3	0.095
	Sometimes/often/very often	141	23.3		19.2		25.3	
Feeling confident	Rarely/never	106	20.0	0.010	14.4	0.017	23.7	0.036 *
	Always/often/sometimes	883	29.7		26.1		31.3	
Feeling depressed	Depressed in any setting	721	25.9	0.994	20.2	0.070	28.7	0.588
	Not depressed	273	25.9		24.6		27.2	
Health risk factors								
Ever smoked	Yes	354	25.9	0.998	22.4	0.784	29.0	0.825
	No	644	25.9		20.7		28.0	
Ever been drunk	Yes	425	28.6	0.019	23.9	0.379	32.1	0.069
	No	437	24.0		19.5		25.4	
Sport team member	Yes	489	33.7	<0.001	26.9	0.067	37.3	<0.001
	No	502	18.4		16.4		19.4	
TV viewing time	>3hrs/day	763	24.1	0.026	20.6	0.585	25.7	0.002
	<3hrs/day	233	31.6		23.7		37.9	

a: Indigenous status was unknown for two respondents (missing data).

b: Participants who did not respond to a specific question were excluded from the analysis for that question.

c: P value refers to tests of bivariate associations for whole sample and stratified by Indigenous status.

d: Achieving high levels of physical activity was defined as participation of a frequency of 'every day' or '4-6 times a week' and '7 or more hours a week' and 'about 4-6 hours a week'.

e: % achieving high levels of physical activity was adjusted for clustering at the school level.

f: A category for where parental unemployment was unknown was included, as a high proportion (16% for father's employment, 10% for mother's) of the sample had missing data for this variable. It is likely that a majority of these missing data were due to respondents coming from single parent families (only 27% and 39% of those with missing data for father's and mother's employment respectively were from dual parent households compared with around two-thirds among those without missing data).

The results of the analyses adjusting for age, sex and the variables significant in the bivariate analyses described above are shown in Table 2. Among the whole sample, achieving higher levels of physical activity did not differ by Indigenous status (OR=0.75, 95% CI 0.51-1.11) once adjusted for other covariates. However, gender, sports team membership, maternal employment and involvement in community remained

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significant correlates of higher physical activity levels.

Among Indigenous students, the odds of achieving higher levels of physical activity were significantly lower for females compared with males, and for those whose mothers were unemployed compared with those whose mother was employed. The odds of achieving higher levels of physical activity were significantly higher among Indigenous students who felt confident 'always, often or sometimes' compared with those who 'rarely or never' felt confident. Among the non-Indigenous sample, sports team membership and 'involvement in community' remained significant independent correlates of achieving higher levels of physical activity.

Discussion

Our findings indicate that less than a quarter of this sample of adolescents achieved higher levels of physical activity in the out-of-school setting. The proportion achieving this level was significantly lower among Indigenous adolescents, but this difference became non-significant after adjusting for other variables.

These low rates of physical activity in both Indigenous and non-Indigenous groups may largely relate to the sampling frame used to recruit high numbers of Indigenous adolescents that resulted in the selection of schools within areas of overall levels of disadvantage. While individual-level measures of SES were not obtained from our questionnaire, social disadvantage was further manifest in the students' survey responses through higher reported rates of paternal unemployment and single parent status in both Indigenous and non-Indigenous groups, compared to the NSW average according to Census data.[29] Relative to those from more advantaged areas, young people experiencing social disadvantage are less active[30] and report more sedentary behaviour.[31,32] This may be due to a combination of complex factors including reduced opportunities and expectations to be active, less supportive families and social networks, poorer access to facilities and neighbourhood safety concerns.[33]

Physical activity levels in both Indigenous and non-Indigenous adolescents in our sample were considerably lower compared with ABS data of 48% and 35% meeting national recommendations, respectively.[7] This is likely due at least in part to the older group sampled for the current study (13–17 years compared with that underlying the ABS data, 5–17 years), reflecting the age-related decline in physical activity described earlier. Additionally, while the ABS data measured total activity, the HBSC measures only activity which occurred outside of school hours, which meant we did not capture all of our respondents' time spent being physically active. However, validation of the HBSC with objective fitness testing allows for comparability across measures and domains of physical activity,[25] giving legitimacy to the data from this sample.

Consistent with previous research, male gender[34] and sports team membership[35] were associated with higher levels of physical activity in this sample, as well as maternal employment and community involvement which are less well established correlates. However, it is evident that the relative importance of some factors and their association with physical activity may differ between Indigenous (gender, maternal employment, confidence) and non-Indigenous (sports team membership, community involvement) adolescents. These findings call for early and targeted, supportive approaches to promote regular physical activity. Some interventions may apply to disadvantaged adolescents broadly, while others may be specifically relevant to Indigenous or non-Indigenous adolescents. There is some demonstrated effectiveness of programs to improve lifestyle behaviours among Indigenous and disadvantaged students within the school setting,[36] however few have focussed on promoting physical activity among Indigenous young people or been rigorously evaluated. Involvement of local Aboriginal organisations can be critical to the delivery and success of sport and lifestyle programs[37] and such partnership approaches are suggested in future policy responses.

Our findings reinforce other research findings that Australian girls are less active than boys.[38] It appears that gender differences begin to emerge during early adolescence[39] and increase year-on-year. Importantly, our data found a stronger gender difference in the Indigenous sample compared to the non-Indigenous participants. This may be due in part to cultural factors relating to gender in Indigenous communities, which may require culture-specific solutions[40] such as initiatives targeted to Indigenous girls. Family support and facility access have been found to be a pathway for associations between sports club participation and socioeconomic status among female adolescents[41] and represent important future avenues for enhancing participation rates.

An important contributor to physical activity in young people is participation in organised

Table 2: Adjusted odds ratios (OR) with 95% confidence intervals (CI) for respondents achieving high levels of physical activity in relation to demographic variables among the whole sample and stratified by Indigenous status.

Variable (reference category)	Whole sample[a] OR (CI)	Indigenous[b] OR (CI)	Non-Indigenous[b] OR (CI)
Socio-demographic factors			
Indigenous (Non-indigenous)	0.75 (0.51-1.11)		
Age 13–14 years (15–17 years)	0.90 (0.57-1.43)	1.15 (0.72-1.85)	0.80 (0.48-1.36)
Gender (Male)	0.67 (0.46-0.98)	0.36 (0.24-0.54)	0.77 (0.47-1.26)
Social influences			
Father unemployed (employed)		0.75 (0.38-1.50)	
Unknown (employed)		0.57 (0.31-1.05)	
Mother unemployed (employed)	0.66 (0.40-1.09)	0.47 (0.24-0.92)	
Unknown (employed)	0.52 (0.35-0.79)	0.78 (0.40-1.52)	
Sports team member (No)	2.13 (1.35-3.38)		2.28 (1.39-3.74)
Involved in community (No)	1.30 (1.00-1.68)	1.40 (0.87-2.24)	1.46 (1.04-2.06)
Psychosocial influences			
Feeling lonely: Always/often/Sometimes (Rarely/never)	0.82 (0.57-1.18)		
Feeling confident: Always/often/Sometimes (Rarely/never)	1.05 (0.68-1.64)	1.93 (1.05-3.57)	1.05 (0.70-1.59)
Health risk factors			
Ever been drunk (No)	1.30 (0.96-1.75)		
TV viewing time >3 hours (<3 hours)	0.67 (0.45-1.00)		0.59 (0.40-1.59)

All models adjusted for age and gender and those variables significant in the bivariate analyses:

a: Whole sample model: adjusted for age; gender; sports team member; TV viewing time; mother employed; ever been drunk; feeling lonely; involved in community;

b: Indigenous model: adjusted for age; gender; mother employed; feeling confident; involved in community; Non-Indigenous model: adjusted for age; gender; sport team member; TV viewing time; feeling confident; involved in community.

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sport.[42] We found sports team membership was associated with higher levels of physical activity in both the total and the stratified non-Indigenous sample, but not among the Indigenous respondents. The lack of association found in this Indigenous sample may reflect cultural preferences towards unstructured physical activity such as Caring for Country programs.[43] Despite experiences of racial stereotyping in sport,[44] there are claims that sport strengthens pride and identity among Indigenous populations in Australia[45] and long standing program practice exist.[46] However, estimations of the positive effects of Indigenous sport programs and their association with health outcomes may be overstated.[47]

Higher levels of feeling confident were found to be associated with higher physical activity among the Indigenous participants only. There is evidence of a relationship between physical activity participation and self-efficacy, the belief in oneself to achieve goals.[48,49] However, previous studies have not examined this association in Indigenous youth. While our findings may provide emerging evidence of a similar relationship, cross-sectional data does now allow for inference of whether this finding can be directly attributed to physical activity.

Our finding that community involvement was significantly positively correlated with higher levels of physical activity in non-Indigenous adolescents may partly relate to higher rates of sports team membership being synonymous with overall community club involvement. This may further reflect the semi-rural nature of this sample; rural adolescents have demonstrated higher fitness levels than their urban counterparts[50] again reflecting higher participation in community based physical activity. While previous research has found lower rates of involvement in organised sport in low SES neighbourhoods,[41,51] such evidence was derived from studies in urban environments. However, physical activity relating to community involvement cannot be tied to sport alone. There is evidence of an association between both neighbourhood and social connections and physical activity among Indigenous and non-Indigenous adults.[52] Identifying the influence of these environments on physical activity levels in adolescents may help identify the specific mechanisms which lead to increased physical activity, which could be targeted in future behavioural interventions.

After adjusting for age, gender and other significant factors in the bivariate analyses, the association between physical activity and TV viewing time in the whole sample was only marginally significant. Previous studies have indicated that TV viewing time is associated with decreased fitness[53] and lower levels of physical activity, yet complex associations between these two behaviours exist.[54]

It is widely accepted that in order to improve rates of adoption of healthy behaviours such as physical activity among adolescents, a broad population approach that targets the fundamental determinants of health, including education, access to facilities and health literacy is important.[55] Improving equity in opportunities for physical activity among all disadvantaged populations, including and especially those with high proportions of Indigenous Australians is necessary. Using approaches which focus on the social determinants of health could translate to culturally appropriate and role modelling initiatives focussed around sport or wellbeing more broadly, together with educational outcomes. Such initiatives show promise.[46,56] Our results also suggest more targeted approaches would be beneficial to increasing physical activity, with specific emphases on the effects of social disadvantage and gender differences, especially among Indigenous adolescents. Further investigation of culturally-based physical activity preferences and their relationship with levels of participation is required. A number of community-based initiatives for young people exist but program evaluation is limited[57] and should be a priority to inform resource allocation. Finally, the emerging evidence of a positive association between feeling confident and being physically activity among our sample should be explored longitudinally in future studies of mental health and physical activity, particularly among Indigenous populations.

Strengths and limitations

A strength of this study was that it included a large sample of young Indigenous Australians, which is rare in research and government data. Whilst the sample was not population representative and may be subject to recruitment bias, the large absolute number of Indigenous adolescents makes these findings indicative and strengthens the evidence base around physical activity behaviour of Indigenous adolescents. It also allows for the identification of some similarities in the issues faced by those of both Indigenous and non-Indigenous background residing in areas of socioeconomic disadvantage. Our measurement tool was based on existing established measures,[20] was reliable and valid and allowed for the examination of a comprehensive range of correlates of physical activity. Although objective measures are generally considered more robust than self-reporting, only one previous study has established the measurement properties of objective physical activity measures among both Indigenous and non-Indigenous young people.[58]

Limitations include the self-reporting measures used and some non-responses arising from school absenteeism and sampling factors. Response rates were however similar among both Indigenous and non-Indigenous adolescents. The cross-sectional nature of the data also limits the causal inferences from this study. Nonetheless, these data provide initial insights into physical activity levels and its correlates in well powered study of a population group where there is little existing information. Comprehensive, regular measurement of physical activity in populations of young people, particularly among those experiencing disadvantage warrants further effort in order to capture trends and monitor progress in policies and initiatives. Such measurement could be strengthened through more detailed examination of temporal and seasonal patterns of physical activity. Longitudinal designs would also facilitate the elucidation of causal mechanisms on the determinants of physical activity among disadvantaged youth.

Conclusion

Physical activity levels in Indigenous and non-Indigenous adolescents in the out-of-school setting were similarly low in this large disadvantaged adolescent sample. Indigenous girls, those from fragmented families, or those feeling disengaged from their community had particularly low activity levels. Improving opportunities for physical activity among disadvantaged populations, including those with high proportions of Indigenous Australians is necessary. These findings can guide future research examining physical activity correlates in priority population groups and provide directions for targeted, supportive approaches within

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schools and the wider community. Further investigation of culturally based physical activity preferences and their relationship with levels of participation is required.

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Chapter 4

Understanding age related declines in physical activity among Aboriginal and non-Aboriginal young people

Under Review

Chapter 3 examined overall physical activity levels among a population of among Aboriginal and non-Aboriginal young people in NSW and socio-demographic, social, psychosocial and health correlates of physical activity.

Chapter 4 contributes to the evidence base around the associations between physical activity and health of Aboriginal and Torres Strait Islander people by examining physical activity levels among Aboriginal and non-Aboriginal young people in NSW through a repeat cross-sectional analysis. This builds on the cross-sectional findings of Chapters 2 and 3 by providing data at two time points and within different domains of physical activity, using secondary data on physical activity that was already collected as part of a broader study conducted between 2007 and 2012.

Understanding age related declines in physical activity among Aboriginal and non-Aboriginal young people

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Abstract

Background Declines in moderate-vigorous physical activity (MVPA) commence before adolescence but descriptive epidemiology of age-related declines among Aboriginal children is limited. We examined MVPA variation by season, setting and type among rural Aboriginal and non-Aboriginal Australian children.

Methods Children aged 10-14 years in 38 schools during 2007/8 (T1) and 2011/12 (T2) self-reported 14 MVPA components. Linear Mixed Models assessed MVPA mean minutes and 95% confidence intervals (CIs) for Aboriginal and non-Aboriginal children and between-group mean differences over time. Community focus groups identified physical activity barriers.

Results A total of 1620 children (251 Aboriginal) at T1 and 1035 children (240 Aboriginal) at T2 provided data. Total MVPA, winter after-school activity and travel to/from school in both seasons declined over time in both groups (≤0.005). Significant declines occurred in both summer and winter non-organised, winter organized and school (-52.3mins) activity among Aboriginal children and group-by-time differences in activity in summer weekend ($p=0.02$), winter organised ($p<0.001$), and school ($p<0.001$) in both seasons. Physical activity barriers data informed the context of these declines.

Conclusions Physical activity declines were stronger among Aboriginal, compared to non-Aboriginal, children. A multi-strategic approach to increase physical activity during the critical time of adolescence is necessary to improve Aboriginal health.

Background

In Australia, the life expectancy of Aboriginal people is around 10 years lower than non-Aboriginal people [1]. Health disparities between Aboriginal and non-Aboriginal Australians commence in childhood; Aboriginal children experience rates of type 2 diabetes six times higher than non-Aboriginal children [2]. Regular participation in physical activity across the lifespan is a recommended strategy for the prevention of diabetes and other chronic diseases [3].

The Australian physical activity recommendations for children aged 5 to 17 years advise accumulation of at least 60 minutes per day of moderate-vigorous physical activity (MVPA) [4]. Physical activity participation across multiple contexts and settings is necessary to ensure children meet national recommendations [5]. Therefore, promoting physical activity and this may vary according to season [6] and on weekdays versus weekends [7]. Sports clubs provide an important organised setting for physical activity [8], yet much of children's physical activity occurs outside organised settings [9]. This may include the period after school [10] and during active commuting to/from school [11].

Global declines in physical activity prior to the period of adolesence are evident and have been demonstrated in children as young as seven years old [12]. In Australia, the New South Wales (NSW) Schools Physical Activity and Nutrition Survey (SPANS) observed decreases in the proportion of children meeting physical activity recommendations between 2004 and 2010 [13]. Physical activity declines may be particularly pronounced in rural settings where children in general are known to be less active than in urban areas [14].

Children's participation in regular physical activity is strongly influenced by individual and environmental barriers. This is well established in mainstream populations where commonly

reported barriers include a lack of time [15], availability and suitability of activities [16], affordability as well as and neighbourhood and home safety, travel distances, weather and parental influence [17]. Studies involving Aborginal participants are rarer but one study of girls in remote Australian communities found 'shame' or being ashamed of being physically active as a barrier negatively influenced participation [18]. A further study in a regional area of Australia found that young people described various environmental barriers such as transport to facilities, poor amenities and asthetics [19].

A recent cross-sectional study, using validated measures, found low levels of overall physical activity in a sample of Aboriginal children [20]. National government data highlights that while Aboriginal children aged 5-17 years are more active than their non-Aboriginal counterparts, the reverse is true for adults [21]. The timing of these age related changes are unknown. Physical activity participation across multiple domains, or across multiple time points has yet to be described. This study aimed to explore how age related changes in physical activity varied according to season, setting and type among Aboriginal and non-Aboriginal children living in rural NSW, Australia and participating in the Many Rivers Diabetes Prevention Project (MRDPP). The MRDPP was an Aboriginal community governed program of research and health promotion conducted between 2002 and 2013 in partnership with two rural NSW Aboriginal Medical Services. Changes in physical activity were examined in relation to barriers identified by the participating communities.

Methods

Study details

Participants in this repeated cross-sectional study were Aboriginal, and non- Aboriginal children in school grades 5, 6, 7 and 8, recruited through all primary and high schools in two towns and surrounding communities on the rural north coast of NSW. For Survey One (T1; 2007/8), children were sampled from all 38 schools (28 NSW Department of Education and Training and 10 independent) in the towns. For Survey Two (T2; 2011/12), 36 of the 38 schools who took part in the previous survey elected to participate again; one school had closed and in another no children consented. Aboriginal Project Officers (APOs) from the participating communities in which the schools were located provided key leadership in managing the information and consent process for all children during the data collection, assisted by casual Aboriginal staff, and participated in data entry and interpretations of results. Details of the comprehensive Aboriginal Community Governance processes and structure are available elsewhere [22 23].

The MRDPP consisted of three phases, and components [22] , including the focus groups, strategies and evaluation described in this paper. In 2007, prior to T1 and as part of community consultation process and health promotion strategy development, Aboriginal and non-Aboriginal employees of local community government and non-governmental organisations from the two towns were recruited to participate in focus groups using 'snowball' sampling technique. Forty one and thirty five participants were recruited from each of the two communities, respectively; 51% and 63% of whom identified as Aboriginal or Torres Strait Islander, respectively. Participants were asked to identify barriers and facilitators to children's participation in physical activity, after discussing a geo-map of local physical activity services compiled by the MRDPP in a separate study, to inform

the development of strategies for the subsequent MRDPP. Group discussions used standard interview schedules and prompts and were tape-recorded and transcribed. Further details have been described elsewhere [22].

The MRDPP health promotion strategies were delivered by APOs between T1 and T2 to all children at the participating schools in the region which includes higher than national proportions of Aboriginal people [24]. The physical activity components were delivered at a light intensity including: supporting the curriculum resource for fundamental movement skills development in all primary schools (n=26); training 74 coaches in Traditional Indigenous Games (TIG), participating in 30 one off community sports events and camps, and geo-mapping of physical activity locations.

Measures

The Many Rivers Physical Activity Recall Questionnaire (MRPARQ) was used to assess the physical activity of the participants before (T1; 2007/8) and after the program implementation (T2; 2011/12). This measure was adapted from the Australian Physical Activity Recall Questionnaire (APARQ) [25] and has been previously validated in a sample of young people from the communities participating in this study [26]. The overall amount of MVPA was calculated based on weekly frequency and duration in 14 categories: summer organised; winter organised; summer non-organised; winter non-organised; summer club; winter club; summer school; winter school; summer travel to/from school; winter travel to/from school; summer after school; winter after school; summer weekend; winter weekend. The MRPARQ also collected information on the socio-demographic variables of self-reported Aboriginal status (Aboriginal vs. non-Aboriginal), gender (male vs. female), age in years and school grade (grades 5-8).

Analyses

Thematic content analysis [27] was used to identify themes discussed and level of consensus in the focus groups. Member checking was achieved with results sent to all participants [28]. The normality of the questionnaire data was examined using histograms for each physical activity category variable. Each category appeared to be normally distributed. Weekly mean minutes and 95% confidence intervals (CIs) at T1 and T2 and change in physical activity for each category from T1 to T2 were calculated using t-tests. Descriptive statistics were used to calculate the proportion meeting recommendations at T1 and T2 in the total sample and among Aboriginal and non-Aboriginal children. Children were categorised as meeting recommendations if they achieved ≥60 min of MVPA and on at least seven occasions. Linear mixed-model regression analysis was used to compare Aboriginal and non-Aboriginal children for change in weekly mean minutes for each of the 14 MRPARQ physical activity variables. A stepwise procedure with backward elimination of non-significant interactions and covariates to identify significant moderators and predictors was used for each outcome. The fixed effects in the model were group (Aboriginal and non-Aboriginal), time (baseline and follow-up), gender, school year, group/time interaction and other interaction terms found to be statistically significant at $P < 0.1$. The random effect in the model was school ID, to account for clustering by school. Differences of adjusted mean change and 95% CIs were determined using the linear mixed models. Cohen's d was used to determine the magnitude of the differences (Post-test difference between baseline and follow-up mean minutes / Pooled pretest standard deviation of Aboriginal and non-Aboriginal scores). Analyses were performed using SPSS 19.0 (IBM Australia, St. Leonards, NSW, Australia) and SAS Version 9.4 (SAS Institute Inc., Cary, NC, USA). $P < 0.05$ was considered statistically significant unless otherwise stated.

Ethics

The study protocol was approved by the Hunter Area Health Service, the Mid North Coast Health Service, the University of Newcastle, the New South Wales (NSW) Department of Education and Training, and the Aboriginal Health and Medical Research Council of NSW, Australia (H-357-1206). Written informed consent from the parents and the children's assent was a requirement for participation. The study was carried out in accordance with the principles of the Declaration of Helsinki as revised in 2000.

Results

In 2007/8 (T1), physical activity data was collected from 1545 children, 246 of whom were Aboriginal (15.9%) in grades 5-8 at 38 schools (overall response rate 43%). The response rate among the Aboriginal children at T1 was 55% and 43% of respondents were male. In 2011/12 (T2), physical activity data was collected from 923 children (240 Aboriginal, 26.0%) in grades 5-8 at 36 schools (overall response rate 29%). The response rate among the Aboriginal children at T2 was 44% of those enrolled and 45% of respondents were male. Respondents were aged between 10 and 14 years at each time point, with 28.3% of Aboriginal and 29.0% of non-Aboriginal children aged 11 years at T1 and 39.6% of Aboriginal and 34.1% of non-Aboriginal children aged 11 years at T2. There were fewer male than female respondents among both Aboriginal and non-Aboriginal children. The distributions of age, gender and school year did not differ over time among either group, with the exception of school year among the non-Aboriginal children where there tended to be few children in grades 7-8 at T2 (Table 1).

Among the Aboriginal children there were overall declines in physical activity from T1 to T2 of 13.2% in summer and 18.7% winter (Table 2; both $p<0.005$). There were declines in weekly mean

minutes of travel to/from school in summer and winter and winter after-school activity (all $p<0.05$). There were also significant declines in weekly mean minutes in summer non-organised (-156.1mins, 95%CI -307.9 to -4.1), winter non-organised (-149.5mins, 95%CI -252.3 to -46.8) and winter organised (-59.0mins, 95%CI -106.7 to -11.4) activity (Table 3). Among the non-Aboriginal children, overall declines also ocured between T1 and T2 (9.6% summer, 9.4% winter; $p<0.001$ (Table 2)). As with the Aboriginal children, there were declines in both samples in weekly mean minutes of travel to/from school in summer and winter and winter after-school activity (all $p<0.05$). There were significant increases in weekly mean minutes in summer school (41.8mins, 95%CI 21.1 to 62.5), winter school (21.8mins, 95%CI 0.6, 43.6) and summer weekend (46.4mins, 95%CI 12.4 to 80.3) activity in the non- Aboriginal sample. There were significant effects of Aboriginal status by time (T1 to T2) for the summer school ($p<0.001$), summer weekend ($p=0.02$), winter organised ($p<0.001$) and winter school ($p<0.001$) categories. In each of these categories, there was a mean decline in the activity of the Aboriginal children and a mean increase in the activity of the non-Aboriginal children.

The focus groups provided information on the context of the changes in children's physical activity participation in these communities. Barriers specific to physical activity were both individual and environmental. Individual barriers included lack of private transport to reach locations inaccessible by public transport, lack of parental education in general impacting on decisions around physical activity for children, few appropriate role models for physical activity and parental concerns about children's safety. Focus groups observed that many parents were not participating in physical activity themselves, were overweight/obese and provided limited encouragement for children to be physically active. The barrier of "shame" or feeling ashamed to walk to sporting venues was

reported particularly by Aboriginal participants, either because this implied the family was too poor to own a vehicle, or it was seen as not "cool" was described as a strong barrier. These social factors contributed significantly to discussions of physical activity among the participants and their experiences of accessing organised sports or activities. Environmental barriers included cost of activities, particularly organised sport, and poor availability, capacity and accessibility of facilities and venues for both organised and non-organised activities. An often described barrier was the combined effect of distance to sporting venues from residential areas and inadequate transport options to these venues. Barriers to physical activity participation particularly experienced by the Aboriginal community were reported and included: racism and prejudicial attitudes from the wider general community; poor community cohesion; welfare dependency; and low self-esteem.

Discussion

We found a significant decline in the proportion of both Aboriginal and non-Aboriginal children meeting Australian physical activity recommendations. This finding is consistent with a recent study reporting low overall physical activity levels among Aboriginal and non-Aboriginal children [20] as well as statewide trends [13] over a similar time period. Barriers identified by the community focus groups may have contributed to these findings.

While overall declines in physical activity between T1 and T2 were evident, there were notable variations in weekly minutes according to season, setting, type and by Aboriginal status. There is evidence that children are more active in summer compared to winter [6] and this was apparent in both Aboriginal and non-Aboriginal children in the present study, possibly reflecting the particular influence of rural river and sub-tropical coastal environments in our sample. This is consistent with our focus group data where weather was not identified as a barrier, in contrast to other studies [29]. Similarly, lower activity levels in summer were found in a recent Australian study conducted in an urban population in Victoria but this likely reflects the influence of seasonal differences in weather and the outdoor environment on physical activity in the two geographically distant samples [30].

We did not find significant changes over time nor differences by Aboriginal status for organised activity in the summer, or for club activity in either season. Organised activity contributed almost a third of the total physical activity in both seasons and for both groups. Club activity levels were over 100mins/week on average for all children, however, physical activity levels of Aboriginal children in the organised and club categories were lower in both seasons and time points than for non- Aboriginal children. Barriers to physical activity identified in pre-program focus groups included several which were relevant to these categories including the cost of organised sport, poor

facilities and transport to such facilities. The lower levels of organised sport may also reflect preferences for alternative physical activities as unstructured outdoor activities that have been found to be more appealing and popular among Aboriginal populations [31]. A number of previous studies have also demonstrated the contribution of organised sport to overall physical activity levels in young people statewide [32] and internationally [9]. However, children in our sample achieved higher levels of organised physical activity than Grade 6 and Grade 8 students in NSW state data from 2010, who achieved 263.2 and 371.0 weekly mean minutes, respectively, averaged across both seasons but through almost identical measures [26,32]. Nonetheless, participation in both organised and non-organised physical activity is essential to achieving recommendations for health and development among young people [32]. Strategies to overcome barriers to participation among Aboriginal children, as identified in our focus groups, are crucial.

Time spent travelling to and from school significantly declined in both Aboriginal and non-Aboriginal children in summer and winter. NSW state data from 1970 to 2003 also illustrates a decline from 44.2% to 21.1% in walking to school among children aged 10-14 years [33]. National active transportation levels of children are also low as exemplified by a 'D' rating in the recent Australian Report Card on Physical Activity for Children and Youth [5]. Current low levels and declines in recent decades can be attributed to dramatic rises in automobile transport during this period [33]. This may have been particularly pertinent in our rural sample where greater distances travelled to school can be an additional barrier to active transport. Given established evidence of the benefits of active travel to school [11], school and community led strategies to increase current low levels of active commuting in children are required.

The decline in overall physical activity levels, as well as in a number of specific categories, was

more notable among Aboriginal children than their non-Aboriginal counterparts. This was statistically significant for four categories; summer school, summer weekend, winter organised and winter school. These findings suggest that the relatively minor focus on physical activity in the Aboriginal-targeted intervention was not sufficient to initiate wider behaviour change. It may also be due in part to the lower questionnaire completion rates for non-Aboriginal children in 2011/12, which may reflect a bias towards families more motivated to make positive health behaviour change. Yet children from disadvantaged communities, such as those in this study sample, are typically less active than their more advantaged counterparts [34]. In 2011 both areas participating in the MRDPP were reported as having a higher proportion of Aboriginal people, who experience greater social disadvantage, than the national average (2.6%), with Kempsey at 11% and the Greater Taree area at 5.4% [24]. While it would not have been possible to obtain accurate self-reported individual level socioeconomic status measures from children as young as 10 years, both areas are classified by the Australian Bureau of Statistics (ABS) as areas of high relative socio-economic disadvantage according to the Socio Economic Indexes for Areas (SEIFA) [35]. The broader barriers identified also reflect the impact of social determinants of health such as income and education [36]. A further explanation of the more marked declines in physical activity across several domains among Aboriginal children may relate to the barriers identified that were Aboriginal-specific. These included feeling 'shame' or embarrassment about being physically active in public [18] and experiences of racism which is a distinct determinant of health [37].

Overall, the MRDPP health promotion strategies for physical activity participation appear to have been of an insufficient intensity to result in increases in activity among children living in the communities where it was delivered. Further the co-existence of a large number of local, state and

national childhood obesity prevention initiatives implemented over the same period of time may have saturated its effects. The MRDPP possessed a modest budget and low staff levels, and was delivered with varying intensity and reach. More intensive efforts to specifically target physical activity behaviour may result in increased activity levels during this critical adolescent time period where physical activity declines have occured internationally [12] and across NSW in a similar time period and age group [13]. However, a greater focus on the broader social and family determinants of health in Aboriginal people and communities, such as education and employment opportunities, [36] is likely to be necessary in order to have an impact on specific health risk factors. Such approaches are likely to similarly benefit low socioeconomic, non-Aboriginal populations and represent a clear policy direction to address inequality.

Limitations of the study include a possible selection bias, given the differential participation rates for Aboriginal and non-Aboriginal children and lower participation rates for non-Aboriginal children in 2011/12 compared to 2007/8. Strengths of the study include a relatively large proportion of Aboriginal participants than is usually found in research studies and government data as well as a comparable non-Aboriginal participants sampled from the same geographical and socio-economic setting. The self-report MRPARQ tool is a robust, established measure which has been validated with objective measures within a similar population [26] and is consistent with existing measures, allowing for comparisons to statewide data. The formative focus group data provided an understanding of the barriers faced by communities, particularly Aboriginal communities given the over representation of Aboriginal people and Aboriginal specific organisations. These data helped explain the specific context of the quantitative findings in the real world settings where they occurred.

A combination of efforts to reduce broader health inequalities are recommended, as well as targeted initatives to specific populations. A recent complilation of physical activity programs in Australia targeting Aborginal and Torres Strait Islanders [38] found that while many programs had some form of evaluation indicators, few disseminated their findings. It is imperative that future programs and policies to improve health behaviours of Aboriginal people and other target populations undergo comprehensive evaluation and sharing of findings to determine effective practice and to guide the planning of future initiatives. Adequate resourcing of programs and their evaluation is critical to generating quality evidence of effectiveness.

Conclusion

In this population of rural, disadvantaged Aboriginal and non-Aboriginal children, physical activity declines were observed over two time points but not across all types, seasons or settings. Declines were more marked among Aboriginal children which was in part explained by formative qualitative data describing individual and community level barriers to physical activity. Strategies to overcome both the influencing cultural barriers of 'shame' and embarrassment around being physically active in public and racism more broadly are recommended. More intensive, specific promotion of physical activity across seasons and settings as well as approaches to improve social determinants of health experienced by rural children from disadvantaged communities, particularly Aboriginal children, are required to prevent declines in participation.

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Tables

Table 1: Socio-demographic characteristics of the sample by survey year for Aboriginal and non Aboriginal children

	Aboriginal			Non-Aboriginal		
	2007/8 (n=246) %	2011/12 (n=240) %	p-value	2007/8 (n=1299) %	2011/12 (n=683) %	p-value
Sex						
Male	41.9	45.8	0.379	43.2	45.2	0.530
Female	58.1	54.2		56.7	54.8	
Age						
10 years	16.5	11.0	0.094	11.4	13.2	0.045
11 years	28.3	39.6		29.0	34.1	
12 years	24.1	21.1		25.7	24.7	
13 years	20.3	17.2		22.4	18.2	
14 years	11.0	11.0		11.4	9.8	
School Year						
Grade 5	30.2	35.3	0.225	28.3	33.5	0.003
Grade 6	29.0	28.6		30.2	33.4	
Grade 7	22.0	15.1		22.7	18.2	
Grade 8	18.8	21.0		18.8	14.9	

Table 2: Changes in proportions of those meeting physical activity recommendations in both seasons in the whole sample and by Aboriginality:

Season	Aboriginal				Non-Aboriginal			
	2007/8 (n=246)	2011/12 (n=240)	% change	p-value	2007/8 (n=1299)	2011/12 (n=683)	% change	p-value
Summer	179 (72.8%)	143 (59.6%)	-13.2%	0.002	1032 (79.4%)	477 (69.8%)	-9.6%	<0.001
Winter	131 (53.3%)	83 (34.6%)	-18.7%	<0.001	774 (59.6%)	343 (50.2%)	-9.4%	<0.001

Table 3: Weekly mean (95% CI) minutes and change of physical activity between baseline and follow-up by category, stratified by Aboriginality and adjusted for school clustering

Physical activity category		Aboriginal				Non- Aboriginal				Group X Time p-value
		Baseline	Follow-up	Change	p-value	Baseline	Follow-up	Change	p-value	
All	Physical Education	157.0 (151.0, 163.1)	144.2 (137.6, 150.8)	-12.8 (-21.8, -3.9)	0.005	160.0 (157.7-162.1)	147.8 (143.9, 151.7)	-12.2 (-16.3, -7.9)	<0.001	0.86
Summer	Organised	470.9 (422.1, 519.7)	446.3 (409.4, 483.2)	-24.6 (-85.6, 36.5)	0.429	484.0 (469.1-499.0)	501.9 (476.9, 526.9)	17.8 (-9.6, 45.3)	0.203	0.16
	Non-Organised	1196.1 (1088.2, 1303.8)	1040.0 (932.4, 1147.6)	-156.1 (-307.9, -4.1)	0.044	1101.3 (1062.8-1139.9)	1106.0 (1041.1-1171.0)	4.7 (-66.2, 75.7)	0.896	0.06
	Club	142.2 (109.2, 175.2)	131.5 (102.0, 161.0)	-10.7 (-54.9, 33.4)	0.633	200.5 (186.2-214.8)	184.7 (164.4, 204.9)	-15.8 (-40.6, 9.0)	0.211	0.84
	School	418.1 (379.9, 456.1)	392.0 (360.6, 423.3)	-26.1 (-75.3, 23.2)	0.299	381.2 (370.7-391.7)	423.0 (402.6, 443.5)	41.8 (21.1, 62.5)	<0.001	<0.001
	Travel to/from school	25.2 (13.7, 37.3)	4.0 (1.2, 6.7)	-21.2 (-33.8, -9.3)	0.001	18.2 (15.1-21.4)	7.5 (3.9, 11.0)	-10.8 (-15.8, -5.7)	<0.001	0.07
	After school	523.4 (458.3, 588.5)	445.6 (370.7, 520.6)	-77.8 (-176.7, 21.1)	0.124	506.1 (481.8-530.5)	469.4 (428.5, 510.3)	-36.7 (-81.5, 8.0)	0.108	0.44
	Weekend	443.0 (389.5, 496.4)	388.6 (338.1, 439.2)	-54.4 (-127.8, 19.1)	0.147	378.4 (361.1-395.7)	424.8 (391.4, 458.1)	46.4 (12.4, 80.3)	0.007	0.02
Winter	Organised	337.1 (299.8, 374.5	278.1 (248.4, 307.8)	-59.0 (-106.7, -11.4)	0.015	353.5 (339.9-367.1)	370.1 (347.2, 393.0)	16.6 (-8.5, 41.7)	0.194	<0.001
	Non-Organised	706.7 (632.8, 780.5)	557.2 (485.4, 629.0)	-149.5 (-252.3, -46.8)	0.004	729.4 (697.8-760.9)	693.7 (642.3, 745.1)	-35.7 (-93.0, 21.6)	0.222	0.07
	Club	149.4 (121.5, 177.4)	114.1 (89.9, 138.2)	-35.3 (-72.1, 1.5)	0.060	175.3 (163.4-187.2)	172.2 (154.0, 190.4)	-3.1 (-24.1, 17.9)	0.714	0.12

	School	373.3 (340.7, 405.8)	321.0 (291.5, 350.5)	-52.3 (-96.0, -8.5)	0.019	360.1 (348.9-371.3)	381.9 (361.8, 402.0)	21.8 (0.6, 43.6)	0.044	<0.001
	Travel to/from school	14.6 (8.6, 20.5)	4.7 (1.1, 8.4)	-9.9 (-16.9, -2.8)	0.006	16.2 (12.7-19.7)	5.9 (3.0, 8.9)	-10.3 (-15.4, -5.0)	<0.001	0.85
	After school	306.9 (259.8, 354.0)	238.4 (189.9, 286.9)	-68.5 (-135.9, -1.0)	0.047	327.2 (307.5-347.0)	289.8 (260.3, 319.4)	-37.4 (-73.0, -1.9)	0.039	0.40
	Weekend	193.9 (165.4, 222.3)	164.6 (132.5, 196.7)	-29.2 (-72.0, 13.5)	0.180	203.5 (190.3-216.7)	221.9 (198.4, 245.3)	18.4 (-6.5, 43.3)	0.148	0.06

1

Chapter 5

A snapshot of physical activity programs targeting Aboriginal and Torres Strait Islander people

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Chapter 1 established the links between physical activity and health and that programs have been demonstrated to be an effective way to increase physical activity participation among both adults and children in mainstream populations. However, little is known about the characteristics and effects of existing physical activity programs for Aboriginal and Torres Strait Islander adults and children.

Chapter 5 contributes to the evidence base around the associations between physical activity and health of Aboriginal and Torres Strait Islander people by describing the characteristics of current and recently delivered physical activity programs targeting Aboriginal and Torres Strait Islander people. The study used primary data collected through desktop research and verification by program coordinators.

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A snapshot of physical activity programs targeting Aboriginal and Torres Strait Islander people in Australia

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Abstract

Issue addressed: Participation in physical activity programs can be an effective strategy to reduce chronic disease risk factors and improve broader social outcomes. Health and social outcomes are worse among Aboriginal and Torres Strait Islanders than non-Indigenous Australians, who represent an important group for culturally specific programs. The extent of current practice in physical activity programs is largely unknown. This study identifies such programs targeting this population group and describes their characteristics.

Methods: Bibliographic and Internet searches and snowball sampling identified eligible programs operating between 2012 and 2015 in Australia (phase 1). Program coordinators were contacted to verify sourced information (phase 2). Descriptive characteristics were documented for each program.

Results: A total of 110 programs were identified across urban, rural and remote locations within all states and territories. Only 11 programs were located through bibliographic sources; the remainder through Internet searches. The programs aimed to influence physical activity for health or broader social outcomes. Sixty five took place in community settings and most involved multiple sectors such as sport, health and education. Almost all were free for participants and involved Indigenous stakeholders. The majority received Government funding and had commenced within the last decade. More than 20 programs reached over 1000 people each; 14 reached 0–100 participants. Most included process or impact evaluation indicators, typically reflecting their aims.

Conclusion: This snapshot provides a comprehensive description of current physical activity program provision for Aboriginal and Torres Strait Islander people across Australia. The majority of programs were only identified through the grey literature. Many programs collect evaluation data, yet this is underrepresented in academic literature.

So what? Capturing current practice can inform future efforts to increase the impact of physical activity programs to improve health and social indicators. Targeted, culturally relevant programs are essential to reduce levels of disadvantage experienced by Aboriginal and Torres Strait Islanders.

Key words: chronic disease, participation, program evaluation.

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Introduction

Physical inactivity is a leading risk factor associated with the burden of disease for Australian Aboriginal and Torres Strait Islander adults.[1] Less than half of those aged 18 years and over living in non-remote areas achieved the minimum national guidelines of at least 150 min of physical activity per week, a rate lower than that of the general population.[2] Yet before European colonisation of Australia, an active hunter-gatherer lifestyle was evident, suggesting that more contemporary introduced factors that have contributed to current health disparities.[3] Physical activity levels in Aboriginal and Torres Strait Islander children are higher than among non-Indigenous children at 48% versus 35%[4] which may reflect higher levels of non-formal active play.

The term 'program' has been defined as a series of activities or events that run over a period of time, or a collection of activities or events with a particular focus.[5] Programs designed to increase physical activity are an effective strategy to reduce chronic disease risk factors.[6] Targeting vulnerable population groups holds particular promise given the known associations between low levels of physical activity and socioeconomic disadvantage.[7]

Considering the unique historical context and health experiences of Aboriginal and Torres Strait Islander people, culturally specific approaches to program interventions are important.[8] Such approaches have been signalled to represent best practice by key stakeholders.[9] Sport, health and community sectors are commonly involved in the delivery of programs, many of which claim to achieve health and social benefits through participation.

Demonstrated evidence of the effectiveness of physical activity programs for Aboriginal and Torres Strait Islander people is limited. A review published in 2004[10] identified only one intervention program that achieved improvements in physical activity levels in a remote community. A more recent systematic review examined the effectiveness of group-based sport and exercise programs for Indigenous adults.[11] Six studies identified in the review demonstrated the effectiveness in achieving health outcomes, such as increased physical activity and reduced weight. This documentation of current program provision and scope in at-risk populations signifies the initial step required to develop the evidence base of best practice.[12] The growing rise of information available through online sources provides an opportunity to locate details on the delivery of additional programs and services. The aim of this study was to identify physical activity and sport programs targeting Australian Aboriginal and Torres Strait Islander people and to describe their characteristics including location, participant numbers and evaluation measures.

Methods

Search strategy

A variety of strategies were used to identify existing program information. First, the Australian Indigenous Health*Info*Net Bibliography (http://www.healthinfonet.ecu.edu.au/key-resources/bibliography, verified 12 December 2016) was searched with the health topic 'physical activity'. Forward and backward citation tracking of articles was also conducted. Second, the Health*Info*Net's collection of programs and projects that address physical activity among Australian Aboriginal and Torres Strait Islander peoples was also searched[13] and the primary website link for each relevant program was located. Additional programs known to the authors were also documented and considered for inclusion.

The following inclusion criteria were applied for identified programs:

- Targets Aboriginal and Torres Strait Islander people
  - Aboriginal and Torres Strait Islander specific program
  - Targeted Aboriginal and Torres Strait Islander component
- Program delivery includes promoting sport or physical activity participation
  - Aims to increase physical activity levels for health benefits
  - Uses sport as a tool to improve social and community outcomes, such as education participation, reduced crime rates
- Operated in Australia at any stage from 2012 to search period (March–September 2015), reflecting current or recent practice.

Data collection

Fig. 1 depicts the process of program identification and inclusion.

Phase 1: Internet and desktop research

Data were extracted during February and March 2015 by the lead author. For each selected program, information was collated using a structured template to document the following aspects: identification (ID) number; program name; timescale; aims; type and focus (Aboriginal and Torres Strait Islander specific or targeted element); setting (e.g. community, school); region (urban, rural or remote); target group (e.g. adults, children); number of participants; involvement of local Aboriginal and Torres Strait Islander stakeholders (yes, no or unknown); process and impact evaluation measures (e.g. physical activity and fitness level, health or social indicators); funding source (e.g. Government, private sector), cost to participants; sectors involved (e.g. health, sport); contact details.

Phase 2: Contact with program coordinators

During April–May 2015, the lead author attempted to contact coordinator(s) for each program identified in phase 1. Where an email address was available, program coordinators were sent a personalised email that contained a Microsoft Excel spread sheet of the information relevant to their program. They were asked to review, verify and return the information. If no email response was received, follow-up emails and telephone calls were made on two occasions during July–December 2015. Where telephone contact was made in the first instance, an explanation of the snapshot project was given, followed by a request for an email address to send the relevant program information. Where program coordinators offered information on additional programs that had not previously been identified by the authors, phase 1 and 2 processes were repeated for these programs.

Data synthesis

The contact details for each program coordinator were removed to preserve anonymity. Programs were alphabetically listed within their population targeted age group categories of adults; young people and adults and young people. Data on participant numbers were summarised into four categories: 0–100 participants; 100–500 participants; 500–1000 participants; and over 1000 participants, reflecting previous categorisation in similar work.[12] Evaluation indicators were categorised as a 'process', such as participation or retention rates, or 'impact',[14] for example, physical activity and fitness level; health indicators, defined as any widely recognised indicator of physical or mental health status (e.g. blood pressure, weight, diet, smoking); and social indicators, defined as any broader societal indicator of benefit (e.g. school attendance, crime rates). Descriptive characteristics were documented for each program aspect. Multiple categories were described where applicable.

The study was approved by the University of Sydney Human Ethics Review Committee (2015/149).

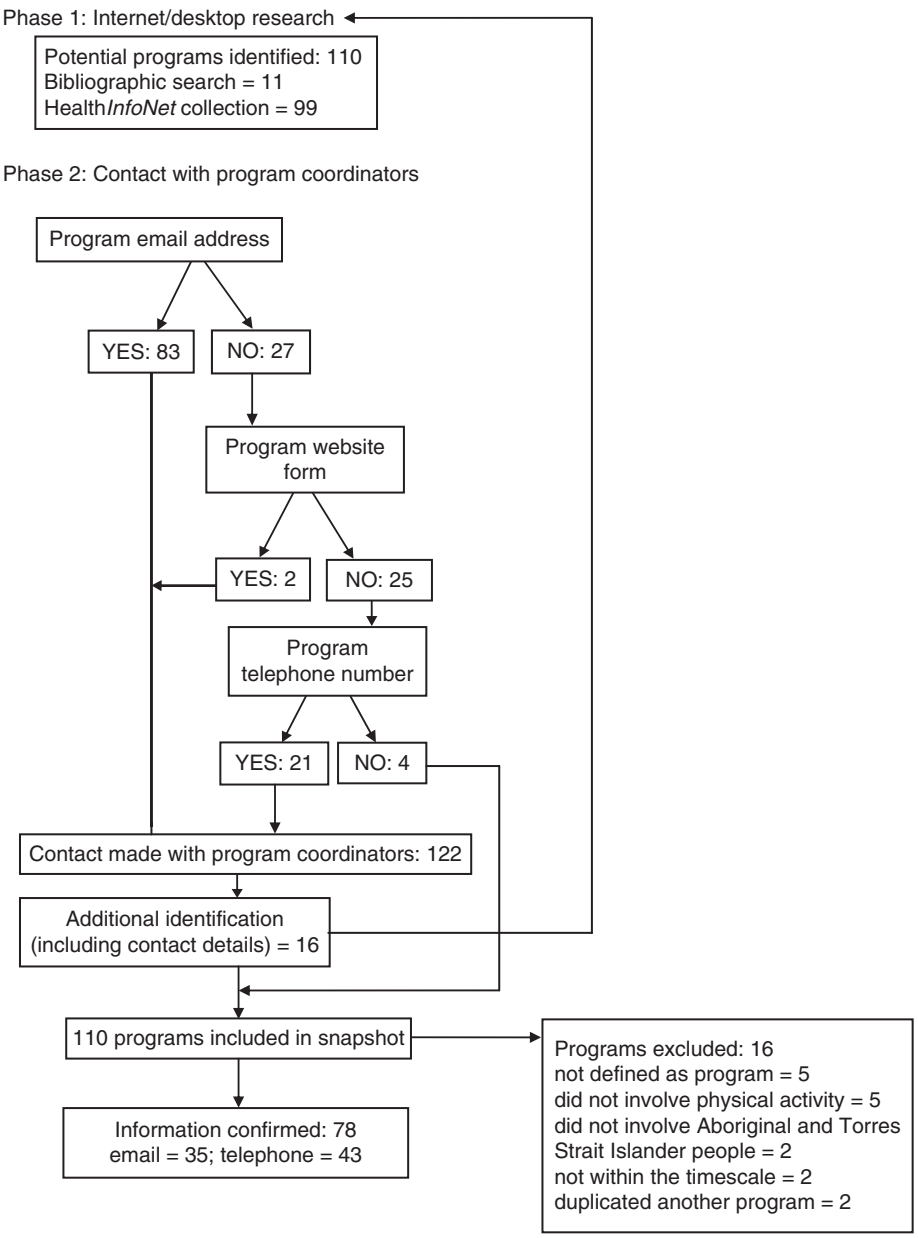

Fig. 1. Flow chart of program identification and inclusion across phases 1 and 2.

Results

A total of 110 programs (Fig. 1) were included in the final results; 78 of which had information confirmed by coordinators (71%). Table 1 presents descriptive information of the program settings, population focus, costs to participants and Aboriginal and Torres Strait Islander stakeholder involvement. Table 2 outlines detailed information of the physical activity programs, including program names. The initial Bibliography search resulted in 11 relevant programs. Thirty nine programs targeted adults, 34 targeted young people and 37 targeted adults and young people. Fourteen programs operated nationally, three in the Australian Capital Territory (ACT), 21 in New South Wales (NSW), 11 in the Northern Territory (NT), 16 in Queensland (Qld) including one in the Torres Strait, two in South Australia (SA), one in Tasmania (Tas.), 12 in Victoria (Vic.), 24 in Western Australia (WA) and seven across two or more state or territory jurisdictions. Five programs commenced before 2000 and had operated continuously since starting, with one in operation since 1970. Thirty three programs commenced between 2000 and 2010, of which 21 were still operating; 35 programs commenced between 2010 and 2012, with 19 still operating. Just under a quarter of programs ($n = 23$) commenced between 2013 and 2015; four of which were ending by the end of 2015. One program commenced in 2009 and included an Aboriginal element from 2012. For 13 programs, the time period was unknown.

Table 1. Setting, population focus, costs to participants and stakeholder involvement ($n = 110$ programs)

Program aspect	Category	Number of programs
Program setting	Community	62
	School	9
	Both community and school	9
	Sport	9
	Health	9
	Both university and sport	2
	Both health and sport	1
	Non-governmental organisation	1
	Residential service	1
	Residential camp	1
	University	1
	Both university and community	1
	Both health and community	1
	Media	1
	Both media and community	1
	Telephone-based	1
Population focus	Aboriginal and Torres Strait Islander people	101
	Targeted Aboriginal[A] component	9
Costs to participant	Yes	9
	No	100
	Unknown	1
Aboriginal and Torres Strait Islander Stakeholder involvement	Yes	93
	No	4
	Unknown	13

[A]Refers to Aboriginal and Torres Strait Islander people.

Most program aims related to increasing physical activity for specific health and fitness gains, such as improving chronic disease risk factors like lowering weight and blood pressure. Nine programs focussed on social gains such as improving educational outcomes (e.g. school attendance), reducing crime rates or increasing employability. Some programs ($n = 21$) cited both health and social aims. Twenty five programs were conducted in all (urban, rural and remote) regions; 25 across urban and rural only; and six across rural and remote only. Fifty three programs were conducted in single regions; 27, 12 and 15 programs in urban, rural and remote regions.

Three programs claimed to reach the whole population directly. Fourteen programs involved 0–100 participants, 16 involved 100–500 participants, six involved 500–1000 participants and 22 involved over 1000 participants. Some programs documented participation numbers on an annual basis and others for the entire time period of the program. For 49 programs, the number of participants was unknown. Most programs ($n = 65$) included evaluation indicators: 23 had process indicators only; 22 had impact indicators only and 20 had both process and impact indicators. Of the programs with impact indicators, most measured multiple indicators: 15 examined physical activity or fitness level; 26 examined health measures such as weight or chronic disease biomarkers; 20 examined social indicators such as school attendance and two examined qualitative measures. Thirty eight programs did not have evaluation indicators and seven programs were unknown.

Forty one programs received funding from more than one source. The majority of programs ($n = 86$) received government support: 49 from the Australian Government, 23 of which received additional funding from other sources; 27 from state or territory governments; and nine from local government. Nine programs received funding from Aboriginal organisations such as community controlled health or medical services, four in conjunction with other sources. Around a quarter received charity or philanthropic funding ($n = 25$) and six received funding from non-governmental organisations (NGOs). Fourteen programs received private sector funding and one was solely funded through participant costs. For 10 programs the funding source was unknown. Almost all programs ($n = 98$) were delivered through partnerships across multiple sectors, comprising community, education, health, media, police, sport, local government, workplace, charities and NGOs. Nine programs charged costs to participants; two of these were initially free for 2–3 years with subsequent costs of A$2 per session. Costs for the other seven programs were typically $5 per session ($n = 5$) or a specific fee for a term or year.

Discussion

These findings represent the first time that programs promoting physical activity among Aboriginal and Torres Strait Islander people in Australia have been documented collectively, describing patterns of current program provision. Previous reviews have elicited only a small number of relevant studies. The scope of this snapshot was programs containing published or online information only. There may be many additional programs in existence, yet without such presence information is difficult to source. However, given the increased proliferation of information available online in the past two decades, it is expected that this snapshot provides an accurate portrayal of current program provision. This is important as sharing information about program practice is an important part of effective health promotion and can serve to guide future initiatives.

The Ottawa Charter outlines a settings based approach to effective health promotion.[15] We found most programs were delivered in community, followed by school, settings. Both have proven efficacy in achieving health outcomes.[6] They are likely be particularly effective settings for reaching Aboriginal and Torres Strait Islander people given the importance of holistic health promotion and whole-of-community approaches.[16] The majority of programs we identified focussed specifically on Aboriginal and Torres Strait Islander people, demonstrating provision of targeted, culturally relevant interventions; a recognised model of good practice.[9] Given the diversity of communities and cultural groups across Australia, varied approaches to, and opportunities for, physical activity specific to local populations are required. Cultural adaptation of mainstream programs through a targeted Aboriginal element occurred in nine programs; this is also commendable as such programs have demonstrated representative reach of Aboriginal participants.[17] Program participation occurred across urban, rural

Table 2. Physical activity programs targeting Aboriginal and Torres Strait Islander people

AFL, Australian Football League; ARMtour, Athletes and Role Models tour; NASCA: National Aboriginal Sporting Chance Academy; NGO, non-governmental organisation; NRL, National Rugby League; ACT, Australian Capital Territory; Qld, Queensland; NSW, New South Wales; NT, Northern Territory; SA, South Australia; Tas., Tasmania; Vic., Victoria; WA, Western Australia

ID	Location	Program name	Time period	Aims	Region[B]	Participant numbers	Evaluation indicators[C]	Sectors involved	Funding source
Adults									
1	NSW	1 Deadly Step	2011-present	Promote screening, early detection and follow up of chronic disease in communities	Urban, rural	200	PROCESS	Community, health, sport	State or Territory Government
2	NT, Qld	A multiple health behaviour change group for Indigenous Australians attending residential substance abuse treatment	2014–15	Examine the feasibility of an 8-week group-based healthy lifestyle intervention in Indigenous substance abuse services to help reduce smoking, improve diet, increase physical activity	Urban, rural	42	IMPACT: physical activity and fitness level, health	Community, health, NGO	Charity funds
3	WA	Aboriginal ladies group	Unknown	Increase physical activity through weekly walking program	Urban, rural	Unknown	None	Community, health	Philanthropy, charity funds
4	NSW	Aboriginal Nambucca walkers	Unknown	Increase physical activity through weekly walking program	Urban, rural	Unknown	None	Community, health	Philanthropy, charity funds
5	WA	Aboriginal women's exercise group	2011-present	Offer a range of culturally appropriate exercise activities to women, such as circuit training, fit-boxing	Urban	30	PROCESS, IMPACT: health	Community	Australian Government, local government
6	WA	Bindjareb yorgas health program[A]	2012-present	Deliver group fitness sessions for women, develop knowledge of the importance of physical activity in maintaining health and well being, group walks on native land to encourage participation in community projects to identify and conserve native flora and fauna	Rural	Unknown	IMPACT: health, social	Community, health	Australian Government, local health service, NGO
7	NSW, Vic.	Bran Nue Me, Better Your Health and Fitness	2012	Provide a specific exercise program for people with or at risk of developing chronic disease who need help to lose weight and get fit	Urban, rural	Unknown	None	Community, health	Aboriginal organisations

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Table 2. (*continued*)

ID	Location	Program name	Time period	Aims	Region[B]	Participant numbers	Evaluation indicators[C]	Sectors involved	Funding source
8	Qld	Eat healthy, drink healthy, live healthy campaign	2014-present	Inspire people to eat healthy, drink healthy and live healthy to reduce their risk of developing type 2 diabetes	Rural	Unknown	None	Health	Philanthropy
9	WA	Exercise as medicine in Indigenous health	2012	Assessing the effects of implementing an exercise program incorporating the ACSM/AHA guidelines for physical activity and health on physiological and quality of life adaptations	Urban	40	IMPACT: physical activity and fitness level, health	Community, education	Unknown
10	WA	Fit 4 Work	2015-present	Improve physical fitness, self-confidence, presentation skills and networking opportunities	Urban	8	PROCESS	Education, NGO, workplace	Charity funds
11	Vic.	Fitzroy Stars Football Netball Club[A]	1970-present	Create a diversionary strategy for youth, provide a safe place for people to get together and participate in sport	Urban	Unknown	IMPACT: health, social	Community, sport	Unknown
12	National	Footy Means Business program	2011-present	Use the power of sport to engage and provide talent, employment and leadership development opportunities for men aged 10–24 years through 2 AFL facilitated residential weeks	All	~250	IMPACT: social	Community, sport	Private sector
13	NSW, ACT, Tas., Qld, SA	Get Healthy Information and Coaching Service® (Get Healthy Service)	2009-present; Aboriginal component since 2012	Supporting adults, especially those at risk of developing chronic disease, to make lifestyle changes for physical activity and nutrition through 6 months of health coaching or information-only package. Aboriginal module: access to a culturally appropriate service, specific coaching and materials	All	23 650 enrolled 2009–2013; 793 Aboriginal (4.7% in 2013)	IMPACT: physical activity and fitness level, health	Health	State or Territory government
14	NSW	HEALInG program: healthy eating activities (and) lifestyles (for) Indigenous groups	2003-present	Provide realistic and practical information on healthy eating and lifestyle activities through 10 weekly sessions including an hour exercise class	Rural	Over 100	PROCESS	Community, health, NGO	Charity funds, local health service

15	WA	Healthy and active in the West Kimberley (HAWK) now!	2010–2014	Offer low impact exercise options, healthy lifestyle workshops to the community, including walking groups, aqua fitness, strength training and sports for adults with, or at risk of developing, chronic disease	Rural, remote	5000	PROCESS, IMPACT: health	Community, health, NGO	Australian Government, local government
16	NSW	Healthy exercise and training program	2012-present	Improve health and well being by targeting positive lifestyle behaviours including exercise	Urban, rural	Unknown	IMPACT: physical activity and fitness level, health	Community, health	Australian Government, Medicare, Rural Doctors Network, universities
17	NSW	Healthy lifestyle program[A]	2007-present	Deliver a 12-week program with weekly meetings including a weigh-in, talk on healthy eating or activity, meal preparation, an exercise session	Rural	35	None	Community, health	Aboriginal organisations
18	National	Healthy start, healthy life	2010–2014	Develop a knowledge base and evaluate tools and resources to assist reduction of risk factors, promote health and support clinical best practice in prevention, detection and management of chronic diseases.	All	Unknown	None	Community, health	Australian Government
19	WA	Heart health 'for our people, by our people'[A]	2009-present	Deliver a weekly program covering a variety of topics including physical activity	Urban	Unknown	PROCESS, IMPACT: physical activity and fitness level, health	Community, health	Unknown
20	National	Hero rewards	2010–2013	Improve health through promoting and encouraging the use of follow up care services, and those through local Aboriginal and Torres Strait Islander health services, including physical activity	All	Unknown	IMPACT: health	Community, health	Australian Government
21	SA	Keep it corka	2013-present	Support communities to prevent chronic disease through physical activity sessions, nutrition education, smoking cessation	Urban	Unknown	None	Community, health	Philanthropy

(*continued next page*)

Table 2. (*continued*)

ID	Location	Program name	Time period	Aims	Region[B]	Participant numbers	Evaluation indicators[C]	Sectors involved	Funding source
22	WA	Life at the core	2010–2014	Improve the health and well being of residents	Urban	Unknown	PROCESS, IMPACT: health	Community, health, local government	Australian Government
23	National	Live longer!	2010–2014	Support communities to 'Get active, eat good tucker, live longer! Provide funding for local community campaigns	All	Unknown	PROCESS	Community, health	Australian Government
24	WA	Live well campaign Kimberly	2008–2013	Deliver a media campaign to promote regular physical activity and healthy diet in communities, improve lifestyle and reduce risk factors for chronic diseases	Rural, remote	Unknown	Unknown	Community, health, media	State or territory government
25	NSW	Lyrebird Exercise Classes	2010-present	Increase regular physical activity, deliver culturally appropriate programs for different fitness abilities, develop a home exercise program, train Aboriginal fitness leaders	Urban	294 participants; 5 Aboriginal fitness leaders trained	None	Community, health	Local health service
26	Qld	Mangabay dhingiga ganggundi bimbi	2010-present	Improve and promote better health for people living with chronic and complex care needs	Urban, rural	Unknown	None	Community, health	Unknown
27	Vic.	Mildura Aboriginal Health Service walking program	Unknown	Increase physical activity through weekly walking program	Urban, rural	Unknown	None	Community, health	Philanthropy, charity funds
28	NSW	Mootang tarimi (living longer) outreach screening program	2008-present	Improve chronic disease outcomes through mobile bus service, including education on smoking, exercise, diet, weight loss	Urban, rural	1350	None	Community, health	State or territory government
29	Qld	Move	2011–2014	Raise awareness of benefits of physical activity, promote healthy lifestyle choices and regular access to health services and programs to prevent and manage chronic diseases	Urban	Unknown	PROCESS	Community, health, media	Australian Government

30	NSW	The NSW State Knockout Challenge	2012-present	Engage communities to target nutrition, physical activity and a healthy weight, where teams of up to 30 members compete in a series of weight loss challenges and for grant funds for communities to promote healthy lifestyles	Urban, rural	Up to 35 teams and 1000 participants per individual challenge	IMPACT: physical activity and fitness level, health	Community, health, sport	State or territory government
31	NSW	Pius × exercise program	2015-present	Promote the health and well being of clients, to prevent and manage chronic diseases and mental health issues	Rural	20	PROCESS, IMPACT: physical activity and fitness level, health	Community, health	Aboriginal Organisations
32	NSW	Sistas and aunties program	Unknown	Empower women to lead healthy lifestyles and model healthy and positive habits for their community and extended families through activities which incorporate healthy eating and physical activity	Urban	Unknown	None	Community	Unknown
33	NSW	Spring into shape program	2003-present	Promote a healthy lifestyle and to help clients manage stress through exercise and nutrition program	Urban, rural	18 in 2015	PROCESS	Community, health	Local health service, Aboriginal organisations
34	Tas.	Tasmanian Aboriginal Centre rehabilitation program[A]	2011-present	Provide culturally accessible cardiac and pulmonary rehabilitation to adults with or at risk of developing chronic disease to increase participation and improve health outcomes for people with established disease and reduce risk factors such as physical inactivity	Urban, rural	92	PROCESS, IMPACT: physical activity and fitness level, health	Health	Australian Government
35	Vic.	Victorian Aboriginal Health Service Healthy Lifestyles	2010-present	Help people make the right lifestyle choices and reduce their chance of developing an avoidable chronic disease	Urban, rural	Unknown	Unknown	Health, community	Australian Government
36	NSW	Waminda's Wellbeing Program[A]	2009-present	Provide women with opportunity to participate in a comprehensive and holistic healthy lifestyle program that incorporates appropriate and accessible physical activities	Rural	51 in 2012	PROCESS, IMPACT: physical activity and fitness level, health	Health	Australian Government, Aboriginal organisations

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Table 2. (*continued*)

ID	Location	Program name	Time period	Aims	Region[B]	Participant numbers	Evaluation indicators[C]	Sectors involved	Funding source
37	NT	Women's footy fitness program	2011–2014	Provide an innovative approach to addressing chronic disease in women, information on the benefits of physical activity, transport for participants to activities, a variety of physical activity sessions with trained instructors	Remote	480	PROCESS, IMPACT: physical activity and fitness level, health, qualitative	Community, local government, health	Australian Government
38	Qld	Work it out!	2011–2013	Close the life expectancy gap through addressing chronic disease, including weekly individually tailored 1 h group exercise sessions	Urban	250	PROCESS, IMPACT: health	Community, health	Australian Government
39	WA	Yoka Yaanginy	2015-present	Increase physical activity through weekly walking program	Urban, rural	10	PROCESS, IMPACT: health	Community, health	Philanthropy, charity funds, NGO
Young people									
40	SA	Aboriginal Power Cup	2008-present	Deliver competitive football program engaging young people in grades 10–12 in education, promoting healthy lifestyle choices and developing teamwork, leadership and life skills	Urban, rural	400 students, 32 schools	None	Sport	State or territory government, private sector
41	NT	Ampilatwatja sport 'n' rec program	Unknown	Delivers a range of activities to promote physical, social, emotional, educational, mental and spiritual well being through out of hours school and vacation care	Remote	Unknown	None	Community	NGO
42	National	Athletics for the outback program	2005-present	Give opportunities to participate in athletics and increase community ownership and management of athletics	Remote	3500 children, 25 Aboriginal coaches trained, 74 activities held	PROCESS	Community, health, sport	Australian Government
43	Qld	Beat da binge[A]	2010–2013	Preventing harm from binge drinking through events focusing on drinking education, alcohol-free community-wide social events and sporting and social activities to facilitate self-empowerment for young people aged 18–24 years.	Remote	1880	PROCESS, IMPACT: health, social	Community, health, sport	Australian Government

44	WA	Beatball (Mirrabooka) - Street Corner Champions	2008-present	Engage young people aged 6–17 years who may not be involved in mainstream sport in Beatball, focusing on healthy lifestyles including physical activity, positive role models, education	Urban	50–150 participants per session	PROCESS	Education, health, sport	Aboriginal organisation, local government, Migrant Resource Centre
45	Qld	Cathy Freeman Foundation Activities program	2009–2015	Promotes school achievement and attendance, healthy living and sociable behaviour by encouraging participation in sport and recreational activities	Remote	500	PROCESS	Education, NGO, sport	Charity funds
46	Qld, NT, NSW, Vic.,WA	Clontarf Foundation[A]	2000-present	Improve the education, discipline, life skills, self-esteem and employment prospects of boys in grades 7–12 through AFL and NRL academies	All	3726	IMPACT: social	Community, NGO, sport	Australian Government, state or territory government, private sector
47	Qld	Deadly choices	2010–2014	Encourages participants aged 15–18 years to be role models and mentors for their family, peer group and community in leading a healthy lifestyle, including physical activity	Urban	300–600 each community event. 250 school children completed program	PROCESS	Community, education	Australian Government
48	National	Evonne Goolagong Foundation (EGF) program	2005–2014	Give children aged 5–15 years the opportunity to achieve their best by promoting quality education and better health through diet and exercise	All	1100 in come and try days	Unknown	Community, sport	Charity funds
49	ACT	Gugan Gulwan school holiday program	2013–2015	Deliver school holiday program to keep the participants active, challenged and entertained	Urban	Unknown	None	Community	Participant cost
50	NT	Hoops 4 health	2006-present	Address adolescent health issues using basketball events, tailored to suit a particular group	All	4797	None	Community, health, sport	Australian Government
51	Qld	Indigenous Youth Sports Program[A]	2010-present	Provide opportunity for high school students to consider university as a potential pathway, while engaging in a week of sporting and team-building activities	Urban	140 annually	None	Community, education	Australian Government, state or territory government, local government, university

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Table 2. (*continued*)

ID	Location	Program name	Time period	Aims	Region[B]	Participant numbers	Evaluation indicators[C]	Sectors involved	Funding source
52	NT	John Moriarty Football	2012-present	Provide children aged 6–16 years with support, training, development and pathways for football success, use the sport as a powerful tool to change educational and life outcomes for footballers and their families	Remote	200 currently	PROCESS, IMPACT: social	Education, health, sport	Australian Government, philanthropy, charity funds
53	NSW	National Aboriginal Sporting Chance Academy (NASCA)	1995-present	Encourage high school attendance and promote self-confidence and health and well being through role models and health, education, sport and cultural programs	Urban	11 000 since 1995	PROCESS, IMPACT: qualitative	Education, NGO, sport	Australian Government, charity funds
54	ACT	Ngadyung	2007-present	Promote essential swimming and survival skills	Urban, rural	500	None	Health, NGO	Australian Government, State/ Territory Government
55	NT	NASCA athletes and role models (ARMtour)	1997-present	Provide inspiration, encouragement and support for school aged children to enhance students' self-esteem and self-confidence; assist in developing life skills in communication, leadership and goal-setting; encourage participation in sport and recreation activities for healthy and positive lifestyles	Remote	8000 since 1997	PROCESS, IMPACT: qualitative	NGO	Federal Government, fundraising
56	National	Raise the bar	2015-present	Provide a chance to discover the pathways to studying and participation through high performance sport for young people in grades 10–12	All	35	IMPACT: social	Education, sport	Australian Government, University
57	NT	Red dust role models Healthy Living Program	2006-present	3 × 1-week community visits. Role models interact with and teach nutrition, hygiene, substance misuse, physical activity and encourage creativity and new skills in sport, arts and healthy cooking	Remote	Approx. 343 in 2007. First half of 2015 engaged 500+ students in schools, 800+ outside of school	PROCESS	NGO, sport	Australian Government, local government, private sector

58	WA, NT and NSW	Role Models and Leaders Australia Girls Academy	2009-present	Empowering school aged girls by equipping them with tools needed to achieve education and career goals, highlighting the importance of physical activity, a healthy lifestyle and cultural connection	All	1000	PROCESS, IMPACT: social	Education, sport	Australian Government, schools, private sector
59	WA	Row AHEAD: Clontarf to Curtin	2014-present	Teach rowing and encourage high school students with career and educational goals.	Urban	20 in 2014, 75 in 2015, 20–30 through endorsed program	PROCESS	Education, sport	State or territory government
60	NSW	Shake a leg	2005-present	Reduce preventable health conditions among primary school children through education, including traditional Indigenous games	Urban, rural	Unknown	IMPACT: health, social	Education, health	Local health service
61	NSW	Souths Cares Healthy and Active Lifestyle program	Unknown	Educate students with the fundamental knowledge to live healthy and active lifestyles	Urban	Unknown	None	Education, NGO	Charity funds
62	National	Stronga sistas, Brothers in Union programs	2014-present	Promote good sportsmanship, nutrition, mental health awareness, drug and alcohol free-living and taking personal responsibility for positive choices in life through residential and 1 day programs for school aged children	All	300–500	PROCESS	Education, health, sport	Australian Government, private sector, charity funds
63	WA	Strong Culture	2014-present	Promote adoption of healthy lifestyle behaviours and encourage traditional activities (e.g. hunting, bush tucker) to prevent chronic disease	All	Unknown	Unknown	Community, education, health	Australian Government
64	WA	Swan Nyungar Sports Education Program	2002-present	Improve educational outcomes among high school children through culture, language and sport	Urban	Unknown	IMPACT: social	Education, sport	Unknown
65	ACT, NSW	Swimming NSW Indigenous participation program	2012–2015	Drive swimming participation among babies and children, implement pathways for the development of talented swimmers and coaches	Urban, rural	1500	PROCESS	Community, health, sport	State or territory government

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Table 2. (*continued*)

ID	Location	Program name	Time period	Aims	Region[B]	Participant numbers	Evaluation indicators[C]	Sectors involved	Funding source
66	NT	Tangentyere youth activity service	Unknown	Enable young people living in town camps to access and experience a range of sport and recreational activities	Urban	Unknown	None	Community, sport	Local government
67	Qld	Tennis Queensland Indigenous program	2012–2014	Develop tennis programs for communities and schools.	All	Unknown	None	Community, education, sport	Australian Government, state or territory government
68	WA	Troy Cook health and leadership program	2008-present	Build a healthy and active lifestyle, cultural identity for communities by educating children aged 10–18 years about health, mental well being and substance abuse, encouraging linking with sports clubs	All	4000	PROCESS	Education, health, sport	State or territory government, private sector, charity funds
69	WA	V Swans active education program	2007-present	To ensure young people are actively and positively participating in physical activity, education and community	Rural, remote	5000 young people and their families annually	IMPACT: social	Community, education, sport	State or Territory Government, Private sector
70	NSW	Walkabout kitchen	2014-present	Improve access to fresh fruit and vegetables, nutrition and physical activity education, improve the health of school children to improve attendance levels	Urban, rural	Unknown	None	Community, health	State or territory government
71	WA	West Coast Eagles Indigenous Leadership Program	2011-present	Teach life skills beyond the classroom to children in grades 8–10 to empower participants to make informed decisions that lead to a healthy lifestyle and about diabetes prevention, healthy eating, physical activity	Urban	150 – 200 per year	PROCESS	Education, health, sport	Private sector
72	ACT	Wirra club ACT	2014-present	Make an impact on closing the health gap through early prevention program delivery, including sessions on physical activity, connection to local sporting clubs for primary school children	Urban	81 in 3 schools	IMPACT: physical activity and fitness level	Community, education, health, NGO, sport	State or territory government, charity funds

73	Qld	Yimba Bira Traditional Indigenous Games	Unknown	Instruct traditional game techniques and encourage participation in games modified from traditional practices. Expose participants to traditional culture, history and tools	Urban, rural	Unknown	None	Education, community	Aboriginal organisation
Adults and young people									
74	WA	Aboriginal sports program	2009-present	Encourage physical activity and sport at all levels, increase opportunities to learn skills to organise, deliver and manage community sport, assist talented people to access support to reach sporting goals	Urban, rural	Unknown	None	Sport	Australian Government
75	National	AFL Kickstart Program[A]	2000-present	Up to 3 community visits per year from professional players and coaches who delivery football activities, act as advocates and mentors to compliment work of community police, health, education and sport and recreation organisations	All	Unknown	PROCESS, IMPACT: social	Community, sport	Australian Government, private sector
76	Vic.	AFL Victoria's Indigenous Program	Unknown	Use football as a vehicle to promote a healthy lifestyle in Indigenous communities	All	Unknown	Unknown	Community, sport	NGO
77	Qld	Beat it lifestyle modification program	2013-present	Improve the prevention and management of type 2 diabetes	Remote	150	IMPACT: physical activity and fitness level, health	Community, health, local government	Local government
78	Vic.	Be deadly, get healthy	2014-present	To improve the health of families and reduce chronic disease through an initial health assessment and participation in regular physical activity sessions	Rural	27 in 12 month period 2014–2015	IMPACT: physical activity and fitness level, health, social	Community, health	Australian Government
79	WA	Bega Garnbirringu's community engagement vehicle	2011-present	Increase opportunities for physical activity, support healthy communities, access to healthy food by tailoring and delivering culturally appropriate services	Rural, remote	1000+	PROCESS	Community, health	Australian Government, Aboriginal organisations
80	Vic.	Budjeri Napan Association Inc.	2007-present	Improve health through encouraging healthy active lifestyles. Promote potential pathways in sport, education and training	Urban, rural	1500	None	Community, health, sport	State or territory government, local health services

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Table 2. (*continued*)

ID	Location	Program name	Time period	Aims	Region[B]	Participant numbers	Evaluation indicators[C]	Sectors involved	Funding source
81	Qld	Chronic illness program	2010–2015	Increase the awareness and understanding of the impact of lifestyle disease, inform the community of what can be done to avoid chronic illness and where to get assistance to change habits	Remote	Unknown	PROCESS	community, local government	Unknown
82	NSW	Clean slate without prejudice	2009-present	Crime prevention initiative, deterrence for at risk youth and their families through boxing training three times a week, healthy breakfast, educational and cultural components	Urban	50 in 2011	IMPACT: social	Community, education, Police	Charity funds
83	NSW	Deadly Sista Girlz	2009-present	Provide health, fitness and well being programs to target and assist women, girls and their families who may not be able to access mainstream programs	Urban, rural	Over 100	IMPACT: health, social	Community, health, NGO	Australian Government, Charity funds
84	Vic.	Deadly Sport Gippsland	2014-present	Encourage and support positive lifestyle change in communities by promoting sporting role models, activities and events using social media	Rural	3000 in region	IMPACT: physical activity and fitness level, health	Community, sport	State or territory government
85	Vic.	East Gippsland Aboriginal sport and physical activity program	2009-present	Promote and support increased participation in sport and recreation	Rural	Unknown	None	Community, health, sport	Australian Government
86	Vic.	Feedin' the mob	2011–2014	Involve community in activities that draw on local culture to teach the benefits of healthy eating and lifestyle.	Urban	Whole of community	PROCESS; IMPACT: health	Community, health	Australian Government
87	Qld	F.I.T (Fit Indigenous trainers) club	Unknown	Build a team of trainers to raise awareness and assist in preventing obesity through fitness activities	Urban	Unknown	None	Community	Unknown
88	National	Football dreaming program	2012-present	Maximise football (soccer) participation opportunities for children and young adults; identify and develop talented footballers; use football as a vehicle to impact social development issues	All	Unknown	None	Sport	Australian Government

89	NT	Healthy Lifestyle & Tobacco Cessation Program	2010-present	Promote and educate about physical activity, nutrition, smoking and chronic disease risk factors	All	Unknown	Unknown	Community, health	Australian Government
90	Qld	Indigenous community sport and recreation program	2013-present	Promote engagement in community sport and recreation activities and social and emotional well being.	All	387 242 attendances in 2014 across 38 communities	PROCESS	Community, Police	State or territory government
91	NSW	Indigenous-FIT Program	2011-present	To increase physical activity through a 10-week, 1 h per week exercise program, ensure sustainability for adults and children in grade 7 and above	Urban, rural	Unknown	IMPACT: physical activity and fitness level, health	Community, education, health	Local health service
92	National	Indigenous Marathon Foundation	2010-present	Celebrate Indigenous achievement and resilience, use running to promote health and build self-worth, promote healthy and active lifestyles to reduce preventable diseases, create Indigenous role models, inspire Indigenous people and promote achievement to all Australia.	All	Approx. 15 runners per year in IMP, and over 5000 community runners	PROCESS, IMPACT: social	Charity, NGO	Australian Government, charity funds
93	NSW	Indigenous mountain bike project	2012–2015	Promote bike riding as a form of physical activity	Urban	Unknown	None	Community, NGO	Unknown
94	National	Indigenous Softball Program - Health Through Softball	2015-present	Provide opportunities for community participation in softball activities to help to improve health and physical well being and provide social benefits	All	100+ participants over 2 or more communities	PROCESS	Community, sport	Australian Government
95	NSW, Qld, Vic., SA	Indigenous surfing program	Unknown	Attract large numbers of young people up to age 25 years to beaches. Promote health, enjoyment and well being through surfing and ocean safety awareness, bringing positive education to remote and local communities.	Rural	700 in NSW	PROCESS, IMPACT: social	Education, Sport	Australian Government, state or Territory government, private sector, philanthropy, Aboriginal organisations
96	Qld	Kombat Chronic Disease (KCD)	1998-present	Promotion physical activity and other health risk factors through sports programs, promotional messages, health events, health checks	Remote	5000 people	None	Community, health, local government, NGO, sport	State or territory government

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Table 2. (*continued*)

ID	Location	Program name	Time period	Aims	Region[B]	Participant numbers	Evaluation indicators[C]	Sectors involved	Funding source
97	Vic.	MAYSAR, Melbourne Aboriginal Youth, Sport and Recreation Co-operative Ltd	1982-present	Provide community services to promote healthier lifestyles, including youth outreach, general fitness, lunches and hub	Urban	Unknown	None	Community, sport	Unknown
98	National	Move it mob style	2012-present	Promoting culture through dance and music in a positive high energy television program to encourage happy healthy lifestyles	All	Unknown	None	Media, health	Australian Government
99	Vic.	Noogal Toengorrt Tani cricket program	Unknown	Provide cricket participation and development opportunities for ages 12–23 years.	All	Unknown	None	Community, sport	State or territory government
100	WA	Remote Aboriginal swimming pools program	2000-present	Work in consultation with communities to run safe, efficient and effective aquatic facilities and to meet the needs and expectations of the communities	Remote	45 000 visits annually across 6 communities	IMPACT: physical activity and fitness level, health, social	Community, health, NGO	State or territory government, private sector
101	NT	RLSSA NT remote pools project	2003-present	Maximise health, social and economic benefits of swimming pools in remote communities	Rural, remote	19 000 in 18 communities	None	Health, NGO	Australian Government, state or territory government, local government
102	Vic.	Rumbalara Football and Netball Club healthy lifestyles program[A]	2006-present	Build a strong and healthy community with a central focus on nutrition and exercise. Encourage healthy lives by making choices that lead to good physical, spiritual, social and well being for people and their families	Rural	Unknown	Unknown	Community, sport	Philanthropy, private sector, NGO
103	National	Sports healthy futures program	2013–2014	Improve overall health and well being of youth through participation in sports, deliver sporting equipment to community organisations, sporting clubs and schools in exchange for team members attending regular health checks	All	Unknown	None	Community, health, sport	Aboriginal organisation

104	NT	Sunrise Health Service physical activity program	2009-present	Promote healthy lifestyles through providing support to communities in developing and implementing strategies to increase the level and quality of physical activity, lifestyle and community well being	Rural, remote	Unknown	None	Community, health	Australian Government, state or territory government
105	NT	Tiwi Islands Youth and Communities	2003-present	Engages youth aged 12–19 years at-risk of entering the criminal justice system in prevention activities, such as cultural activities, sport and recreation	Remote	131 since 2003. Deliver preventive program to all school children	PROCESS, IMPACT: social	Community, education, health, police, sport	Local government, NGO
106	WA	Tobacco & Healthy Lifestyles Program	2015-present	Reduce the risk of chronic disease by lowering smoking and tobacco-use, increasing exercise and improving nutrition	Remote	Whole of community	PROCESS, IMPACT: health	Community, education, health	Australian Government
107	WA	WA Healthy Schools Project	2008–2015	Increase physical activity participation and healthy food and drink consumption	All	Unknown	PROCESS	Education, health, sport	Australian Government
108	Qld	Walkabout wonders	2013-present	Increase the knowledge of participants' own health and chronic disease and the benefits of regular exercise	Urban, rural	Unknown	None	Community, health	Australian Government, State or territory government
109	WA	Western Desert Sports Program	2002-present	Support healthier lifestyle choices	Remote	500	PROCESS	Community, sport	State or territory government, private sector
110	WA	Wirraka Maya's Leap Leadership swim for life program	2013–2014	Develop youth leadership skills and achievement in a structured environment. Enhance problem-solving and decision-making skills while improving self-esteem through swimming. Provide an opportunity to gain valuable water safety and lifesaving skills	Rural	Unknown	None	Community, health, NGO	Charity funds

[A]Program was identified in the bibliographic search.
[B]Region, according to Australian Institute of Health and Welfare Rural, Remote and Metropolitan Areas (RRMA) classification:[40]
Urban: capital cities and other metropolitan centres (urban centre population >100 000)
Rural: rural centres (urban centre population 10 000–99 999)
Remote: Remote centres (urban centre population >4999) and other remote areas (<5000).
[C]Evaluation indicators, according to Nutbeam and Bauman (2006):[14]
Process: 'set of activities designed to assess the success of program implementation'
Impact: 'set of activities designed to assess short-term progress in the implementation of a health promotion intervention'
Physical activity: any bodily movement produced by skeletal muscles that requires energy expenditure.[41]
Fitness: 'the condition of being physically fit and healthy'[42]Health: any widely recognised indicator of physical or mental health status (e.g. blood pressure, weight, diet, smoking)
Social: any broader societal indicator of benefit (e.g. school attendance, crime rates).

and remote locations. The majority of Aboriginal and Torres Strait Islander people reside in areas defined as urban, as reflected in our program location findings, despite a higher proportion living in rural or remote areas when compared with the overall Australian population.[18] WA had the largest number of programs, followed by NSW and Qld; all three states have the largest population of Aboriginal and Torres Strait Islanders in Australia at 43 731, 103 907 and 94 082.[18] Ten programs were located in NT, which has the highest population proportion of Aboriginal and Torres Strait Islander people at ~30%[19] and the fourth highest absolute number. However, the total number of remote programs identified ($n = 14$) indicates gaps in program provision specific to population density are likely. While program development according to locally identified community needs is a vital component of self-determination and program success,[20] the widespread provision of culturally appropriate services is integral to initiatives to reduce population inequalities. It is encouraging that the majority of programs we identified involved Aboriginal and Torres Strait Islander stakeholders, as optimum program practice should encompass culturally specific input at all stages of development, implementation and evaluation.[21]

Since 2008, 'Closing the Gap' has been the main policy initiative to achieve Aboriginal and Torres Strait Islander health equality.[22] We found that while a small number of programs had operated continuously for over a decade; the majority had shorter lifespans, limiting their sustainability. This may reflect current policy direction and typical short-term funding periods but ongoing commitment will be inherent to the success of the policy. Estimations of participant numbers were available for over half of sourced programs. Some programs had small numbers of participants (10-–-20) and others involved over 1000 people, but the extent of regular participation was unknown. Obtaining detailed information on reach and measuring its resultant impact was beyond the scope of this study, it also appeared to be beyond the scope of many of the program operations. Upstream initiatives and policies which reach larger numbers of people are likely to have greater population level effects. This has been suggested in mainstream public policy through approaching the social determinants of health[23] and is particularly pertinent for Aboriginal and Torres Strait Islander Australians.[24] However, current policy for disadvantaged groups focuses predominantly on individual behaviours. There is demonstrated effectiveness of group-based physical activity programs;[11,25] such practice is recommended in combination with approaches to improve broader, structural determinants of health.[26]

We found program aims predominantly focussed on physical activity to prevent or treat chronic diseases that are the major cause of the gap in life expectancy.[1] However, the Indigenous Chronic Disease Package (ICDP) which focussed comprehensively on both the prevention and management of chronic diseases existed only from 2009–2013.[27] This policy change may result in fewer programs in the future, subsequently leading to poorer health in Aboriginal and Torres Strait Islander people, given the known benefits of physical activity. Almost a third of programs aimed to promote physical activity to achieve broader social benefits such as educational and employment outcomes and reduced rates of crime. Health and sport programs are worthy crime prevention approaches.[28] There are also recognised relationships between physical activity and fitness level and academic achievement[29] as well as social and mental health benefits specific to Aboriginal and Torres Strait Islander populations.[30,31] However, a cautious approach to alluding to wider social benefits directly arising from individual programs should be taken in the absence of empirical evidence, as well as the direct effects of standalone programs on health. Yet the documentation of existing program evaluation measures in this snapshot represents a vital first step in reviewing programs collectively and some have demonstrated encouraging evidence of positive educational and employment outcomes.[32,33] There is also some evidence of social benefits, such as community cohesion and cultural identity; derived from sport programs in this snapshot,[31,34] which are important for Aboriginal and Torres Strait Islander health. Such programs might therefore contribute to corresponding 'Closing the Gap' policy indicators and should be resourced accordingly.

Most programs received financial support from national, state, territory or local government, which is a commendable response to population health disparities. However, funding sources across multiple jurisdictions also often lack long-term synergy and support. Sustainable program funding is challenging but more likely to be achieved where public, private and philanthropic sources can be combined, as was found for several programs. While financial contributions from participants can ensure continuation, this may not be appropriate for this population group given income inequalities.[35] Cost has been identified as a barrier to physical activity participation among Aboriginal and Torres Strait Islander people,[36] therefore, it is encouraging that the majority of programs incurred no participant costs. Multi-sector partnerships, evident for the majority of programs, can help ensure continuous support across organisations.

All 11 programs identified in the bibliography search included formal evaluation results. Yet of the 110 programs sourced, 65 had formal evaluation measures; the results of which cannot be found in academic literature. This discrepancy could be partly due to evaluation proposals currently in their infancy with results anticipated in the future, as well as a lag time before findings are published. There is an increasing requirement from funding sources to conduct formal evaluation of programs[37] which may translate to published results in the future. However, such program evaluation results may not be made publically available. Recommendations to improve the collection of quality evaluation data[38] may also be influencing current practice. The low number of published evaluations represents a current gap in the sharing of evidence

informed practice and rigorous science. No economic evaluations were uncovered; this also represents an avenue for future research to support ongoing investment in programs. While the purpose of this snapshot was to capture evaluation measures rather than results, findings suggest that evaluation of physical activity programs for Aboriginal and Torres Strait Islander people is more prevalent than published literature suggests. In order to ensure program effectiveness and future planning, the dissemination in a timely manner of well-designed process and impact evaluations,[14] through formal and informal publication and media channels, is essential.

Strengths of this study include the comprehensive inclusion of relevant physical activity programs targeting Aboriginal and Torres Strait Islander people and the standardised documentation and description of program aspects. The inclusion of both published literature and online or grey sources enhances the scope and completeness of this work. Verification by program coordinators adds further accuracy to the findings. There are some limitations; other programs may exist, but their information was unable to be sourced. Given the widespread current use of the Internet to profile organisational information, we can be confident that the majority of existing, relevant programs were captured. The snapshot could only identify organised programs yet Aboriginal and Torres Strait Islander people may be more likely than non-Indigenous people to achieve physical activity through incidental means,[30] via necessary transport related activity associated with socioeconomic disadvantage[39] and within mainstream programs.[17] Contact with some program coordinators was not possible and some differences in the understanding of program indicator information may have occurred.

Conclusion

This snapshot provides a comprehensive description of current physical activity program provision for Aboriginal and Torres Strait Islander people across Australia, representing an important first step in monitoring the implementation of programs to increase physical activity. Such programs are an essential part of closing the gap in health disparities.

Over 100 programs were found to be operating between 2012 and 2015 but identification of the majority of programs occurred through non-academic sources. It is recommended that all programs targeting Aboriginal and Torres Strait Islander people disseminate publically accessible details. This would provide a more complete picture of program provision, identify gaps in services and shared information platform on components of programs that could benefit populations in other locations. Many programs collect evaluation data, yet this data is commonly underrepresented in academic literature. The timescale of programs may be limited by short funding cycles, possibly affecting their overall impact and not typically allowing economic provision for analysis of program effects when programs are increasingly required to show cost benefits. Culturally appropriate, sustainable and effective programs to improve chronic disease risk factors, such as physical activity initiatives, are an integral element of efforts to improve health for Indigenous communities.

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Chapter 6

The ripple effect: health and community impacts of the Indigenous Marathon Program on Thursday Island

Under review

Chapter 5 identified 110 programs that aimed to increase physical activity for health or broader social outcomes and that while around half were found to collect process or impact evaluation data, this is underrepresented in the scientific literature.

Chapter 6 contributes to the evidence base around the associations between physical activity and health of Aboriginal and Torres Strait Islander people by conducting a pilot evaluation of one of the initiatives featured in Chapter 5. The pilot evaluation examined the perceived health and community impacts of the Indigenous Marathon Program within one community: Thursday Island in the Torres Strait through primary data using quantitative and qualitative methods.

The 'ripple effect': health and community perceptions of the Indigenous Marathon Program on Thursday Island in the Torres Strait, Australia

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Abstract

Issue addressed: Physical inactivity is a key health risk among Aboriginal and Torres Strait Islander (Indigenous) Australians. We examined perceptions of the Indigenous Marathon Program (IMP) in a remote Torres Strait island community.

Methods: Semi-structured interviews with community and program stakeholders (n=18; 14 Indigenous) examined barriers and enablers to running and the influence of the IMP on the community. A questionnaire asked 104 running event participants (n=42 Indigenous) about their physical activity behaviours, running motivation and perceptions of program impact. Qualitative data were analysed using thematic content analysis and quantitative data were analysed using descriptive statistics.

Results: Interviews revealed six main themes; community readiness, changing social norms to adopt healthy lifestyles, importance of social support, program appeal to hard-to-reach population groups, program sustainability and initiation of broader healthy lifestyle ripple effects beyond running. Barriers to running in the community were personal (cultural attitudes; shyness) and environmental (infrastructure; weather; dogs). Enablers reflected potential strategies to overcome described barriers. Indigenous questionnaire respondents were more likely to report being inspired to run by IMP runners than non-Indigenous respondents.

Conclusions: Positive 'ripple' effects of the IMP on running and broader health we described to have occurred through local role modelling of healthy lifestyles by IMP runners that reduced levels of 'shame' and embarrassment, a common barrier to physical activity among Indigenous Australians. A high initial level of community readiness for behaviour change was also reported.

So what? Strategies to overcome this 'shame' factor and community readiness measurement should be incorporated into the design of future Indigenous physical activity programs.

Introduction

The life expectancy of Aboriginal and Torres Strait Islander (Indigenous) people is around 10 years lower than non-Indigenous Australians 1. Much of this gap in life expectancy has been attributed to preventable chronic disease 2. Physical inactivity is a key risk factor for chronic disease and one of the leading causes of both mortality and morbidity 3.

The Torres Strait is a remote region between Cape York in Queensland and southern Papua New Guinea that has been inhabited for at least 70,000 years and consists of over 270 islands and reefs, including 17 currently inhabited islands 4. In 2011, there were 5,921 people of the two culturally distinct Australian Indigenous groups, Torres Strait Islander (Melanesian), and Aboriginal in the region 4, 5; 79.0% of the total population. Thursday Island (2,610; 64.7% Torres Strait Islander/Aboriginal) has the largest population of all the islands. The Torres Strait has high rates of diabetes at approximately a third of all adults 6. Levels of overweight and obesity are also high at 30% and 51% respectively 6.

Physical inactivity is a well-established risk factor for diabetes 7 and obesity 8. Few previous studies on physical activity in this population exist. Australia-wide, only 38% of Torres Strait Islander/Aboriginal adults in non-remote areas are sufficiently active for health benefits, with no data available for remote areas 9. State-level data includes local area physical activity prevalence data from the Torres Strait and parts of neighbouring Cape York but these data cannot be considered population-representative for the Torres Strait specifically 10. Physical activity

participation is influenced by personal and environmental barriers and enablers 11. A study with women and girls from 21 families living in the Torres Strait and the Cape York Northern Peninsula Area (NPA) reported a theme of 'shame', defined as being ashamed or embarrassed by being physically active in public, as a barrier to physical activity participation 12.

A key policy response to chronic disease has been to deliver programs to increase physical activity for health benefits 13. Programs in mainstream community programs have demonstrated effectiveness in reducing chronic disease risk factors 14. However, little is known about the effectiveness of physical activity programs for Torres Strait Islander/Aboriginal people 13.

The Indigenous Marathon Program 15 (IMP) is a not-for profit initiative established in 2010 which uses running and local role models to promote healthy lifestyles in Indigenous communities. Annually, a squad of 12 young Indigenous adults aged 18-30 years are selected to train to run a marathon whilst living in their communities. They also undertake vocational courses in health, fitness and running coaching and are encouraged to establish and co-ordinate local community Indigenous running groups and fun runs. These groups are named 'Deadly Runners'; 'Deadly' being a popular, positive and colloquial cultural term. In 2014, two of the 12 IMP squad runners lived on Thursday Island and established the island's Deadly Runners. In both the 2015 and 2016, a new representative from Thursday Island was selected to the squad.

This pilot study aims to examine perceptions of the health and community impact of the IMP on Thursday Island. The study population includes the whole Thursday Island community, given the demographic breakdown and to allow for comparisons by Indigenous status, but with a specific focus on Torres Strait Islander/Aboriginal people according to community health priorities 2, 6.

Methods

Design

The study used a multimethod approach using qualitative interviews with community and program stakeholders and a quantitative questionnaire completed by participants of the 2016 Thursday Island Running Festival (TIRF). TIRF is a community fun run event organised by the local IMP and Deadly Runners, with four race distances ranging from 2.5 kilometres to 21.1 kilometres (half-marathon).

Participants

Key informant qualitative interviews were conducted with two groups of stakeholders. Community stakeholders (n=11) held professional roles in the following sectors relevant to community-based health lifestyle promotion: not-for-profit organizations; local government; health; sport. Program stakeholders (n=7) were also community stakeholders in specific capacity as program coaches and/or co-ordinators of the Thursday Island Deadly Runners group. Quantitative questionnaire respondents were TIRF adult participants.

Procedure

In 2012, the researchers commenced a partnership for evaluation with IMP staff through engaging with IMP events and discussing possibilities for research. The researchers had previously met the 2014 and 2015 Thursday Island marathon runners at these events. Thursday Island was selected as the pilot study community by IMP and in March 2016, two researchers spent four days on the island to plan the evaluation in partnership with the community. This scoping visit was timed to coincide with the 'Return to Community' event, which celebrated the achievements of the island's 2015 squad runner. On the scoping visit, we met with community stakeholders and attended Deadly Runners training sessions to meet participants, learn about

their experiences and to obtain feedback on evaluation ideas and methods from both stakeholder groups. Given the retrospective timing of the pilot evaluation when IMP activities were already established, it was not possible to conduct an impact evaluation. A multimethod approach was considered the most feasible data collection method given its value in triangulating insights from quantitative and qualitative research 17.

We were invited back to undertake data collection during the week of the TIRF. Interview participants were recruited through snowball sampling of stakeholders with whom contact had previously been established. Potential interviewees were invited to participate through email, telephone or face-to-face contact and asked to provide a recommendation of any other suitable interviewees. Interviews were conducted face-to-face at a time and place convenient to the participant with the exception of two telephone interviews with stakeholders who did not reside on Thursday Island. Interview duration ranged from 10-50 minutes (average 30 minutes). One researcher conducted all the interviews which were audio recorded and transcribed verbatim.

TIRF participants completed the questionnaire either at the event expo the day before when they collected their running bib or at the event prior to race starts. Participants were approached by the researchers at the registration point, invited to consent to participate in the study. Consenting participants placed their completed questionnaire in a closed box.

Ethical approval was given by The University of Sydney (approval number R2015/10/05) and support for the research was given by the Torres Shire Council. All participants provided written informed consent to participate and interviewees also consented to be audio recorded.

Measures

Interviewees' perception of the impact of the IMP on the community and its broader effects and barriers and enablers to running through five semi-structured interview questions (Figure 1). The one-page quantitative questionnaire (Supplementary file) was developed in consultation with local Deadly Runners, IMP staff and community stakeholders during the scoping visit and in subsequent communication (face to face, telephone and electronic). Potential questions relevant to the study aims were discussed with stakeholders, leading to question testing by stakeholders and their suggested community contacts. It took approximately ten minutes to complete and asked TIRF participants about their running experience and their perceptions of running in the community and of the impact of IMP. Self-rated health was assessed through the Short Form Health Survey, question 1; SF 1 18. Socio-demographic questions asked respondents their age in years, gender, place of residence and level of education 19 to better understand the study population. Participants were asked to record their event bib number/name as a unique identifier.

INSERT FIGURE 1 ABOUT HERE

Data analyses

Qualitative data were analysed using thematic content analysis 20. Data coding and analysis was performed in NVivo software version 10 (QSR International). Interview transcripts were coded by the first author with a sample of 10% cross-checked by the last author. Initial codes were refined and combined to generate higher level themes. Quantitative data were analysed through descriptive statistics using SPSS version 21.0. As the data were not normally distributed, non-parametric Chi-squared were used to examine response variation by Indigenous status. Fisher's exact tests were used where cell sizes were <5. The significance level was set at $p<0.05$.

Following data analyses, a third visit to Thursday Island by the first author for ten days during March 2017 occurred in order to engage in 'Member Checking' 21. Findings were presented to interested stakeholders and participants in individual and small group meetings. A presentation was also delivered at the 'Return to Community' celebration for the island's 2016 squad runner. Stakeholders and participants were encouraged to ask questions of the initial findings and to provide comments and perspectives to assist interpret their context and understanding. During and subsequent to this third visit, the interpretation of the findings were finalised.

Results

Stakeholder interviews

Most (14/18) of interviewees identified as Torres Strait Islander/Aboriginal. Six key findings emerged from the interviews (Figure 2). Firstly, respondents indicated that the community had experienced increased levels of readiness for healthy lifestyles in recent years. Interviewees spoke of prior whole-of-community initiatives that had raised awareness of chronic disease risk factors including physical activity 13. This awareness may have meant that when local IMP activities commenced, they were perceived by respondents as a practical way for people to embrace healthy lifestyle activities. Secondly, interviewees described how it is becoming normal to run and do physical activity on Thursday Island. They spoke of the local, cultural phenomenon of "shame" 12 but how this was gradually reducing in the community. The impact of local Torres Strait Islander/Aboriginal people participating in running and other physical activities seemed to have made it more appropriate for others to be similarly active, translating to a perceived increase in running by local people.

INSERT FIGURE 2 ABOUT HERE

The third theme was that other healthy lifestyle changes also happened in conjunction with running. Interviewees described how this could have occurred first with increased running participation, followed by improvements in other areas like nutrition and mental health. Conversely, other improvements like food affordability occurring in the community at a similar time were thought to have encouraged people to consider initiating physical activity as part of a healthy lifestyle. The fourth theme was that interviewees perceived IMP and Deadly Runners to have reached different, harder to reach, groups of people, particularly older females and those who did not participate in existing team sports. Interviewees described surprise at seeing people running who they would not have expect to run. This seemed to have a subsequent effect that influenced other people to consider running themselves. However, challenges remained in increasing participation among males.

The fifth theme was the importance of support for individuals and groups to participate in running. This support took two main forms. Firstly, in the form of social support 32 where increased benefit occurred when people participated in group activities where group support among individuals was a key element. Secondly, interviewees spoke of the importance for individualized support to initiate a program of exercise and to provide guidance and reassurance of safety to be physically active. The final theme was that the growth in healthy lifestyles occurring in the past few years should continue and become sustainable. Deadly Runners is led by several qualified coordinators. There was enthusiasm for increasing running participation beyond Thursday Island to the wider Torres Strait and to the next generation; a phenomenon referred to by interviewees as the ‘ripple effect’.

Barriers to running discussed by interviewees were a mixture of personal/cultural and environmental (Figure 3). The strongest barriers appeared to be personal/cultural around the

192 "shame" factor, consistent with theme 2 (social norms). Interviewees spoke about how people
193 did not want to be seen running in public by others, especially if they were overweight, for fear
194 of being judged. This had a strong influence on behaviour and participation. Further personal
195 barriers included (lack of) motivation, perceived age and weight constraints.

196 INSERT FIGURE 3 ABOUT HERE

197 The built and natural environment on Thursday Island was generally viewed as supportive for
198 running, having a waterfront track for walking/running and a variety of places to run, even on a
199 small island. However, a lack of complete footpaths/pavements, safety concerns and dangerous
200 dogs on the island were considered significant barriers as well as hot and wet weather
201 experienced in the tropical climate.

202 Interviewees provided suggestions of how these personal/cultural and environmental barriers
203 could be overcome. They spoke of the importance of local Torres Strait Islander/Aboriginal role
204 models for running; people who they could relate to who had achieved significant goals through
205 running such as marathon completion and weight loss. Interviewees also described support for
206 individuals to be active, consistent with theme 5, as an enabler. Suggestions to overcome the
207 environmental barriers cited were provided. These included improving infrastructure provision
208 for complete footpaths and supportive environments for running and walking as well as more
209 creative solutions to overcome issues with dogs.

210 TIRF questionnaire

211 A total of 113 adults completed the TIRF questionnaire; 66.9% of the 169 adult participants.
212 Nine responses were excluded due to respondents residing outside of the Torres Strait and NPA.
213 Of the final sample of 104 adults, 42 (40.4%) identified as Torres Strait Islander/Aboriginal, the

majority resided on Thursday Island (87.5%) and most (76.0%) were female. Over half had participated in Deadly Runners (51.9%; 53.0% of females) and the majority had participated in individual exercise (71.2%; 73.4% of females) during the past year (Table 1). Half of respondents were 30-39 years; 24.0% were 40-49 years. The main motivation to run was fitness (92.3%) and over half said they were inspired by local IMP (59.6%) and Deadly Runner (51.0%) role models. IMP awareness was high (90.4%) and almost 60% strongly agreed that IMP had an impact on their community (58.7%). Half (50.0%) claimed to be running and walking more/much more compared to one year prior, 66.3% agreed/strongly agreed that there are lots of people running regularly on Thursday Island and 84.6% thought that running has become more popular in their community in the last three years. The majority (55.8%) self-rated their health as excellent/very good.

INSERT TABLE 1 ABOUT HERE

A higher proportion of Torres Strait Islander/Aboriginal respondents (9.6%) indicated they were more likely to run because of health problems than non-Indigenous respondents (4.8%; p=0.03). More non-Indigenous respondents indicated they exercised individually (48.1% vs. 23.1%; p=0.009) and had university level education (49.0% vs. 10.6%) than Torres Strait Islander/Aboriginal respondents (p<0.001). Chi-squared test results are presented; significance levels did not differ in Fisher's exact tests.

Discussion

We examined perceptions of the IMP on Thursday Island, including running participation and broader health and lifestyle factors. Qualitative results revealed that the community reported a high initial level of readiness for healthy lifestyles and this occurred concurrent with reported

shifting social norms towards healthy lifestyles. Support from program leaders and the social support of other participants were important and broader healthy lifestyle effects beyond running were reported since IMP had commenced. IMP appeared to appeal to hard-to-reach groups and the growth in healthy lifestyles seemed well established, but had room for further program expansion. Barriers and enablers to running were personal/cultural and environmental. Quantitative findings revealed higher participation by females, and those who participated in IMP activities. A higher proportion of Torres Strait Islanders/Aboriginal adults ran to improve health problems and were inspired to run by local IMP runners, than non-Indigenous adults.

Previous research that has found lower physical activity participation levels among females 20. However, men are also an important target group for healthy lifestyle programs as they have higher rates of obesity, smoking and alcohol consumption than women 21. This is relevant to our study community where participation rates in running and walking appeared lower among men, representing an identified future target group for the program.

A higher proportion of non-Indigenous respondents reported participating in individual exercise which is consistent with previous evidence where participation for individual gain is considered culturally inappropriate in the Torres Strait 22. However, individual level participation among Torres Strait Islander/Aboriginal people has been deemed appropriate in relation to the management of illness 22. This was similar to our finding that Torres Strait Islander/Aboriginal people were more likely to cite 'health problems' as a reason for why they run or walk.

A larger proportion of non-Indigenous respondents were university educated, compared to Torres Strait Islander/Aboriginal people but this is unsurprising given disparities in education evident Australia-wide and on Thursday Island 5. The non-Indigenous population on Thursday Island

typically comprises people who relocating for professional roles and differ socio-economically to the local population 5.

Interviews revealed a high level of community readiness, related to two further findings around the initiation of broader healthy lifestyle effects and sustainability regarding their growth. Interviewees described the positive response to IMP activities and related running participation as being linked to the community being ready to take up such an initiative. Some interviewees reflected on previous government community health initiatives that had achieved increased awareness of chronic disease 15. This seemed to make IMP, offering a practical way for people to prevent chronic disease, accessible and appealing extending to broader health factors such as diet and mental health, which naturally fit with holistic views of Indigenous health 24. Previous community readiness research identified sustainability as a crucial element for success 25, which was consistent with our findings. The capacity building of local Torres Strait Islander/ Aboriginal people to lead future development of community running activities appeared crucial to this sustainability. Several tools and interview techniques to measure community readiness have been developed 25 and used to select communities for an obesity prevention program 26. We recommend that IMP and other programs wishing to achieve impact should measure initial levels of community readiness using established tools prior to implementation.

Our findings indicate that dog attacks and fear of such an occurrence was a barrier to running. A Torres Strait study in the late 1990s also identified dogs as a barrier to physical activity 27. In the present study some improved management of dog issues was described. The previous study also found a lack of local role models and council support as barriers. In contrast, we found more positive views of council support although areas for improvement were identified. We found the

existence of local role models a key personal/cultural enabler, consistent with our quantitative finding of Torres Strait Islander/Aboriginal respondents being inspired by local IMP runners.

Although shame or shyness factors were evident barriers to physical activity in our research and earlier 12, it seemed that running and being physically active in public around Thursday Island was becoming normalised. This may be attributed to some of the activities of IMP, in making running by Torres Strait Islander/Aboriginal people more common through IMP marathon training, broader community participation of Deadly Runners and empowerment of local leaders. Our findings around shame as a barrier and the importance of group-level support are also consistent to those from a study in urban Australia where physical activity participation was viewed as acceptable within the context of the family and community 28. On the whole, we found personal/cultural barriers appeared to be stronger than environmental barriers. The environmental barriers described are consistent with other local 29, Australian (Indigenous) and international study findings 30-32. However, our participants also spoke of positive physical environment aspects such as the presence of a waterfront path and different places to run, even on a small island.

Strengths of this study include the strong community consultation process in the development of the evaluation and in the interpreting of results. However, we experienced unavoidable challenges in conducting an evaluation of a program that had already commenced, influencing our choice of reflective, retrospective enquiry. Thus the application of experimental or quasi-experimental designs where data collection commences prior to program implementation are recommended for any future larger scale IMP evaluation beyond this pilot study and to community program evaluation more broadly. There may also have been a social desirability bias where participants may have been influenced to give more positive responses to questions

about IMP from a researcher deemed to be associated with the program, despite the research being conducted independently. Nonetheless, there are strengths in adopting the multimethod approach employed in this study where quantitative and qualitative findings can corroborate each other to some extent. Our quantitative questionnaire response rate was high although the proportion of Torres Strait Islander/Aboriginal respondents was lower than the resident population proportion. This quantitative finding may have been due to the shame or embarrassment factors around being physically active in public, evident in the Torres Strait culture 12, apparent in the qualitative findings. However, almost all interview participants were Torres Strait Islander/Aboriginal, giving a strong local voice to the data.

Conclusion

This multimethod pilot study provides useful evidence of the perceived impact of IMP on Thursday Island. Qualitative interviews gave the community a strong voice to describe their accounts of the program, supplemented by quantitative running festival questionnaire data. Overall, positive 'ripple' effects of the IMP on running and broader health and lifestyle factors were reported in this remote island community with a high initial level of community readiness for such changes. These effects were reported through local role modelling of healthy lifestyles by IMP runners that had led to reduced levels of 'shame' and embarrassment that were prominent barriers to running and walking. We recommend that these strategies to overcome 'shame' factor and the measurement of community readiness be incorporated into the design and evaluation of future Torres Strait Islander/Aboriginal physical activity programs. Building on this pilot study, an up-scaled evaluation of IMP in multiple communities across Australia would determine the external validity of these pilot findings beyond the Thursday Island community.

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Figure 1: Stakeholder interview questions

1. What is your experience of the IMP & Deadly Runners?
2. What do the community think of the IMP & Deadly Runners?
3. What are the 'ripple effects' of the IMP and Deadly Runners?
4. What are the barriers to running in the community?
5. What could help overcome these barriers?

Figure 2: Qualitative interview themes

Theme 1: High initial levels of community readiness

"There's a lot of people taking their own initiative, the community was ready for a change. We need to do things for ourselves in relation to changing our health. For too long we've been having things done to us." (Community stakeholder 1).

Theme 2: Physical activity becoming a social norm

"Shame is a big factor with Indigenous people but I think we're slowly getting over that. If everyone's doing it, it's a social norm, normal to exercise." (Community stakeholder 2).

Theme 3: Other healthy lifestyle changes have occurred

"I think people have become more health conscious. I know IBIS (supermarket) sells more water and the selection is getting bigger, fruit and veggies. A lot of things have happened in the last 3 years that have brought everything together – IMP, sports store coming in, IBIS lifting their game." (Community stakeholder 3);

"I see IMP as a good thing for the community health wise, mental health wise and that physical exercise, being healthy all contributes to social & emotional health so it can only be a positive thing." (Community stakeholder 2).

Theme 4: IMP reaches different groups of people

"I've seen a big difference in people doing exercise, more joining up, always different people, like older people that I wouldn't have thought would run or join the Deadly Runners, seeing those people makes me think that if they can do it, I can do it." (Community stakeholder 4).

Theme 5: Importance of support for individuals and groups

"The social aspect as well has really benefited the community, being with people who want to do similar things, exercise and health & wellbeing, just being in that group, having that conversation, relating to people, it can do wonders." (Community stakeholder 5);

"I think having that support of the group to feel that you can run safely in terms of health. A lot of older people think they're too old to run, whether it's their knees or heart. With the group, there's people there who are experienced who can help in a first aid situation or leading up to running to gain confidence that you can be a part of this." (Program stakeholder 1).

Theme 6: Increase in healthy lifestyles should become sustainable

"The ripple effect will take time and it'll come in waves. We'd like to see the outer islands involved, that'll all eventually happen but we just gotta figure out how and who can help make it happen. If it helps our people here, it's going to help our people out on the outer islands" (Program stakeholder 2);

"It's been introduced now at a young age which we didn't have. The ripple effect has been massive and it'll be good to see in the next 5-10 years what our children achieve." (Program stakeholder 3).

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Figure 3: Perceived barriers and enablers to running and walking

Personal/cultural barriers: *"Most people are still trying to step out of their comfort zone. There's a big shame factor that is strongly embedded within the Torres Strait culture. People are too scared of what other people are going to think and that's a cycle we're trying to break."* (Community stakeholder 1);

"Some of the barriers, especially the older people and some younger people is motivation and you have some obesity and excuses they come up with. They think they see their body being fat and they're thinking 'I can't do it, I can't run'." (Program stakeholder 4).

Environmental barriers: *"Dogs are a big issue, really scare some people, no matter how much they are really keen, they won't go out and walk."* (Program stakeholder 2).

"The heat is always an issue. Footpaths are getting better but they're still not great, the footpath doesn't go all the way around so you end up on the road." (Community stakeholder 6).

Personal/cultural enablers: *"Just finding normal people who have gone through that phase to be able to stand in front of the community and be motivational speakers to say 'I've been that person before and I know you feel the same way."* (Program stakeholder 5).

Environmental enablers: *"I know it's expensive but get a good path that goes around the island and to areas of the island where people feel safe to go."* (Community stakeholder 7);

"I think the Council needs to put some more water taps around the place and distances marked out on the island or on the running routes. And dog control but I think they're getting that under control." (Program stakeholder 3).

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415 Table 1: Responses to the 2016 Thursday Island Running Festival (TIRF) questionnaire by

416 Indigenous status

		% Torres Strait Islander/Aboriginal (N=42)	% Non-Indigenous (N=62)	p
Age	18-39 yrs	27.9	22.1	0.518
	40+ yrs	12.5	37.5	
Gender	Male	12.5	11.5	0.174
	Female	27.9	48.1	
Education level	Year 10/12/TAFE	29.8	10.6	<0.001
	University	10.6	49.0	
2016 TIRF Event	5k/10k team	8.7	19.2	0.227
	10k solo/21.1k	31.7	40.4	
Participate in: Deadly Runners	Yes	23.1	28.8	0.381
	No	17.3	30.8	
Participate in: Deadly Fun Run Series	Yes	7.7	15.4	0.422
	No	32.7	44.2	
Participate in: Individual exercise	Yes	23.1	48.1	0.009
	No	17.3	11.5	
Participate in: 2015 TIRF	Yes	7.7	20.2	0.098
	No	32.7	39.4	
Participate in: Team sports	Yes	14.4	20.2	0.846
	No	26.0	39.4	
Participate in: Other running events	Yes	7.7	24.0	0.022
	No	32.7	35.6	
Compare to 1yr ago do you run/walk	Much more/more	20.2	29.8	0.904
	About the same/less	19.2	29.8	
Why do you run: Fitness	Yes	37.5	54.8	0.863
	No	2.9	4.8	
Why do you run: Health problems	Yes	9.6	4.8	0.025
	No	30.8	54.8	
Why do you run:	Yes	22.1	21.2	0.052

Weight control	No	18.3	38.5	
Why do you run: Mental well-being	Yes	14.4	37.5	0.006
	No	26.0	22.1	
Why do you run: Sense of community	Yes	9.6	26.9	0.027
	No	30.8	32.7	
Why do you run: Fun	Yes	19.2	31.7	0.575
	No	21.2	27.9	
Inspired by: IMP Runners	Yes	28.8	30.8	0.043
	No	11.5	28.8	
Inspired by: Deadly Runners	Yes	22.1	29.8	0.633
	No	18.3	29.8	
Inspired by: Family	Yes	20.2	19.2	0.069
	No	20.2	40.4	
Inspired by: Friends	Yes	17.3	34.6	0.128
	No	23.1	25.0	
Lots of adults run regularly	Neutral/disagree	15.4	17.3	0.291
	Strongly agree/agree	24.0	42.3	
Running become more popular, past 3yrs	Strongly agree	30.8	19.2	0.629
	Other	27.9	21.2	
IMP has had community impact	Strongly agree	34.6	24.0	0.882
	Other	25.0	16.3	
Self-rated health	Good/fair/poor	19.2	25.0	0.567
	Excellent/v. good	21.2	34.6	

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Chapter 7

Discussion and Conclusions

1. Overview of key findings

This thesis presents a series of research studies on patterns of physical activity among Aboriginal and Torres Strait Islander Australians identifying current physical activity program elements and approaches to program evaluation.

The research:

1) Examined cross-sectional associations between physical activity and a range of lifestyle, environmental and social factors among Aboriginal adults;

2) Described physical activity patterns and influencing factors among Aboriginal adolescents;

3) Identified and described characteristics of physical activity programs targeting Aboriginal and Torres Strait Islanders;

4) Investigated the effects of a community-based physical activity program in the Torres Strait.

In this discussion chapter, I summmarise the findings from the studies in this thesis and critically describe these findings in relation to relevant literature. I discuss the strengths and limitations of the thesis and explain the implications for Aboriginal and Torres Strait Islander health. Finally, I outline future work that should build on the findings of this thesis.

Table 1 summarises the findings from each chapter, and the conclusions reached by each of these studies. Chapter 2 found similar physical activity levels among Aboriginal and non-Aboriginal adults and similar correlates of being active, despite less favourable neighbourhood features and social support experienced by Aboriginal adults (1). Chapter 3 found that physical activity levels were low among both Aboriginal and non-Aboriginal adolescents. Some factors associated with these levels were the same for both groups and some factors differed by Aboriginality (2). Chapter 4 demonstrated a decline in physical activity in a population of Aboriginal and non-Aboriginal young people over a period of five years, but not across all seasons, settings and types (3). The review in Chapter 5 identifies and describes current and recent

programs aimed at increasing physical activity for health and broader social outcomes (4). The pilot evaluation of the impact of Indigenous Marathon Program in Chapter 6 found running and broader healthy lifestyle factors had been adopted in a remote community with a high initial level of community readiness (5).

Table 1: Summary of key findings and conclusions from studies presented in this thesis

Chapter	Main findings	Conclusions
2 Physical activity, healthy lifestyle behaviors, neighborhood environment characteristics and social support among Australian Aboriginal and non-Aboriginal adults (1)	• 63.1% of Aboriginal and 65.4% of non-Aboriginal mid/older aged adults met the physical activity recommendations • Odds of - unhealthy sleep duration (OR=2.03 (95% CI=1.60-2.59) - receiving GP advice to be active (OR=1.81 (95% CI=1.43-2.30) - having spent no time in past week at social clubs/group meetings (OR=1.36 (95% CI=1.07-1.72) - having only 0-3 people outside home (within 1hr travel) to depend on (OR=1.31 (95% CI=1.04-1.64) were higher among Aboriginal versus non-Aboriginal participants • Aboriginal respondents had higher odds than non-Aboriginal respondents of - reporting that crime rates made walking unsafe (OR=3.09 (95% CI=2.20, 4.43) - no public transport within 10-15 min walk (OR=1.63 (95% CI=1.29, 2.07) - disagreeing they have local shops (OR=1.28 (95% CI=1.01, 1.61) or footpaths (OR=1.49 (95% CI=1.19, 1.87) - free/low cost recreation facilities (OR=1.40 (95% CI=1.10, 1.78) • Correlates of physical activity, such as age, gender, education, residential remoteness and disadvantage were similar in both groups	• Physical activity levels were similar among Aboriginal and non-Aboriginal adults • Many neighbourhood and social features were less favourable for physical activity among Aboriginal participants • Factors associated with physical activity were similar in Aboriginal and non-Aboriginal people • Multiple possible avenues for increasing physical activity through neighbourhood and social structures exist
3 Correlates of physical activity among Indigenous and non-Indigenous adolescents (2)	• 21% (95% CI=17, 25%) of Indigenous adolescents achieved higher levels of physical activity, compared with 28% (95% CI=25, 31%) of non-Indigenous adolescents (p=0.01) • In the whole sample, higher activity levels were associated with being male; sports team membership; lower levels of TV viewing time; and having an employed mother • Indigenous girls were less active than boys (OR=0.36; 85% CI=0.24, 0.54) and Indigenous adolescents whose mothers were unemployed were less active than those whose mothers were employed (OR=0.66; 95% CI=0.40, 1.09)	• Physical activity levels were low among both Indigenous and non-Indigenous adolescents • Some correlates existed across the whole sample; others for Indigenous or non-Indigenous only • Early and targeted, supportive approaches are necessary to increase physical activity

Chapter	Main findings	Conclusions
4 Understanding age-related declines in physical activity among Aboriginal and non-Aboriginal young people (3)	• Total MVPA, winter after-school activity and travel to/from school in both seasons declined over time in both groups (≤0.005) • Declines in: - both summer (-156.1mins, 95% CI=-307.9, -4.1) and winter non-organised (-149.5mins, 95% CI=-252.3, -46.8) - winter organised (-59.0mins, 95% CI=-106.7, -11.4) - school (-52.3mins, 95% CI=-96.0, -8.5) activity were among Aboriginal children only • Community-identified individual and environmental barriers are likely to have influenced these declines	• Physical activity declines in early adolescence were greater among Aboriginal children. • Data on barriers informed the context of declines • Holistic strategies to increase physical activity during this critical life stage are required to improve Aboriginal health
5 A snapshot of physical activity programs targeting Aboriginal and Torres Strait Islander people (4)	• 110 programs were identified in urban, rural and remote locations within all Australian states and territories but only 11 of these programs were located through bibliographic sources (peer reviewed journals) • Programs aimed to influence physical activity either for health or for broader social outcomes • 65 programs took place in community settings and most involved multiple sectors (e.g. sport, health and education). • Almost all programs were free for participants and involved Indigenous stakeholders; most received Government funding; and most had started within the last decade • 14 programs reached 0–100 participants; 14 reached 100-500 participants; 6 reached 500-1000 participants; and 22 reached over 1000 people (n=54 unknown reach) • Most programs collected process or impact evaluation indicators that typically reflected their aims	• Most programs were only identified through the grey literature • Capturing current practice can inform future efforts to increase the impact of physical activity programs to improve health and social indicators • Programs aiming to increase physical activity should also be culturally relevant • Many programs collect some evaluation data, yet this is underrepresented in academic literature

Chapter	Main findings	Conclusions
6 The 'ripple effect': health and community impacts of the Indigenous Marathon Program on Thursday Island (5)	• Evaluation interviews revealed six main themes: - community readiness to adopt health lifestyles; - changes in social norms towards healthy lifestyles; - the importance of social support - appeal to hard-to-reach population groups - program sustainability - the initiation of broader healthy lifestyle ripple effects beyond running • Barriers to running in the community were personal (cultural attitudes; shyness) and environmental (infrastructure; weather; dogs); enablers reflected strategies to overcome these barriers and the importance of local Torres Strait Islander role models • The majority of questionnaire respondents were female; had participated in both IMP activities and individual exercise; and their main motivation to run was fitness • Torres Strait Islanders were more likely than non-Indigenous respondents to have been inspired to run by local role models and to address health problems; non-Indigenous respondents were more likely than Torres Strait Islanders to have done individual exercise and to run for a 'sense of community' and mental wellbeing (all $p<0.05$).	• Positive ripple effects of the IMP on running and broader health and lifestyle factors were evident, with a high initial level of community readiness • Quantitative and qualitative data underscored the importance of local role models in initiating running among Torres Strait Islanders to run • Shifting social norms were evident where the acceptability of physical activity participation had increased.

2. Discussion of how findings relate to literature on physical activity and health among Aboriginal and Torres Strait Islander people

The first three chapters focus on associations between physical activity and Aboriginal and Torres Strait Islander health. Individually and together, they make a unique contribution to the literature on epidemiological and correlational associations in Aboriginal and Torres Strait Islander populations.

2.1 Physical activity prevalence and trends

Chapters 2, 3 and 4 present new data on physical activity prevalence in three Aboriginal and Torres Strait Islander population groups in NSW. These populations were: mid-older aged Aboriginal and non-Aboriginal adults living across the state; Aboriginal and non-Aboriginal adolescents aged 13-17 years living in disadvantaged regions; and Aboriginal and non-Aboriginal children aged 10-14 years living in two mid-NSW rural coastal towns, again located in areas with high levels of socio-economic disadvantage.

The non-Aboriginal participants in each study provided an important population group that allowed comparison of differences by Aboriginal status. In the case of the 45 & Up/SEEF Study (Chapter 2), I found the characteristics of the sample to differ: Aboriginal participants were significantly younger than non-Aboriginal participants, and more likely to live in a disadvantaged area, be married/partnered, live in a major city and have lower education and income. However, the physical activity levels of the Aboriginal and non-Aboriginal participants did not substanitally differ (63.1% and 65.4% respectively meeting recommendations). These proportions were derived by using the upper threshold of the national physical activity recommendations of 300 minutes of weekly MVPA (6) (7), as measured through the validated Active Australia survey. I chose to use this threshold because participants tend to overestimate their self-reported physical activity (8). In supplementary analyses I conducted using the lower, minimum, threshold of the national physical activity recommendations (150 minutes of weekly MVPA), the

proportion of Aboriginal and non-Aboriginal adults achieving these recommendations were even higher at 76.9% and 80.5% respectively.

These proportions of 76.9% and 80.5% can be more directly compared to the threshold used by the ABS of at least 150 minutes of physical activity in five or more sessions over a seven day period - broadly similar to the Active Australia Survey. However, nationally-representative ABS data on physical activity among 1170 Aboriginal and Torres Strait Islander adults, collected during 2011-12 (9), found that only 38% met this recommendation - which differs substantially from the SEEF study findings. These adults were sampled from non-remote areas, similar to those in the SEEF study (Chapter 2), although the latter study was only conducted in NSW. These differences between the SEEF data and the ABS data can possibly be explained, at least in part, by the 'healthy cohort effect' (10) mentioned in Chapter 2. That is, where participants who volunteer to participate in cohort studies are typically healthier than the broader population who are more comprehensively captured in national level government studies such as those collected by the ABS (11). A further explanation could be the greater levels of socio-economic disadvantage among Aboriginal, compared to non-Aboriginal, people as evidenced both in the differences in the sample characteristics in this study and the broader literature (12). There is evidence of an Aboriginal social gradient in smoking (13) where smoking prevalence is positively associated with social disadvantage, but this has not been found in physical activity studies, including Chapter 2. While it is not known whether this healthy cohort effect applies to Aboriginal and Torres Strait Islander people, and it was beyond the scope of Chapter 2 to measure its effect, it is likely that it would have a similar impact to that of mainstream populations. Regardless, few studies have collected physical activity data from an Aboriginal population as large as the SEEF study (n=314), using a validated measure. Thus it provides useful data to increase the evidence base relating to the prevalence of physical activity among Aboriginal and Torres Strait Islander people. Indeed, other than the ABS data and the baseline 45 & Up Study from which the SEEF study participants were drawn (60.4% response rate), no other studies of this magnitude

exist from where comparisons can be made. The Active Australia Survey has been validated in mainstream and diverse populations (8). However, its measurement properties have not been formally assessed among Aboriginal and Torres Strait Islander people and further validation may provide a greater understanding of its usefulness in capturing physical activity prevalence among this population. Towards the end of my thesis, I conducted formative pilot testing of the survey among a population of Torres Strait Islanders. That will be examined in section 3 of this chapter and when discussing future research directions arising from this thesis.

In both of my studies of young people, the non-Aboriginal population was similar to the Aboriginal population as both were sampled through the same schools and all participants lived in the same geographical areas. These areas were all within locations of high socio-economic disadvantage (14), relative to the Australian population. Some differences in their characteristics were evident however. For example, among the sample of 359 Indigenous and 637 non-Indigenous 13-17 years olds in Chapter 3, rates of single parent families were significantly higher among the Indigenous participants. The participants in Chapter 4 were slightly younger (10-14 years) than in Chapter 3 therefore there were some limitations in the socio-demographic characteristics that they could provide through self-report measures so only brief details on their individual-level variables could be gathered. Thus the differences found in the prevalence of sufficient physical activity in Aboriginal and non-Aboriginal young people in Chapters 3 and 4 cannot be accounted for by differences in population sampling to the same extent as those in Chapter 2. However, some of the correlates relating to these physical activity levels differed by Aboriginality, which will be discussed in the next section (2.2).

Physical activity prevalence differed between groups in Chapter 3: 21% of Indigenous and 28% of non-Indigenous young people achieved the higher activity levels, using the HBSC measure which asks about frequency and duration of activity outside of school hours only (15). In Chapter 4, there were also

significant differences in the physical activity levels of Aboriginal and non-Aboriginal children, derived from a measure that included both school and non-school physical activity and categorised all activity according to two seasons (16). In 2007/8, the proportion of Aboriginal and non-Aboriginal children meeting the physical activity recommendations (17) in summer were 72.8% and 79.4%, respectively. The corresponding proportions in winter were 53.3% and 59.6% respectively. In 2011/2, the proportion of Aboriginal and non-Aboriginal children meeting the physical activity recommendations (17) in summer were 59.6% and 69.8%, respectively. The corresponding proportions in winter were 34.6% and 50.2%, respectively.

These prevalence rates in Chapters 3 and 4 cannot be compared directly due to their different measurement tools, the seasonal focus in the Many Rivers study and its specific domains of physical activity. However, the multi-component nature of the MRPARQ allowed for more detailed investigation of domain-specific physical activity, allowing rough comparisons to be made, once the school-based physical activity component is removed. I conducted supplementary analyses to determine physical activity undertaken in two additional domains: 'in-school' and 'out-of-school', in order to compare these prevalence rates with the data from the HBSC in Chapter 3. The 'in-school' domain comprised the MRPARQ individually-reported school domain and the school-reported PE. The 'out-of-school' domain comprised the remaining MRPARQ domains: organised; non-organised; club; travel to/from school; after school; and weekend. In 2007/8, the proportion of Aboriginal and non-Aboriginal children meeting the physical activity recommendations in summer 'out-of-school' only were 52.8% and 56.0%, respectively. The corresponding proportions in winter were 29.3% and 33.9%, respectively. In 2011/2, the proportion of Aboriginal and non-Aboriginal children meeting the physical activity recommendations (17) in summer 'out-of-school' only were 45.0% and 53.0%, respectively. The corresponding proportions in winter were 22.1% and 34.4%, respectively. These proportions can be more directly compared with data from Chapter 3.

As the summer and winter categories of the MRPARQ cannot be combined to an average prevalence that can be compared to the prevalence in Chapter 3 or to data from other studies, comparisons will be made in the context of these seasons. In both seasons, physical activity levels were higher among the participants of Chapter 4 than the participants in Chapter 3. The smallest difference was just over 1%, between the Chapter 3 Indigenous children (21%) and the Chapter 4 Aboriginal children during winter 2011/12 (22.1%). The largest difference was 28% between the Chapter 3 non-Indigenous children and the Chapter 4 non-Aboriginal children during summer 2007/8. These differences in prevalence rates in Chapters 3 & 4 can be attributed to differences in the study populations and measurement tools employed. The different (but overlapping) age ranges of participants of 13-17 years and 10-14 years, respectively, reflect a critical time period during adolescence where physical activity is known to decline (18) so similar levels of physical activity would not be expected. The HBSC measure requires children to achieve both frequency and duration of physical activity, more closely reflecting the national recommendations whereas the MRPARQ supplementary analyses could include duration only. However, the differences arising in prevalence correspond to the expected directions of these differences in measurement and known physical activity declines, where levels were higher among the younger population. This was the case for both the Indigenous/Aboriginal and non-Indigenous/Aboriginal young people. While the samples were largely similar in terms of area level disadvantage and urbanicity (19), these differences could also be partially explained by specific contexts. For example, the Many Rivers study was conducted in coastal locations with a sub-tropical climate which is consistent with evidence of seasonality affecting physical activity levels (20). The qualitative data on barriers to physical activity collected as part of the Many Rivers study and described in Chapter 4 also provided valuable context to explain levels of participation but this data was not collected as part of the Chapter 3 study. Mixed methods studies, obtaining qualitative data to supplement and assist understanding and interpretation of quantitative data, are advised for future studies with Aboriginal and Torres Strait Islander populations. This could be particularly

important among this population group, as the determinants of health and other behaviours can differ due to historical and cultural factors (21).

In the pilot study of the measurement properties of the MRPARQ, indicative physical activity levels were established in a similar population of children aged 10-12 years living in the same two mid-NSW coastal towns (16) as the participants of Chapter 4. This pilot study found the 84 Aboriginal children achieved 162-172 minutes/day of MVPA and the 146 non-Aboriginal children achieved 123-149 minutes/day of MVPA. The higher levels among the Aboriginal children compared to the non-Aboriginal children in the pilot study (which were also evident in accelerometry data) are surprising as Chapter 4 found higher levels among the non-Aboriginal children. These pilot study daily levels correspond to 1134-1204 minutes/week and 861-1043 minutes/week for the Aboriginal and non-Aboriginal children respectively, which are within the same broad range as the main study (Chapter 4). In the case of the Aboriginal children, the 2007/8 weekly levels were 1667.0 minutes/week in summer and 1043.8 minutes/week in winter and their 2011/12 weekly levels were 1483.8 minutes/week in summer and 835.3 minutes/week in winter (Chapter 4 Supplementary table). The differences by Aboriginality could be merely due to the pilot study sampling slightly younger children (10-12 years compared to the adolescents aged 10-14 years in the main study) who have higher physical activity levels, thus creating a 'ceiling effect'. The other pilot study by Trost et al. also found higher levels of physical activity among the Indigenous children compared to the non-Indigenous children in their sample (22).

These physical activity prevalence rates in Chapters 3 & 4 can also be compared to data from national surveillance studies. The most recent ABS data gives higher physical activity levels among Aboriginal and Torres Strait Islander children compared to non-Indigenous children where 48% compared to 35% met the recommendations (9). These data are for children in non-remote areas, which are relevant for comparisons with the data in Chapters 3 & 4 which were also from non-remote areas. However, a

difference between these data and my findings from Chapters 3 & 4 was that, in both studies, the Indigenous physical activity levels were lower than those of the non-Indigenous children, in contrast to the ABS findings. The children's level of disadvantage and geographical location of residence in rural towns and surrounding areas is likely to have had an important impact here. A recent review of 16 studies from the U.S. comparing physical activity levels of rural and urban populations could not conclude which population group had higher prevalence levels due to methodological differences in the studies (23). An Australian study also found complexities in rural and urban physical activity differences (24). However, urban and rural differences in physical activity have not been investigated among Aboriginal and Torres Strait Islander children. Indeed, there are no known data sources allowing this to be investigated. Other factors especially socio-demographic and cultural issues may have an influence on my relatively homogenous study samples compared to the more heterogeneous ABS samples. However, these factors could not be captured or compared as socio-economic data about the ABS sample were not published.

A further difference relates to actual prevalence discrepancies between the data from Chapters 3 & 4 and the ABS data in the proportion of children meeting recommendations, of up to 24%. However, a recent review of different child physical activity measures found much variability in Australian studies of physical activity prevalence and that it was difficult to establish rates of meeting physical activity recommendations (25). This variability was found to be due to differences in questionnaires, survey administration modes, survey time frames, and definitions of physical activity recommendations. The review recommended greater standardisation of data collection and processing protocols. While these findings and subsequent suggested improvements would also apply to prevalence studies with Aboriginal and Torres Strait Islander populations, the importance of community input and involvement in all aspects of research cannot be overstated (26). Appropriate modification of standardized protocols and measures and their subsequent validation, as occurred in the development of the MRPARQ from the APARQ, would overcome some of these methodological issues (27).

As well as presenting new physical activity prevalence data, Chapter 4 provides serial physical activity trend data about Aboriginal and non-Aboriginal children aged 10-14 years at two time points five years apart. Previous trend data on physical activity specific to Aboriginal adults or children does not exist and there is little research on temporal trends among mainstream populations (28). However, the NSW-wide SPANS study also found declines in physical activity over a similar time period and among a similar age group of children (29). A recent review of studies found conflicting results and inconsistent size of physical activity changes across different contexts of physical activity for Australian children and adolescents over the last few decades (25). While, consistent with findings from Chapter 4, declines in active transport were evident, there was little evidence for a general decrease in children's and adolescents' physical activity levels. Again, methodological standardisation and the consistent use of repeated measures over time would provide invaluable future knowledge of how the physical activity of Aboriginal and Torres Strait Islander adults and children might change over time. This information is important in determining the effects of strategies to increase physical activity levels to reduce the burden of disease (30).

2.2 Associations between physical activity and health

Little data exists on the associations between physical activity and socio-demographic and health factors in Aboriginal and Torres Strait Islander populations. The findings from Chapters 2 and 3, as well as both appendices, contribute new understanding of these associations.

The SEEF findings from Chapter 2 also demonstrate similar correlates of physical activity participation among both Aboriginal and non-Aboriginal adults. These correlates included a number of socio-demographic factors, healthy lifestyle behaviours, neighbourhood built environment, neighbourhood connections and social support aspects. Socio-demographic factors associated with higher physical activity were being female, middle (rather than older) aged, married/living with a partner and higher education and income levels. While most of these associations only correlated significantly among non-Aboriginal participants, the direction of these correlates were the same for Aboriginal and non-Aboriginal adults across all variables. For example physical activity levels were lower among older adults, compared to middle-aged adults, in both groups. This can largely be explained by the large differences in sample sizes of the two groups (n=314 Aboriginal; n=59,175 non-Aboriginal). Given the small number of Aboriginal and Torres Strait Islander people, it is hard to achieve populations of a comparative size in epidemiological studies, even in studies such as this where Aboriginal participants were oversampled (31). Neighbourhood built environment and neighbourhood connections were similarly correlated with physical activity among non-Aboriginal adults only, despite these aspects being less favourable (e.g. lower social connections) among the Aboriginal adults. However, both Aboriginal and non-Aboriginal participants who were told to be more physically active by their GP in the past 12 months had a lower odds of meeting the physical activity recommendations. Chapter 2 discusses how this finding could be due to GP counselling based on patients' current activity levels.

Findings from two collaborative studies undertaken concurrently to this thesis, also using data from the

45 & Up and SEEF Study provide additional context and understanding of the associations between physical activity and health among Aboriginal and Torres Strait Islander people. They also demonstrate new epidemiological associations of health outcomes. Characteristics relating to participation in the SEEF follow-up to the 45 & Up Study in Aboriginal and non-Aboriginal adults identified that Aboriginal people were less likely to respond to the follow-up study than non-Aboriginal people (see Appendix 1) (32). However, factors related to response rates were similar among both groups. Those who responded were more likely than non-responders to have higher education and income levels. Adults who were current smokers, or who reported poor self-rated health, poor quality of life and very high psychological distress, were less likely to respond. Physical activity was not found to be associated with response rate but the socio-economic factors of income and education correlated with both non-response and physical activity in the findings of Chapter 2 (1) and the wider literature (33, 34) among adults.

The second collaborative study using data from the SEEF follow-up to the 45 & Up Study explored physical functional limitations among Aboriginal and non-Aboriginal adults and associations with socio-demographic factors and health (Appendix 2) (35). The prevalence of severe physical limitation among Aboriginal people was much higher at 26% than the 13% prevalence among non-Aboriginal people, an almost threefold higher rate after adjustment for age and sex. The prevalence of severe reported functional limitation was greater among those with higher versus lower levels of sedentary (screen and sitting) time and 50%-60% lower among those who achieved physical activity recommendations (at least 150 min of physical activity in 5 or more sessions a week). Therefore, the greater presence of functional limitations among Aboriginal people may have had a larger impact on their physical activity and the correlates identified in Chapter 2. Other factors associated with physical functional limitations were also similar among both groups - being over 70 years old, having no tertiary education qualifications, having low income levels, being a current smoker, being obese, and sitting for over seven hours per day.

In Chapter 3, the physical activity correlates evident across the whole sample were a mixture of socio-demographic (being male, and having an employed mother) and factors related to a healthy lifestyle (being a member of a sports team, and spending less time watching TV). These two socio-demographic associations were also significant among the Indigenous adolescents - but only being a member of a sports team, as well as community involvement, were significant among the non-Indigenous adolescents. This suggests a potentially greater influence of socio-demographic factors on physical activity although causal inferences cannot be made from this cross-sectional study. The community involvement finding also suggests that this concept may hold a different meaning among Aboriginal and Torres Strait Islander and non-Indigenous populations. This will be discussed further with reference to the IMP evaluation findings in Chapter 6, where only the non-Indigenous participants of the quantitative component reported that they were physically active (through running) for a 'sense of community'.

Taken together, however, the findings from Chapters 2 & 3 highlight similar strong associations between physical activity and the main socio-economic indicators of education, employment and income in Aboriginal and Torres Strait Islanders and non-Indigenous Australians. The two collaborative studies in the appendices of this thesis highlight the similarity of other associations between these indicators and other health-related factors between these two population groups as well. Each of these findings contributes to knowledge of how the social determinants of health have a strong influence on the health of both groups alike. However, the historical legacy of punitive policies on Aboriginal and Torres Strait Islander people has resulted in greater socio-economic disadvantage than that of non-Indigenous Australians (36). Thus socio-economic status could have a greater impact on the health of Aboriginal and Torres Strait Islander people, more than for non-Indigenous Australians. However, it is unlikely that socio-economic factors alone entirely explain the gaps in life expectancy and health disparities between Aboriginal and Torres Strait Islander people and non-Indigenous people, given other established determinants of a cultural and historical nature such as cultural fragmentation (21).

A study by the Centre for Aboriginal Economic Policy Research has established an Index of Relative Indigenous Socioeconomic Outcomes, based on the 2001 and 2006 Censuses, to identify and rank areas where both relative and absolute need is greatest (37). It uses nine socio-economic measures across employment, education, income and housing to create a single index for 37 Indigenous Regions and 531 Indigenous Areas. While this resource has not been updated since the 2006 Census, it appears to provide a more precise and appropriate indicator of the disadvantage experienced by Aboriginal and Torres Strait Islander people than measures of SEIFA can give (14) as it provides a *relative* ranking of areas. Previous research by the Centre also found that socio-economic status does not offer the same protective factors for Indigenous peoples as it does for non-Indigenous people (38). For example, high-income Indigenous families were only 1.2% less likely to experience long-term health problems than low-income Indigenous families whereas such associations are much stronger among non-Indigenous Australians. Better socio-economic measures are needed to increase understanding of how these factors may affect Aboriginal and Torres Strait Islander health in order to respond with strategies to improve indicators that contribute to Closing the Gap (36).

The 'Glasgow effect' describes a phenomenon that has been uncovered through research on the differences in life expectancy and other health outcomes between Glasgow, Scotland, and other UK cities of a similar level of deprivation (39). These differences have been found to have diverged at an increasing rate during the second half of the 20th century and beyond. In Glasgow, compared with the socio-economically similar cities Liverpool, Manchester and Belfast, premature mortality is 30% higher, and 15% higher for deaths at all ages (39). However, the term 'Glasgow effect' should not be considered a finite classification in itself, rather a reference to disparities that have been discovered which cannot be explained by socio-economic aspects alone (40). The phenomenon is considered to have arisen from a complex and difficult-to-measure interplay of health determinants acting at different levels in society

through the life span (41). Previous enquiries have investigated associations between the Glasgow effect and the lifestyle behaviours of diet (42) and smoking (43). However, as physical activity levels were similar in Glasgow and its comparator cities (44) and in Scotland and England as a whole (45), physical activity does not appear to have an influencing role.

Yet the Glasgow effect is relevant as differences in health that cannot be explained by socio-economic factors alone are consistent with findings in this thesis. Modelling of the Glasgow effect also includes the impact of 'unknown effect modifiers' in the existence of the unexplained differences in mortality. In this thesis, many of the prevalence and correlates findings were similar among Aboriginal and Torres Strait Islander and their corresponding non-Indigenous populations. However, differences between the two groups were also apparent, even after adjusting for relevant contributory socio-economic factors. As with the Glasgow effect, these differences may also have been affected by unknown factors. It is possible that these factors reflect the numerous, complex, multi-level determinants affecting the health of Aboriginal and Torres Strait Islander people.

3. Discussion of how findings relate to the literature on Aboriginal and Torres Strait Islander physical activity programs and their evaluation

My physical activity snapshot (Chapter 5) found that, while over 100 interventions and programs existed since 2012, fewer than 10% had empirically investigated their effectiveness in increasing physical activity levels or improving health or social outcomes (4). Chapter 6 presents findings from a pilot evaluation of health and community impact of the Indigenous Marathon Program (5), one of the 110 programs identified in the snapshot.

The snapshot was published around the same time as another review which systematically examined whether physical activity interventions in Indigenous people improve activity levels and health outcomes (46) following the PRISMA statement for systematic reviews (47). The review by Sushames et al (46) found only nine evaluations of physical activity interventions involving Indigenous Australians, using no date restrictions, while my review focused on comprehensively describing current and recent program practice between 2012 and 2015. Although both reviews differed greatly in their methods and inclusion criteria, each concluded that there is a lack of evidence of the effectiveness of physical activity interventions for Aboriginal people.

There are a number of program features identified in the snapshot of 110 programs that align with the International Society for Physical Activity and Health's 7 Best Investments for Physical Activity (48) outlined in Box 5:

Box 5: 7 Best Investments for Physical Activity

1. 'Whole-of-school' programs;
2. Transport policies and systems that prioritise walking, cycling and public transport;
3. Urban design regulations and infrastructure that provides for equitable and safe access for recreational physical activity, and recreational and transport-related walking and cycling across the life course;
4. Physical activity and NCD prevention integrated into primary health care systems;
5. Public education, including mass media to raise awareness and change social norms on physical activity;
6. Community-wide programs involving multiple settings and sectors and that mobilize and integrate community engagement and resources;
7. Sports systems and programs that promote 'sport for all' and encourage participation across the life span.

The Investment 1, 'whole of school' programs, is defined as incorporating a range of strategies such as regular, quality physical education and supportive broader school policies for physical activity. My snapshot review found nine programs within the school setting exclusively and a further nine within a combined school and community setting. While the school-exclusive programs might not be classified as 'whole of school' in their delivery focus, the latter nine programs could be more accurately collectively described as taking a 'whole of school' approach. In addition to these nine combined school and community programs, the majority of the identified programs (n=62; 56.4%) operated in the community setting (only) which is the focus of Investment 6. A key component of these community-wide programs is the involvement of 'multiple settings and sectors that mobilize and integrate community engagement and resources'. I also found evidence of strong involvement of multiple sectors such as sport, health, and education in almost all programs and the vast majority had Aboriginal and Torres Strait Islander stakeholder involvement (84.5%) - both facets consistent with this investment. Thus the stakeholder and community engagement of strategies to improve Aboriginal and Torres Strait Islander health (49) together

with the evidence base for this investment (derived from benefits within mainstream communities (50, 51)) may be of particular value to Indigenous communities.

None of the snapshot programs specifically promoted active transport (Investment 2). A reason for this could be differing cultural meanings of active transport which predominantly means walking and cycling to work and other destinations in mainstream society. But for many Aboriginal and Torres Strait Islander people, walking occurs for cultural reasons and practices such as hunting and natural resource management, which is also viewed as a key determinant of health (52). However, the Chapter 4 findings demonstrated significant declines in travel to/from school among Aboriginal (and non-Aboriginal) children, representing an opportunity to adopt this investment. Future programs aiming to increase physical activity among Aboriginal and Torres Strait Islander people could consider incorporating active travel to regularly-frequented locations, such as school, at least for children. However, the relevancy of this recommendation depends on specific community urban features and level of remoteness; options for active travel and distances involved would vary substantially in urban, compared to remote, communities.

Investment 3 is also focused on the built environment: 'urban design regulations and infrastructure that provides for equitable and safe access for recreational physical activity, and recreational and transport-related walking and cycling across the life course'. While a number of snapshot programs promoted recreational physical activity, a focus on the components of Investment 3 was rare. Several of my findings from Chapter 2 relate to both Investments 3 and 4. I found that Aboriginal adults were more likely to report that the crime rate made it unsafe to walk, that local public transport was not within a 10-15 minute walk and that there were few footpaths and free/low cost recreation facilities. These findings stress how important Investments 3 and 4 might be to Aboriginal and Torres Strait Islander adults and they could be more widely incorporated into future strategies to increase physical activity. It is essential that such implementation be carried out in a manner that is culturally relevant (52), the detail of which could vary

according to community context and remoteness (19).

Investment 4 promotes 'physical activity and NCD prevention integrated into primary health care systems'. Health was a key focus of many of the snapshot programs, in terms of their setting, aims, evaluation indicators and partnership sectors involved although primary health care integration was not specifically examined. The majority of these program aimed to increase physical activity for specific health gains such as improving chronic disease prevention and treatment. This is commendable as NCDs represent a major challenge to Aboriginal and Torres Strait Islander health (30) and the healthcare setting is crucial in supporting patients in prevention and treatment across the lifespan in a culturally appropriate manner (53). As Aboriginal and Torres Strait Islander health care and broader health systems are often delivered in culturally appropriate AMSs and ACCHO, it is likely that many of these health-focused programs in Chapter 5 involved integrated delivery. However, this cannot be assumed and despite these culturally appropriate services, Aboriginal and Torres Strait Islander people often experience poorer access to care within mainstream systems (53). This can also be negatively impacted by a lack of services in remote areas where Aboriginal and Torres Strait Islander people are more likely to live (54). Therefore, increasing physical activity through specific programs targeting this population group may help overcome these disadvantages.

Only three programs within the snapshot used public education (such as mass media) to raise awareness and change social norms (Investment 5). However, changing social norms resulting in increased community interest in physical activity was a key finding from Chapter 6, the pilot evaluation of IMP, despite this finding having resulted from a different program implementation focus.

Investment 7 recommends 'sports systems and programs that promote 'sport for all' and encourage participation across the life span'. Many of the snapshot programs aimed to use sport as a vehicle to

improve social outcomes such as improved education or employment outcomes either as a sole focus or in conjunction with aims to improve health outcomes. This role of sport in improving the lives of Aboriginal and Torres Strait Islander people is an emerging theme in the literature (4).

In 2013, the Australian Government conducted an inquiry into the contribution of sport to Indigenous wellbeing (and mentoring). The report found evidence that sport can assist in achieving outcomes for Indigenous communities and provided 11 recommendations around the three themes (55). The three themes were: Sport as a vehicle to Close the Gap (36); Participation in sport for Indigenous Australians; and Partnerships, mentoring and culture. Several of the 11 recommendations within these themes are particularly relevant to the findings in this thesis on physical activity programs and their evaluation. These findings are:

- More evidence-based research;
- Robust evaluation of programs using sport for both sport participation and non-sport outcomes;
- New or increased funding for programs and activities including the Learn Earn Legend program, Indigenous sporting carnivals, and increasing the physical activity of Indigenous women and girls;
- Developing and promoting Indigenous coaches, umpires, health workers, administrators, and role models at both community and elite levels.

While capturing information on Indigenous sporting carnivals and promoting Indigenous staff in sport support provision (such as coaching) was beyond the scope of the review, the other four recommendations directly resonate with findings from the snapshot. Investigating the impact of sporting carnivals would be a worthy future research endeavour as part of a similar project to identify and describe physical activity events. Sporting carnivals have been identified in a previous study of sporting events as part of health programs (56), in a review of programs that targeted environmental influences on Indigenous health (57). However, I considered physical activity events (including carnivals) to be beyond the focus of the

snapshot and its definition of ‘program’ (58). Events, which often occur as a standalone occasion, would therefore be worthy of a distinct piece of work in their own right.

Increasing physical activity of Indigenous women and girls is a recommendation with an evidence-based approach, given gender disparities in participation among adults (59) and children (60). Several findings from this thesis are relevant to these disparities. While physical activity levels did not significantly differ among Aboriginal adults in the SEEF study, Chapter 3 found that Indigenous girls were less active than boys. Investigating gender differences was beyond the scope of the Chapter 4 trends but Chapter 5 found that, while the majority of the 110 programs targeted both males and females, seven were female-only while only two were male-only. Conversely, Chapter 6 found higher participation in community IMP activities among females. However this is consistent with males being an appropriate target group for broader health programs given their lower life expectancy relative to females and higher prevalence of most NCD risk factors (61). The program also increased participation in running and walking by older, hard-to-reach women.

The recommendations advise new or increased funding for programs and activities supporting the Learn Earn Legend program. This program was considered for inclusion in the snapshot but was excluded as it did not directly involve physical activity promotion. Rather, it aims to improve educational and employment outcomes through messaging and partnership activities, delivered by community leaders, sport stars and everyday 'local legends' and at other events and programs (62). Yet, consistent with many programs identified in Chapter 5, its impact is unknown as no evaluation has been conducted. The broader recommendation from the inquiry was to increase program funding. This is necessary to adequately resource strategies to improve Aboriginal and Torres Strait Islander health. Such funding should be targeted at programs of greatest need, as determined by epidemiological research and community consultation. Evaluation should be incorporated into all aspects of program design, planning and

implementation from the outset and continuously throughout the duration of the program. The evaluation of initiatives aimed at increasing physical activity, to generate evidence effective and cost-effective actions is also a key recommendation embedded within the 7 Best Investments for Physical Activity (48). This recommendation can also be adopted as a key recommendation arising from findings of this thesis.

Rossi discusses whether sport can genuinely contribute to Closing the Gap (36) through community development in Indigenous Australian communities, using cases from sports-based programs through a five year research project informed by a theoretical framework (63). He concludes that sport can be a robust developmental tool capable of delivering social outcomes to marginalised communities. However, in contrast to the findings of the 2013 Government inquiry (55), Rossi argues that claims of the impact of sport in improving the health of Aboriginal and Torres Strait Islander people have often been overstated (64) in the absence of empirical evidence. Therefore, investigating the effect of sport programs on health and broader social outcomes is important in future research on physical activity among Aboriginal and Torres Strait Islander people; a conclusion consistent with findings from this thesis.

Since my snapshot review was published, broader research evaluating Indigenous programs delivered by government entities in Australia (65) identified a total of 1082 programs, only 88 of which (8%) had been evaluated. This proportion is similar to the 10% of the 110 physical activity programs I identified in my snapshot review which had undergone more rigorous evaluation, evidenced in published studies of their findings. A Productivity Commission report in 2013 (66), focused on the Indigenous Advancement Strategy, also found insufficient evidence was being collected about program outcomes. In response, a four year evaluation program was announced, with resourcing of $40 million, as well as $50 million for research into Indigenous policy and its implementation – although no details of the distribution of these funds have been provided. This research was followed up with an accompanying toolkit with specific guidance for Indigenous program evaluation (67). The toolkit calls for evaluation to be embedded into a

program's design and operations as part of a continuous quality improvement process, given the large costs of delivering independent program evaluation for large numbers of programs. This embedding of evaluation into program practice should be viewed as an opportunity to learn from the information the process brings. These recommendations could also apply to the physical activity programs within the snapshot.

The findings around barriers to physical activity, specifically running and walking, in Chapter 6 could be described as a mixture of personal, cultural and environmental. Barriers to physical activity more broadly were also investigated in the Many Rivers study (68) and were described in Chapter 4 as they provided important holistic context to assist understanding the observed declines in physical activity. These were also a mixture of personal, cultural and environmental barriers including a number that either uniquely or disproportionally affected the Aboriginal children to a greater degree than the non-Aboriginal children.

Personal barriers in the Many Rivers study related to low socio-economic status, such as a lack of parental education around physical activity. Cultural barriers included a lack of appropriate role modelling by parents who were often inactive and/or overweight/obese themselves, and 'shame' or feeling ashamed to walk to sporting venues as an indicator of the absence of car ownership. Environmental barriers included cost and poor availability and accessibility of sporting and recreational facilities and venues. Some similar barriers were observed in the IMP evaluation. In this study, personal barriers included low motivation and perceived age and weight constrictions. Cultural barriers included the 'shame' factor. Environmental barriers included hot and wet weather and aggressive dogs and a lack of footpaths.

The personal and environmental barriers in both studies are consistent with individual and socio-economic barriers to physical activity that occur in mainstream communities and populations (69, 70). However, specific cultural barriers such as shame have been well established as important influencers of

physical activity among Aboriginal and Torres Strait Islander adults and young people in urban, regional and remote settings (71-75). This barrier appeared to have contributed to the declines in physical activity among Aboriginal children observed in Chapter 4. However, it was evident in Chapter 6 that a positive impact of IMP on the Thursday Island community was the reduction of shame as a barrier to running and walking, than was recalled by participants to have been the case in the past. This was attributed to increased community participation in running and the presence of role models who were also physically active in public. While this shift related to running and walking only, these activities are fundamental to broader physical activity participation as a basis of the skills and fitness required in other sports and activities (76). These activities are low cost compared to team sports requiring specific clothing and equipment, as well as organised structures such as community clubs through which to play.

A further aim of the IMP pilot study was to conduct formative testing of a more detailed questionnaire about the health and community impacts among a group of regular runners on Thursday Island who were part of a community running group (Appendix 4). The questionnaire was less than three pages in length. It asked respondents about their physical activity through the Active Australia Survey (8) and dietary indicators of fruit, vegetable, junk food, soft drinks as well as consumption of alcohol and tobacco through questions from the NSW Adult Survey (77). Mental well-being was measured using the WHO-5 Well-Being Index (78). The questionnaire also asked about basic demographic factors such as age, gender, place of residence, self-rated health (79), types of physical activity participated in, as well as perceptions that were the same as the corresponding questions in the brief running festival questionnaire, reported in Chapter 6. As the questionnaire included components that should be administered as a guided interview rather than self-report, a group interview administered technique was adopted. Formative testing demonstrated that the questionnaire took between 20-30 minutes to complete and that the questions were well-understood by respondents, as determined by the local Torres Strait Islander data collectors as well as from my own observations.

While the learning from this pilot study component was not reported as findings in Chapter 6, it represents a vital process towards developing culturally appropriate measurement tools to assess physical activity and other health behaviours among Aboriginal and Torres Strait Islander people. Few previous studies with Aboriginal and Torres Strait Islander participants have formally assessed the transferability of measures to this population, with the exception of those by Cunningham & Beneforti (80), Trost et al. (22) and the Many Rivers study (16). The use of measures that have been validated and used previously in mainstream populations, such as the Active Australia Survey (8), may also be valid in Aboriginal and Torres Strait Islander groups. However, this cannot be assumed without conducting testing with the population group for which the measure is intended. Nor will establishing measurement properties in one community or with a specific group be assumed to be relevant for all Aboriginal and Torres Strait Islander populations, given the diversity of population groups across Australia (81). Further measurement development is a key consideration when discussing future research directions below.

4. Strengths and limitations

In this section I will outline the broad strengths and limitations of the five studies presented in this thesis. Specific strengths and limitations of each study have been discussed in more detail in their relevant chapter.

One strength of the thesis is the use of larger samples sizes of Aboriginal people in the studies of physical activity prevalence, correlates and trends (Chapters 2-4) than have generally existed in previous research studies of Aboriginal and Torres Strait Islander populations. These sample sizes of several hundred people provided sufficient statistical power to conduct multivariate multiple regression modelling of physical activity correlates, adjusting for known determinants of physical activity and potential and confounders (82). In Chapter 2 (1), I presented different models, adjusting for age and sex with additional adjustment for remoteness of residence (19) and education level. In Chapter 3 (2), I presented three different models for the whole sample and for the Indigenous and non-Indigenous populations separately. Each model was adjusted for known influencing determinants of age and gender as well as variables found to be significant in the initial bivariate analyses. The sample size in Chapter 4 (3) allowed for the use of linear mixed-model regression analyses, adjusting for school clustering as a random effect as well as fixed effects of Aboriginal status, time, gender and school year (as a proxy for age).

The representativeness of the population samples within this thesis has been discussed in their Chapter in relation to their main findings. While the findings from this thesis on the physical activity of Aboriginal and Torres Strait Islander people should be considered accurate, their broader generalisability across Australia should not be assumed, given that populations cannot be considered a homogenous group. Therefore, these findings should not be considered conclusive; further exploration should be considered in other populations and communities, across a range of urban, rural and remote areas.

A further strength of this thesis is that it examined physical activity of Aboriginal and Torres Strait Islander people across the lifespan. While children under the age of 10 years were not participants in any of the five studies, the program snapshot (Chapter 5) included several physical activity programs for this age group. The 45 & Up Study included octogenarian participants as well as those who were middle aged and Chapters 3 & 4 considered children aged 10-17 years. Again, while the study populations are by no means representative of the full diversity of Aboriginal and Torres Strait Islander people and communities, the inclusion of both Aboriginal and Torres Strait Islander participants is a further strength of this thesis. A strength of the snapshot review (Chapter 5) was the almost real time identification of programs and the current state of their evaluation efforts. This importantly highlights future priority programs for empirical investigation of their effectiveness.

A limitation of the pilot IMP evaluation in Chapter 6 is that IMP activities were already occurring in the community before the evaluation commenced, making the true impact hard to capture in the absence of a more rigorous study design (83). However, rigorous designs such as RCTs may not be the most appropriate or feasible way of generating evidence when evaluating community programs (84). This may be particularly the case for Aboriginal and Torres Strait Islander communities given the importance of community involvement in research (26) therefore, the pragmatic nature of the pilot evaluation may have been more appropriate to the community (26). This study also provided an important opportunity to conduct face and content validity of a questionnaire containing the existing measures of the SF1 (79), Active Australia survey (8), WHO-5 Well-Being Index (78) and nutrition questions from state health surveillance (77) in a remote Torres Strait community. The collection method was also a strength - led by local community members who could provide local context and meaning to the questionnaire. This process provided a tool that could be used in future evaluation of Aboriginal and Torres Strait Islander physical activity programs.

Validated measures were also used in the self-report tools in Chapters 2-4. These included the Active Australia Survey (8), the Physical Activity and Neighbourhood Environment Scale (PANES) (85), and the Health Behavior of School Children (15) survey, all of which have been validated in mainstream and diverse (86) populations. Yet, aside from the MRPARQ (16), the validity of the measures used has not been investigated in Aboriginal and Torres Strait Islander groups. However, psychometric testing of the measures used in Chapters 2 & 3, such as reliability testing and face and content validity was conducted before the main studies report in pilot populations from which the main sample was taken.

In physical activity research, there is much debate regarding the comparative accuracy of self-report and objective measures (87). Self-report measures are typically used in large population studies (88) such as the 45 & Up Study. However, self-report measures may have less utility in intervention studies with smaller sample sizes that need measures sensitive to change and objective measures such as accelerometers are considered more appropriate measures (89). Yet it has been shown that physical activity participation rates can vary widely depending on the type of (self-report or objective) measure used (90). In research with Aboriginal and Torres Strait Islander people, community involvement in the design and planning stages can help determine the most appropriate methods for use, rather than simply relying on methodological literature. Even when previously reliable and valid self-report and objective measures have community acceptance, their testing in the population group of intended use is a recommendation for future research and evaluation with Aboriginal and Torres Strait Islander people, based on the findings of this thesis.

This thesis combines both epidemiological, correlational and program/evaluation studies, the findings of which do not easily provide implications for theory. However, the thesis findings can be considered within the context of the work of Nelson et al. (91) who used a social ecological model to review the literature about Indigenous Australians and physical activity. Social ecological theory is broadly relevant

to the mixture of studies in the thesis as it combines individual, social and environmental level factors as they relate to health (92). The three levels described by Nelson et al. relate to the thesis findings and can serve to enhance this review. 'Structural macro-social' physical activities like camping and hunting were not a particular focus of the thesis but were recommended as culturally appropriate ways to increase physical activity among children in Chapters 3 and 4. The 'structural environment' comprised barriers and facilitators which were found to have a strong influence on physical activity in Chapter 6. 'Social connections' were evident in each of the study findings across both adult and child populations. The individual level characteristics within Nelson's review are also highly relevant (psychosocial, socio-economic and behavioural) to the findings from each chapter and have been discussed extensively within each chapter.

The NHMRC strategic framework for improving the health of Aboriginal and Torres Strait Islander people through research (26) stipulates the importance of Aboriginal and Torres Strait Islander led research and for findings to be communicated back to participating communities. This was achieved in each of the studies within this thesis and is a strength of the thesis. Each study engaged with community stakeholders and cultural mentors at each stage of the study and involved Aboriginal and Torres Strait Islander co-authors and/or chief investigators. In Chapter 2, one of the chief investigators was Aboriginal and established a community reference group for this epidemiological study where communication to communities is challenging as the population-based research design does not offer a distinct community. Chapter 3 was a secondary analysis of data collected by an Aboriginal researcher who provided culturally appropriate guidance in the analysis and interpretation of the findings and direct contact with the participating communities. The MRDPP study (Chapter 4) had two Aboriginal collaborators who were involved at each stage of the study, as well as the extensive community consultation described in this chapter and elsewhere (93). I developed a two-page community summary of the Chapter 4 findings (Appendix 5) and face to face presentations of the findings to the two communities has been planned with

the communities' Aboriginal Medical Services whose preference was for this to occur when the final study publication is available. For Chapter 5, I collaborated with an Aboriginal and Torres Strait Islander focused organization (94) and program coordinators of Aboriginal and Torres Strait Islander programs. Findings were directly communicated back to individual program coordinators which has led to discussion of opportunities for further collaboration, building on the Chapter 5 findings. The IMP pilot evaluation study (Chapter 6) describes the collaboration components, including the community co-design, data collection and 'Return to Community' visit. I also invited a local Torres Strait Islander academic to join the study team as a collaborator in addition to an existing Aboriginal colleague.

5. Future research directions

This thesis contributes research about the physical activity of Aboriginal and Torres Strait Islander people. Its findings and conclusions have established new knowledge of physical activity associations, programs and their evaluation in this population. However, this thesis has also generated future research questions that should be addressed to improve understanding of the benefits of physical activity among Aboriginal and Torres Strait Islander people.

Fundamentally, Aboriginal and Torres Strait Islander research should be determined by this population group. The NHMRC Road Map II strategic framework for improving the health of Aboriginal and Torres Strait Islander people through research provides nine specific recommendations for contemporary Indigenous health research (26), listed in Box 6.

Box 6: NHMRC Recommendations for contemporary Indigenous health research

1. Improve Aboriginal health, as defined by Aboriginal people
2. Focus on culture and identity
3. Improve communities through capacity building
4. Address social determinants of health
5. Use multidisciplinary, holistic approaches
6. Examine how culture impacts on the resilience and wellness of individuals/communities
7. Embrace self-determination and cultural respect as part of the research
8. Support community initiation and participation in research
9. Identify sustainable and transferable outcomes

The studies in this thesis have been driven by this framework through the involvement of participant and community engagement groups and expertise. Specifically, the thesis has built capacity in IMP runners (Chapter 6) to conduct local data collection (number 3), addressed the social determinants of health through investigated associations between physical activity and socio-economic factors in Chapters 2 and 3 (number 4) and supported initiation and participation in research by the Many Rivers communities in Chapter 4 (number 8).

These recommendations from the NHMRC should be embedded in the design, planning, data collection, analyses, reporting and communication of all future research relating to the physical activity of Aboriginal and Torres Strait Islander people. The recommendations could also extend to apply to mainstream community-wide research more broadly (95). A further suggested avenue for future research is to develop and incorporate Indigenous research methodologies (96), such as the inductive methodology of *Dadirri* (97) that was used in qualitative research on physical activity participation by Stronach et al. (98). Specific recommendations for future research on physical activity among Aboriginal and Torres Strait Islander people, building on the program of research within this thesis, and informed by the

NHMRC recommendations, fall into two categories - epidemiology and program evaluation.

5.1 Epidemiology

5.1.1 Identify relationships between physical activity and health outcomes among adult and child Aboriginal and Torres Strait Islander populations using longitudinal cohort & national surveillance studies

Studies with appropriately-powered samples of Aboriginal and Torres Strait Islander people are required to determine valid associations. A recent study of smoking prevalence in finer geographical areas with high Indigenous populations highlights the need for larger sample sizes in national survey data (99) . This was also evident among the very small population sample sizes from which the area-level prevalence of physical activity in the Torres Strait from Queensland Health data (100) was established, as identified in the discussion of the findings from Chapter 6. However, several appropriately-powered data sources in Australia exist: in addition to the 45 and Up Study (n=1939 Aboriginal) (31), the Footprints in Time - Longitudinal Study of Indigenous Children (LSIC; n=1700) (101) could be used to investigate relationships among children. Secondary analysis of both adult (n=4778) and child (n=3841) population-level physical activity data from the ABS Australian Aboriginal and Torres Strait Islander Health Survey (11) could also be conducted. These studies could investigate establish new knowledge of relationships between physical activity and health and broader social outcomes, building on the cross-sectional associations found in this thesis. Large cohort studies could also be used to investigate whether age related declines in physical activity (69) occur at the same age in Aboriginal and Torres Strait Islander children and whether a social gradient for physical activity prevalence exists, as has been found for smoking (95).

5.2 Program evaluation

5.2.1 Refine previously-validated physical activity measures (subjective and objective) following an assessment of the feasibility, acceptability and adaptability of such measures in community-based pilot studies

The validation of measures among Aboriginal and Torres Strait Islander populations should involve training community research assistants to lead local data collection and data collection procedures which build local capacity to conduct research (26) and determine optimal adaptation to best suit their communities. This builds on preliminary formative work I conducted as a sub-study of the IMP pilot evaluation in the Torres Strait. Measures that could be prioritised for validation include the Active Australia Survey used in Chapter 2, in the Torres Strait sub-study and in many previous studies of non-Indigenous participants.

5.2.2 Conduct evaluation studies looking at the effectiveness of interventions to increase Aboriginal physical activity levels for health and social outcomes, using mixed methods

The evaluation of physical activity interventions in urban, rural and remote areas of Australia would make a substantial contribution towards building the evidence base of effective interventions. Evaluation could adopt the improved reliable and valid measures described above. The pilot evaluation of the IMP could be built upon and expanded into a multi-site comprehensive national evaluation with baseline and follow-up measures of new participants. The snapshot paper (Chapter 5) also highlights current programs where formal evaluation has not been conducted to date. Randomised controlled trials (RCTs) may be the preferred evaluation design as they provide the most rigorous evidence (83). However, community involvement in, and acceptance of, research procedures is a vital component of Aboriginal and Torres Strait Islander research (93). The use of a control group has not been well-accepted in previous health research and has often made such intervention designs unfeasible (102). So thorough community consultation and the testing and refinement of established measures in community settings must be inherent in the research methodology (93). Practical adaptations of RCT protocols, such as wait-listed

comparison groups or alternative multiple-baseline study designs, are examples of how rigorous methodologies could be retained whilst achieving community acceptance. Ideally, evaluation would start during the developmental stage of an intervention when participants are yet to be recruited and/or when the intervention is expanding to new Aboriginal communities and/or participant groups.

5.2.3 Synthesise past evidence and results from these evaluation studies to generate definitive conclusions on the effectiveness of physical activity interventions for Aboriginal and Torres Strait Islander people

Evidence could be synthesised in two main ways. Firstly, a Delphi survey technique (103) could be employed to achieve an expert group consensus on principles for best practice in the evaluation of physical activity interventions for Aboriginal people, to inform and enhance the methodological quality of future research and evaluation. A series of three structured questionnaires (rounds) could be used to reach consensus among a group of experts recruited through a snowball sampling technique of leading researchers, policy makers and practitioners. Secondly, a synthesis or possibly a meta-analysis of pooled data on the effectiveness of previous physical activity interventions for Aboriginal people could compare data, if comparable reliable and valid measures and outcomes are to be adopted in future studies.

This proposed future research would provide new directions of health and social outcome improvement through physical activity for Aboriginal and Torres Strait Islander people and how the positive effects of physical activity can be capitalised upon to benefit this population group.

6. Conclusion

Physical inactivity is a key risk factor for NCDs among Aboriginal and Torres Strait Islander people. Increasing physical activity among this population group could have considerable public health benefit in Australia. Programs to increase physical activity could improve health and broader social outcomes but little empirical evaluation has been conducted of such programs that target Aboriginal and Torres Strait Islander people has been conducted.

This thesis has presented a series of research studies on physical activity prevalence, trends, correlates, programs and their evaluation among Aboriginal and Torres Strait Islander people. The findings contribute new knowledge about the associations between physical activity participation and socio-demographic characteristics, neighbourhood environment and other health risks, social and lifestyle factors in three different Aboriginal populations in NSW. I identified key attributes of current and recent physical activity programs targeting Aboriginal and Torres Strait Islander people. I then conducted a pilot evaluation of one of these programs to capture health and community impacts and barriers to, and enablers of, physical activity in a Torres Strait Islander community.

Future research to identify longitudinal relationships between physical activity, health and broader social outcomes will help develop determinants that could be modified through strategies to increase physical activity. Conducting future evaluation studies looking at the effectiveness of such strategies could elicit ways to improve the health of Aboriginal and Torres Strait Islander people across the lifespan.

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Appendix 1

Factors relating to participation in follow-up to the 45 and up study in Aboriginal and non-Aboriginal individuals

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Factors relating to participation in follow-up to the 45 and up study in Aboriginal and non-Aboriginal individuals

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Abstract

Background: This study aimed to characterise the factors relating to participation in a postal follow-up study in Aboriginal and non-Aboriginal individuals, given the need to quantify potential biases from loss to follow-up and the lack of evidence regarding postal surveys among Aboriginal people.

Methods: The first 100,000 participants from the Sax Institute's 45 and Up Study, a large scale cohort study, were posted a follow-up questionnaire gathering general demographic, health and risk factor data, emphasising Social, Economic and Environmental Factors ("The SEEF Study"). For each variable of interest, percentages of those invited who went on to participate in follow-up were tabulated separately for Aboriginal and non-Aboriginal participants and age- and sex-adjusted participation rate ratios (aPRR) were calculated.

Results: Of the 692 Aboriginal and 97,178 non-Aboriginal invitees to the study, 314 Aboriginal (45 %) and 59,175 non-Aboriginal (61 %) individuals responded. While Aboriginal people were less likely to respond than non-Aboriginal people (aPRR 0.72, 95 % CI 0.66–0.78), factors related to response were similar. Follow-up study participants were more likely than non-participants to have university versus no educational qualifications (1.6, 1.3–2.0 [Aboriginal]; 1.5, 1.5–1.5 [non-Aboriginal]) and an annual income of ≥70,000 versus < $20,000 (1.6, 1.3–2.0; 1.2, 1.2–1.3 [$\chi^2 = 7.7$; $p = 0.001$]). Current smokers (0.55, 0.42–0.72; 0.76, 0.74–0.77 [$\chi^2 = 7.14$; $p = 0.03$]), those reporting poor self-rated health (0.68, 0.47–0.99; 0.65, 0.61–0.69), poor quality of life (0.63, 0.41–0.97; 0.61, 0.57–0.66) and very high psychological distress (0.71, 0.68–0.75 [non-Aboriginal]) were less likely than other cohort members to respond.

Conclusions: Relatively large numbers of Aboriginal and non-Aboriginal individuals participated in the first 45 and Up Study follow-up suggesting that postal surveys can be used to follow Aboriginal participants in cohort studies. Despite somewhat greater loss to follow-up in Aboriginal people (after considering socio-demographic and health characteristics), factors related to follow-up participation were similar in both groups: greater loss was observed in those experiencing disadvantage, ill-health and health risk, with implications for interpretation of future findings. Aboriginal low income earners and current regular smokers had a particularly elevated likelihood of non-participation compared to non-Aboriginal people. These findings highlight the importance of identifying and addressing barriers to participation among hard-to-reach population groups.

Keywords: Aboriginal people, Cohort study, Loss-to-follow up, Participation rates, Socio-demographic factors, Health behaviours

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Background

Prospective cohort studies have demonstrated their importance in providing reliable data on estimates of incidence and the relative risk of various outcomes in populations of interest. Despite their well-established use in epidemiology and population health, it is recognised that major differences in the characteristics of the participants who were initially studied at baseline from those who are followed-up can lead to bias [1, 2]. A sound quantitative understanding of patterns of non-response is important for interpreting longitudinal data from cohort studies, including whether such non-response is likely to materially affect findings.

It is well known that although postal surveys are a useful, convenient and cost-effective method of conducting longitudinal follow-up studies, particularly among geographically dispersed population groups [3], this method is prone to non-response [4]. Therefore, it is important to quantify participant characteristics associated with non-response in postal follow-up surveys in order to aid in interpretation of study findings and guide future studies. Willingness to participate in health research surveys among the general Australian population has recently been examined by Glass and colleagues (2015) [5]; they reported greater willingness among women versus men, older versus younger people and those with a long-term disease or disability. However, few studies to date have examined characteristics of participants lost to follow-up.

Loss to follow-up is likely to vary by population level characteristics. A systematic literature review of attrition between waves in longitudinal studies in the elderly due to reasons other than death reported that in general, people in worse health were less likely to be re-contactable [6]. The review also found that very few longitudinal studies actually report the risk factors for attrition. Among those that have reported such findings, social factors such as contact with friends/family and level of social support have not been examined as often as the basic socio-demographic factors such as education, income and marital status.

It has also often been reported that recruitment and retention of ethnic minorities in research studies is a challenge [7–9]. In Australia, due to the history of how Aboriginal health research had been previously conducted, including issues relating to ethical conduct, Aboriginal people are justified in viewing research studies negatively [10, 11]. It has also been widely speculated that retaining Aboriginal people in cohort studies, particularly through postal surveys is difficult given the highly mobile nature of the Aboriginal population in Australia [12]. Previous longitudinal studies have reported higher attrition rates among Aboriginal participants compared to non-Aboriginal participants [13–15]. However, to date there have been no studies that have examined the characteristics of responders versus non-responders in Aboriginal people and whether these differ between Aboriginal and non-Aboriginal people. Therefore, the aim of this study was to examine the socio-demographic and health-related characteristics of Aboriginal and non-Aboriginal participants in an initial postal follow-up of the 45 and Up study.

Methods

The Sax Institute's 45 and Up Study is a large scale longitudinal cohort study of men and women aged 45 years and older from the general population of New South Wales (NSW), Australia that has been designed to provide reliable evidence to inform policy to support healthy ageing. Further information about the study is available at http://www.45andup.org.au/ .

Details of participant recruitment and data collection have been reported previously [16]. Briefly, individuals aged 45 years and over were randomly selected from the Medicare Australia database (the national universal health insurance scheme), with a two-fold oversampling of rural areas and individuals aged 80 years and over. Participants entered the study by completing a baseline postal questionnaire which was distributed between 1 February 2006 to 31 December 2008 and providing written consent to follow their long term health, through repeat questionnaires and linkage to health records. A total of 267,153 people were recruited to the study over this time; the study had an overall 18 % response rate [16].

Aboriginal status was self-identified in the baseline questionnaire in response to the question: 'Are you of Aboriginal or Torres Strait Islander Origin? With the following tick box options: 1) No 2) Yes, Aboriginal and 3) Yes, Torres Strait Islander; participants were able to select both Aboriginal and Torres Strait Islander. Of the total participants, 1949 people identified as being of Aboriginal and/or Torres Strait Islander origin. The study's baseline questionnaire included a range of questions related to socio-demographic factors, physical and psychological health, behavioural risk factors, social support and past and present medical history. Baseline characteristics of Aboriginal and non-Aboriginal participants have been reported previously [17].

The initial follow-up to the 45 and Up study was undertaken from September-November 2010 where the first ~100,000 participants to join the 45 and Up Study were posted a questionnaire gathering general demographic, health and risk factor data, emphasising Social, Economic and Environmental Factors (as part of "The SEEF Study"). Participants who had requested not be contacted further, had already been contacted for other sub-studies or were deceased (ascertained through linkages to death registries) were not eligible for the follow-up study. A total of 99,927 participants of the 45 and Up study were invited to participate in the follow-up survey.

Ethics, consent and permissions

The 45 and Up and SEEF studies as a whole have received ethical approval from the Human Research Ethics Committees of the University of New South Wales (reference 10186) and the University of Sydney (Ref No. 10-2009/12187), respectively. Ethical approval for the current study has been granted by the Aboriginal Health and Medical Research Council of New South Wales (912/13). All participants of this study provided written informed consent.

Variables

All variables used in this study were derived from the self-reported 45 and Up baseline questionnaire apart from the Accessibility Remoteness Index of Australia Plus (ARIA+) score and the Index of Relative Socio-economic Disadvantage (IRSD) which were derived for each participant's postcode of residence at the time of original recruitment as recorded by Medicare Australia. Australian Standard Geographical Classification (ASGC) Remoteness areas, based on enhanced measures of remoteness (ARIA+) developed by the National Key Centre for Social Applications of Geographic Information Systems, categorises areas as 'major cities', 'inner regional', 'outer regional', 'remote' and 'very remote.' The ARIA+ index values are based on road distance from a locality to the closest service centre [18]. IRSD is one of the four indexes in the Socio-Economic Indexes for Areas (SEIFA) and is primarily based on disadvantage and the variable is derived from census variables such as low income, low educational attainment, unemployment and dwellings without motor vehicles [19]. Socio-demographic information included age, sex, formal educational qualification, marital status, household annual pre-tax income, employment status, ARIA+ score and IRSD. Participants were grouped into quintiles of the IRSD score. Those in quintile 1 were the most disadvantaged and those in quintile 5 were the least disadvantaged [19].

Lifestyle and health risk factor variables included those relating to smoking, alcohol and body mass index (BMI), screen time, hours spent sitting, physical activity and diet. Self-reported weight and height measurements were used to calculate BMI, as weight in kilograms divided by the square of their height in metres (kg/m^2). BMI was categorized according to the World Health Organization (WHO) criteria as underweight (BMI < 18.5 kg/m^2), healthy weight (18.5–24.99 kg/m^2), overweight (25.0–29.99 kg/m^2) and obese (BMI ≥ 30 kg/m^2) [20]. Participants' overall level of physical activity was classified according to their responses to questions on the number of weekly sessions (of any duration) of moderate and vigorous physical activity and episodes of walking for longer than 10 min, using items from the validated Active Australia questionnaire [21]. A weighted weekly average number of sessions were calculated for each participant by adding the total number of sessions, with vigorous activity sessions receiving twice the weighting of moderate activity or walking sessions. Physical activity was classified as either 'sufficient' (150 min of physical activity in 5 or more sessions a week) or 'insufficient' (greater than 1 but less than or equal to 149 min), based on the guidelines from the Australian Institute of Health and Welfare [21]. Sedentary time was assessed based on 'screen time' which was the number of hours spent per day watching television or using the computer and 'sitting time' which was the number of hours per day spent sitting. Fruit (including fruit juice) and vegetable (including both raw and cooked vegetables) intake was assessed as servings per day and classified as adequate (≥2 servings of fruit and ≥ 5 servings of vegetables per day) or inadequate (less than these amounts) according to the National Health and Medical Research Council guidelines [22].

Self-rated health and quality of life were based on the question, "In general, how would you rate your: Overall health? Quality of life?" followed by options of excellent, very good, good, fair and poor. In order to determine the level of social support provided by close contacts, participants were asked "How many people outside your home, but within 1 h of travel, do you feel you can depend on or you feel very close to?" Based on the responses the social support variable was categorised as follows: none, 1–3 people, 4–6 people and 7 or more people. Psychological distress was measured using the Kessler-10 score [23]; a scale based on 10 items used to measure non-specific psychological distress. Logical imputations were performed for missing values where there is a valid value for a similar but more severe item. For example, when the value "how often did you feel: depressed" is missing, then the value for "how often did you feel: so depressed that nothing could cheer you up" is imputed to the less severe item. The average of all non-missing items is imputed for up to one missing item, and then the final score is calculated; a higher score indicated a higher level of psychological distress. Final scores were only calculated for those participants that had a response for all ten questions after imputation as described above. Kessler-10 scores were classified into 4 groups: low psychological distress (score 10–15), moderate psychological distress (score 16–21), high psychological distress (score 22–29) and very high psychological distress (score 30 or higher) [24].

Past history of and current treatment for certain medical conditions were assessed based on the participant's response to the questions 'Has the doctor ever told you that you have…' and 'In the last month have you been treated for…", respectively, followed by a list of conditions that the participant could select. Categories of multiple morbidity were as follows: 0, 1–2 conditions, 3–4 conditions, 5 or more conditions.

Individuals who reported needing assistance with daily tasks because of long-term illness or disability were considered to have a major disability. Functional capacity was assessed using the Medical Outcomes Study Physical Functioning Scale [25]; a lower physical functioning score indicates more severe functional limitation [26]. The questions on the physical functioning scale asked whether participants are limited in their ability to perform vigorous and moderate physical activities and tasks such as: lifting shopping, climbing stairs, walking, bending, kneeling or stooping and bathing or dressing. A score is calculated where there are up to 5 missing items [25]. Functional limitation scores were classified into 5 groups: no limitation (score of 100), minor limitation (score 95–99), mild limitation (score 86–94), moderate limitation (60–84) and severe limitation (score 0–59).

Statistical analyses

For each variable of interest, frequencies and percentages (expressed as a percentage of those invited to the study) were tabulated separately for Aboriginal and non-Aboriginal participants. Generalised linear models with a binomial distribution and a log link function (binomial regression) (proc genmod in SAS, v9.4) adjusted for age and sex was used to determine participation rate ratios (PRR) with participation in the follow-up (yes/no) as the outcome. To examine the mediating role of education and income, models were further adjusted for formal educational qualifications and household annual income level. Analyses were conducted separately in Aboriginal and in non-Aboriginal participants. Effect measure modification of the association between participation and each specific factor by Aboriginal status was assessed using likelihood-ratio tests which compare the age and sex adjusted model with and without the interaction term [27]. All statistical analyses were undertaken using SAS software version 9.4 (SAS Institute Inc, Cary, NC, USA).

Results

Overall response to the invitation to participate in the follow-up study

A total of 99,927 participants (97,178 non-Aboriginal; 692 Aboriginal; 2057 unknown Aboriginal status) were invited to participate in the follow-up study of whom 60,399 responded (overall response rate = 60 %). Among Aboriginal people, 692 were invited, of whom 314 responded giving a response rate of 45 %. Among non-Aboriginal people 97,178 were invited, of whom 59,175 responded, giving a response rate of 61 % (Fig. 1). Participants without a valid Aboriginal status were excluded from the analyses. Aboriginal people were less likely to participate in the follow-up study compared to non-Aboriginal people; adjusting for age and sex the participation rate ratio was 0.72 (95 % CI 0.66–0.78). Following further adjustment for formal educational qualifications, annual household income and remoteness of residence, Aboriginal people remained significantly less likely to participate in the follow-up study compared to non-Aboriginal people (0.81, 0.74-0.87). Furthermore, after taking into account smoking status and number of medical conditions, Aboriginal people were still significantly less likely to participate in the follow-up study compared to non-Aboriginal people (0.83, 0.77-0.90).

Response rate to the follow-up survey according to socio-demographic factors at baseline (Fig. 2)

Among both Aboriginal and non-Aboriginal people, females were marginally more likely to respond compared to males (49 % vs 41 % [Aboriginal] and 62 % vs 59 % [non-Aboriginal]). Participants between the ages of 50–69 at baseline were more likely to respond to the survey compared to those aged 45–49 years; this association strengthened among both Aboriginal and non-Aboriginal participants in the fully adjusted model (further adjustment for formal educational qualifications and household income level) (Additional file 1: Table S1). Rates of participation increased steadily with increasing levels of formal educational qualifications among both Aboriginal and non-Aboriginal people. Participants with a university degree or higher were more likely to participate compared to those with no educational qualifications (1.58, 1.25–2.01 [Aboriginal] and 1.49, 1.46–1.52 [non-Aboriginal]); the strength of this association was attenuated (1.24, 0.97–1.59 [Aboriginal] and 1.38, 1.35–1.41 [non-Aboriginal]) in the fully adjusted model (Additional file 1: Table S1). Unmarried/not-partnered participants were less likely to participate compared to those who were married or living with a partner; only about a third of Aboriginal participants who were single or widowed participated in the follow up survey. Participants who were disabled/sick/unemployed were significantly less likely to participate compared to those who were working full-time/part-time (0.72, 0.54–0.95 [Aboriginal] and 0.76, 0.74–0.79 [non-Aboriginal]); the strength of this association was attenuated in the fully adjusted model (0.95, 0.71–1.28 [Aboriginal] and 0.89, 0.87–0.92 [non-Aboriginal]) (Additional file 1: Table S1). Accordingly, those earning a higher annual household income were more likely to participate compared to those earning less than $20,000/year. The relationship between household income and participation persisted in the fully adjusted model, however the prevalence ratio was slightly attenuated (Additional file 1: Table S1). The association between annual household income and participation showed a statistically significant interaction with Aboriginal status ($\chi^2 = 7.7$; $P = 0.001$), suggesting that the relationship between household income and participation differed among Aboriginal people in comparison to non-Aboriginal

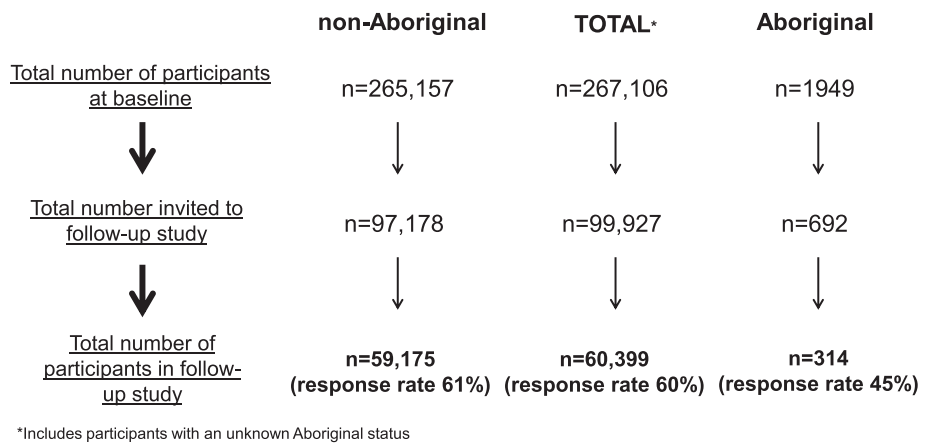

Fig. 1 Number of Aboriginal and non-Aboriginal participants in the baseline 45 and Up study and follow-up study

people. Participants with a health care card were significantly less likely to participate compared to participants with private health insurance; the relationship between having private health insurance and participation differed according to Aboriginal status ($\chi^2 = 7.92$; $P = 0.02$). Participants living in inner regional areas were more likely to participate compared to those living in major cities. The relationship between remoteness of residence and participation also differed with Aboriginal status ($\chi^2 = 14.3$; $P = 0.003$). Aboriginal participants

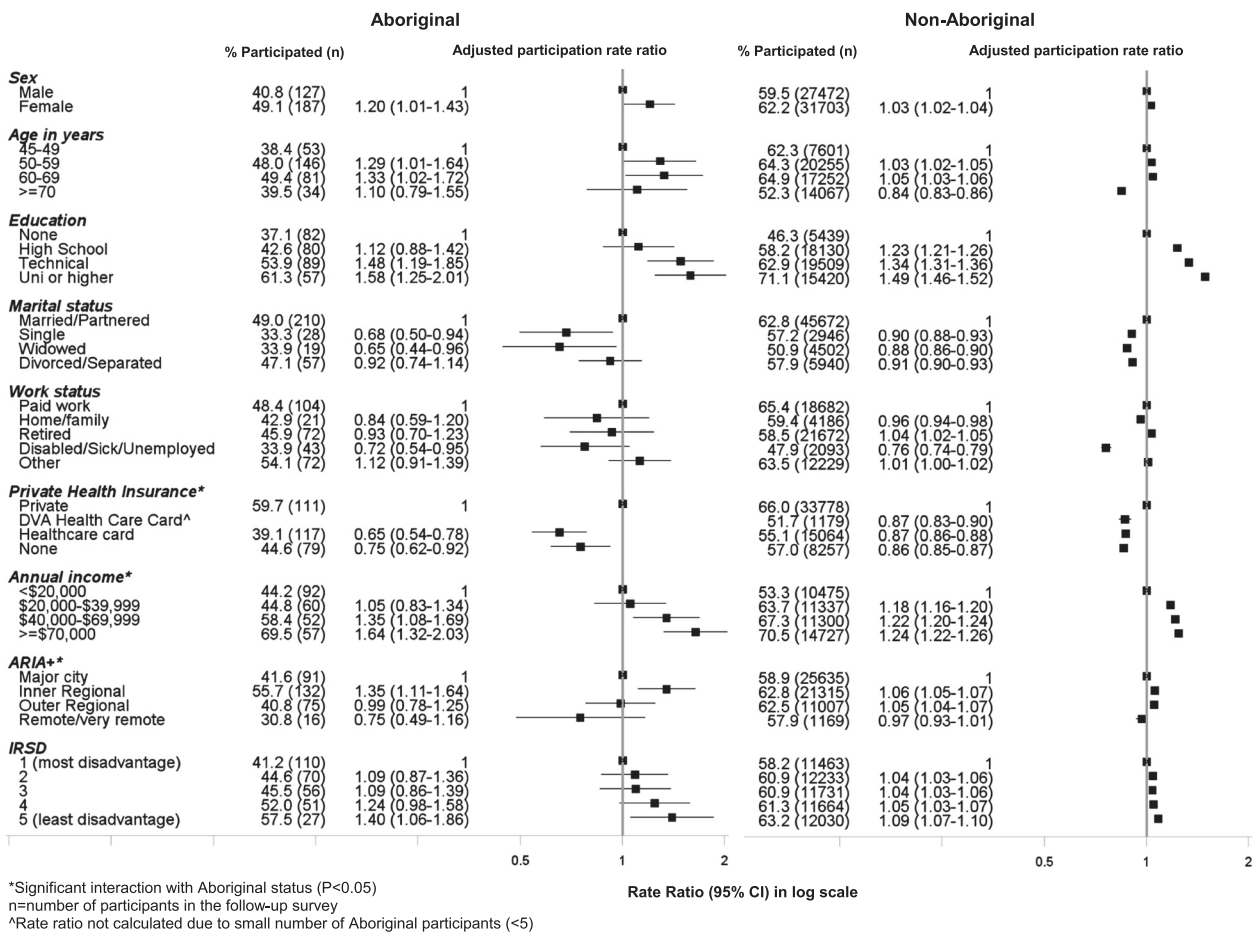

Fig. 2 Follow-up participation in the 45 and Up Study among Aboriginal and non-Aboriginal individuals by socio-demographic characteristics at baseline

living in inner regional areas had a greater likelihood of participation compared to non-Aboriginal participants.

Response rate to the follow-up survey according to health behaviours at baseline (Fig. 3)

Both Aboriginal and non-Aboriginal people who reported being regular smokers at baseline were significantly less likely to participate in the SEEF study compared to never smokers (0.55, 0.42–0.72 [Aboriginal]; 0.76, 0.74–0.77 [non-Aboriginal], respectively). This association persisted in the fully adjusted model (0.61, 0.47–0.79 [Aboriginal]; 0.81, 0.79–0.83 [non-Aboriginal) (Additional file 1: Table S2). The association between smoking status and participation showed a statistically significant interaction with Aboriginal status ($\chi^2 = 7.14$; $P = 0.03$). Aboriginal smokers were even less likely to participate compared to non-Aboriginal smokers. Among Aboriginal people, only 30 % of current smokers who were invited to the follow-up participated compared to 50 % among non-Aboriginal people. Those who consumed more than one alcoholic drink per week were more likely to participate in the follow-up study compared to those who did not consume alcohol. Compared to those who were normal weight, those who were underweight or obese were slightly less likely to participate in the study. Those people who did not meet the physical activity recommendations and had a poor diet (insufficient vegetable and fruit intake) were less likely to participate in the follow-up study. Those people who spent more time sitting (≥7 h) were marginally more likely to participate in the study compared to those who spent less time sitting (0–3 h).

Response rate to the follow-up survey according to psychosocial factors at baseline (Fig. 4)

Psychosocial correlates of participation were very similar between Aboriginal and non-Aboriginal participants. Among both Aboriginal and non-Aboriginal groups, those people who had poor self-rated health were significantly less likely to participate compared to those who self-rated their health as excellent/very good (0.69, 0.47–0.99 [Aboriginal]; 0.65, 0.61–0.69 [non-Aboriginal]). Similarly, those participants with poor self-rated quality of life were also

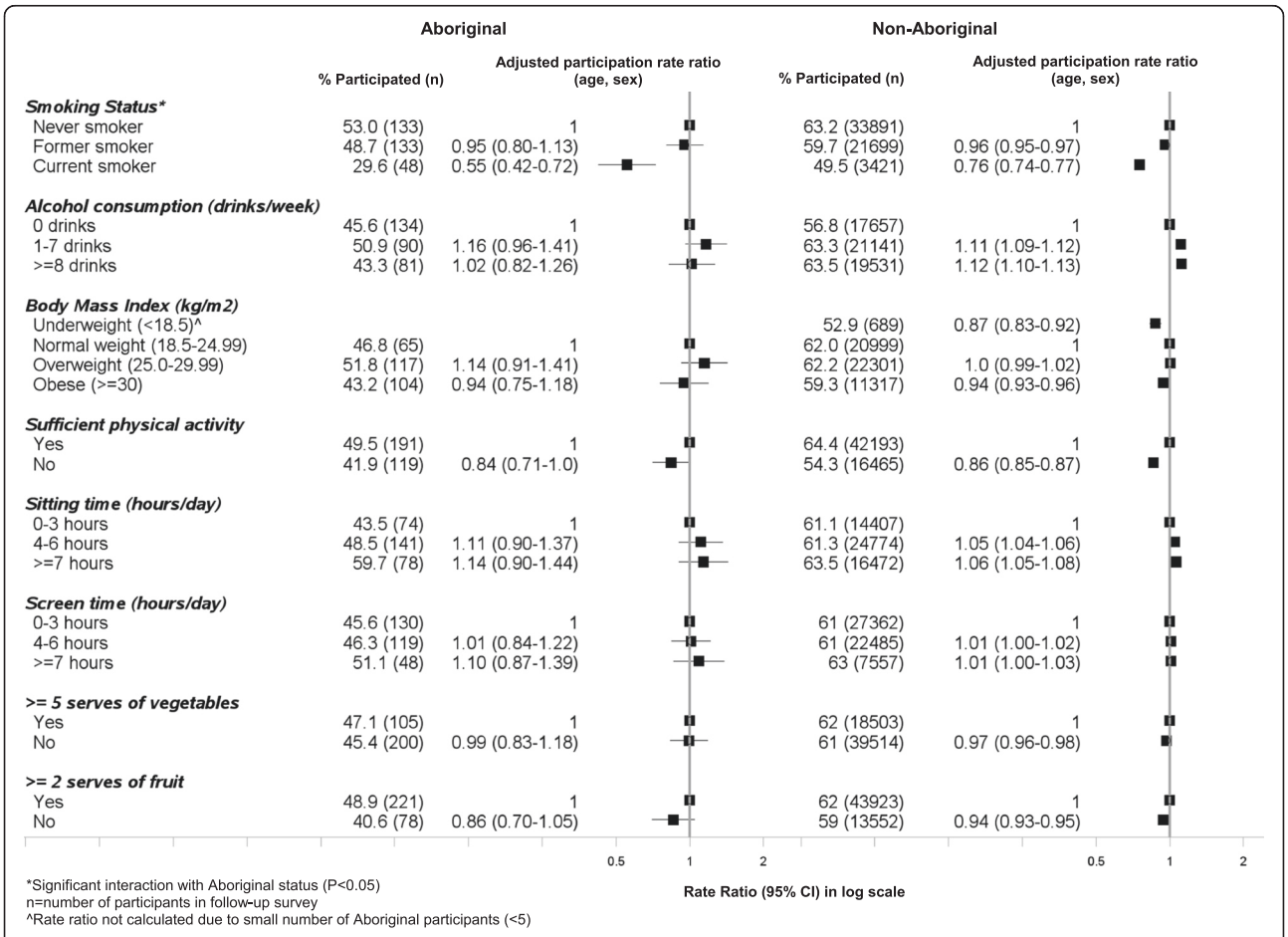

Fig. 3 Follow-up participation in the 45 and Up Study among Aboriginal and non-Aboriginal individuals by health behaviours at baseline

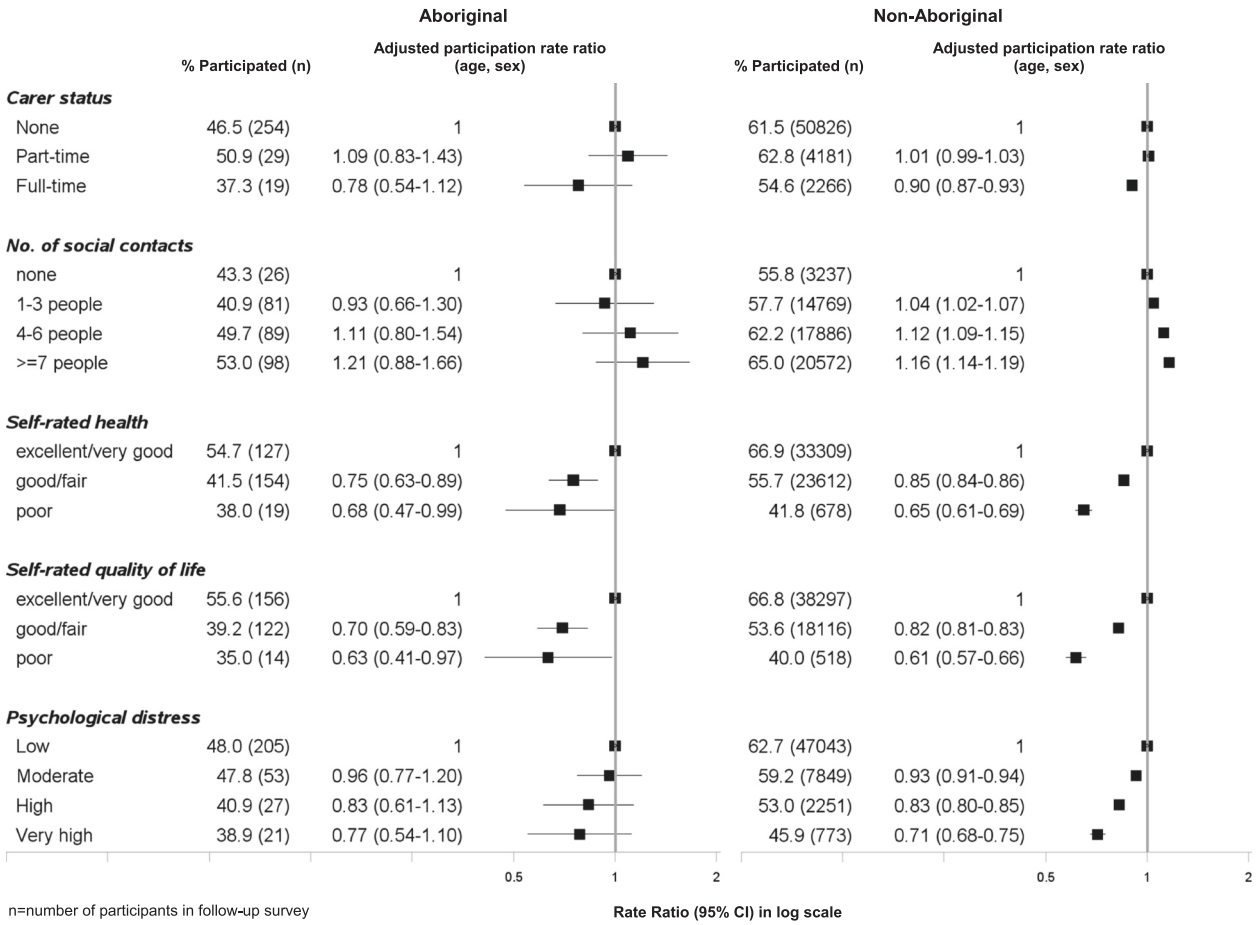

Fig. 4 Follow-up participation in the 45 and Up Study among Aboriginal and non-Aboriginal individuals by psychosocial factors at baseline

less likely to participate. Participation rate also decreased steadily with increasing levels of psychological distress. Among Aboriginal and non-Aboriginal people with high levels of psychological distress, 39 % and 46 % participated, respectively. The absolute and relative proportions of people participating in the follow up increased with increasing number of social contacts. Those individuals with full-time carer responsibilities were marginally less likely to participate compared to those with no carer responsibilities. The observed associations between psychosocial factors and participation in the follow-up survey among both Aboriginal and non-Aboriginal participants persisted in the fully adjusted model (Additional file 1: Table S3).

Response rate to the follow-up survey according to medical history and current treatments for selected conditions at baseline (Figs. 5 and 6)

Both Aboriginal and non-Aboriginal people who had ever been diagnosed with diabetes were less likely to participate in the follow-up study (0.76, 0.58–0.98 [Aboriginal] vs 0.90, 0.89–0.92 [non-Aboriginal]); this association persisted in the fully adjusted model (Additional file 1: Table S4). Only 35 % of Aboriginal people who had ever been diagnosed with diabetes, participated in the study. Those with severe physical functional limitations were significantly less likely to participate compared to those with no limitations (0.77, 0.75–0.79 [non-Aboriginal]); this association was slightly attenuated in the fully adjusted model (0.82, 0.80–0.84 [non-Aboriginal]). Similarly, those needing help with daily tasks were also less likely to participate in the study compared to those who did not need help (0.71, 0.69–0.74 [non-Aboriginal]), even following further adjustment for formal education and income level (0.76, 0.74–0.79 [non-Aboriginal]). Among current treatments for selected conditions at baseline, Aboriginal and non-Aboriginal individuals who were being treated for heart attack/angina (0.43, 0.21–0.88 [Aboriginal]; 0.92, 0.88–0.95 [non-Aboriginal]) were less likely to participate; this association persisted in the fully adjusted model (0.45, 0.22–0.92 [Aboriginal]; 0.94 (0.91–0.97) [non-aboriginal) (Additional file 1: Table S5). There was a significant statistical interaction in the relationship between study participation and current treatment for

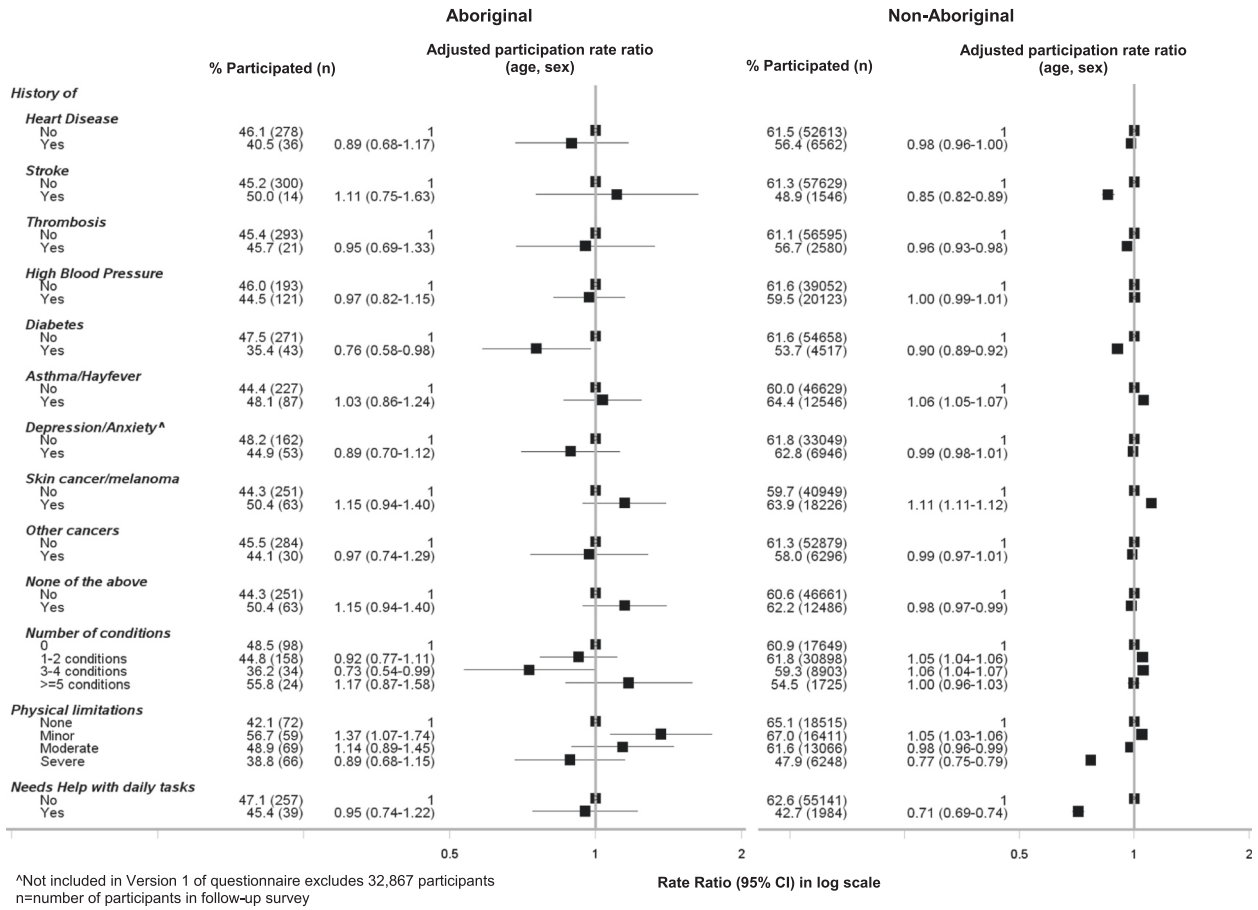

Fig. 5 Follow-up participation in the 45 and Up Study among Aboriginal and non-Aboriginal individuals by medical history at baseline

heart attack/angina such that Aboriginal participants were even less likely to participate compared to non-Aboriginal people ($\chi^2 = 6.56$; $P = 0.01$). Those participants who were not undergoing treatment for any of the conditions listed were significantly more likely to participate compared to those who were currently undergoing treatment (1.21, 1.02–1.43 [Aboriginal]; 1.06, 1.05–1.07 [non-Aboriginal]); adjusting for formal educational qualifications and household income attenuated this relationship among both Aboriginal (1.11, 0.94–1.30) and non-Aboriginal (1.03, 1.02–1.04) participants (Additional file 1: Table S5).

Discussion

Relatively large numbers of Aboriginal and non-Aboriginal people participated in the first follow-up to the 45 and Up Study. Individuals who responded to the follow-up survey were more likely than non-responders to have tertiary qualifications, earning a higher income and residing in less disadvantaged areas. Individuals who reported being regular smokers at baseline and participants with poor self-rated health/quality of life, high levels of psychological distress and those with fewer social contacts at baseline were significantly less likely to participate in the follow-up survey. Those participants who were being treated for medical conditions at baseline were less likely to respond to the follow-up survey compared to those who were not. Overall, Aboriginal people were less likely to respond to the follow-up study compared to non-Aboriginal people, particularly those participants earning a low income and participants who reported being regular smokers at baseline.

Our finding that almost half of the Aboriginal invitees to the follow-up study participated in the postal survey is encouraging and provides evidence to show that postal surveys can be used to undertake follow-up studies among Aboriginal people. A study, recently published by Marin and colleagues, on obtaining a representative sample for the South Australian Aboriginal population-based health survey [28] reported a 57.7 % response rate; that study used a variety of recruitment strategies and face-to-face interviews for data collection. Reasons for non-participation included: refusals (19.4 %), unavailable for interview (19.5 %),

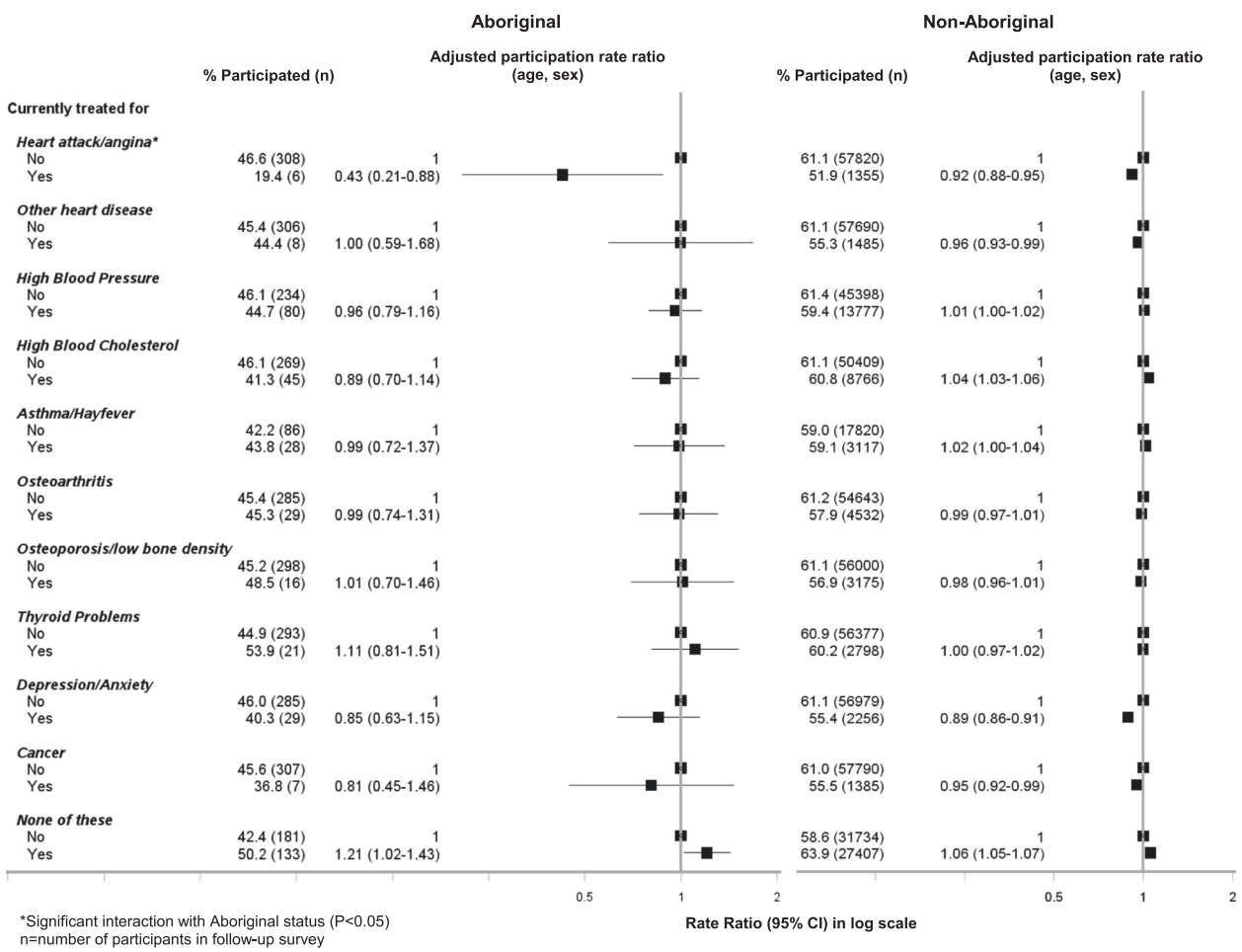

Fig. 6 Follow-up participation in the 45 and Up Study among Aboriginal and non-Aboriginal individuals by current treatments for selected medical conditions at baseline

illness/incapability to undertake interview or having moved house since first contact (3.3 %). Previous longitudinal studies that have compared attrition rates among Aboriginal versus non-Aboriginal participants have also shown greater attrition among Aboriginal participants [13–15]. For example, in the Household, Income and Labour Dynamics (HILDA) survey it has been reported that the attrition rate of Aboriginal participants from Wave 1 to Wave 2 was significantly greater compared to non-Aboriginal participants (20 % versus 13 %) [13]; loss to follow-up among Aboriginal people was mostly due to difficulties encountered in contacting the household. In the current study, even after taking into account socio-demographic factors, remoteness of residence, smoking status and number of medical conditions, Aboriginal people were still less likely to participate in the follow-up survey which suggests that other factors not captured in this study (such as cultural differences and opinions on health research) may be related to the lower participation rate.

In the current study, we found that although the response rates were lower among Aboriginal people, the socio-demographic and health-related correlates of participation in follow-up were similar between Aboriginal and non-Aboriginal people. Although studies to examine such associations have not been undertaken in Aboriginal population groups, in Australia or internationally, a Danish study has also suggested that although barriers to participation were relevant to the general population, ethnic minorities may be more exposed to those barriers compared to the general population [29].

The finding that responders of follow-up studies are more socio-economically advantaged compared to non-responders has been shown in a number of previous studies [30–32]. It has been previously suggested that higher education is related to a greater understanding and interest in research studies [33]. Increased participation rates in follow-up studies and in health surveys in general among those socially advantaged may also be associated with higher levels of health literacy. In the

current study, a statistically significant interaction with Aboriginal status was found in the association between annual household income and participation in the follow-up survey. This suggests that cohort retention among Aboriginal people who are on a low income may be more difficult compared to non-Aboriginal people.

It is well known that people with a greater level of health risk factors such as tobacco smoking, drug and alcohol abuse are less likely to participate in research studies and also more likely to be lost to follow-up in longitudinal studies [34, 35]. Accordingly, in this study, amongst all the health behaviours examined, we found current smoking to be significantly associated with non-participation in the follow-up study; particularly among the Aboriginal cohort. In general, it is possible that current smokers have a lower interest in aspects of health, including health research compared to non-smokers.

The 'healthy cohort effect' is a well-known concept that has been reported in a number of previous studies [34, 36, 37]; the findings of this study also suggest that the individuals in the cohort retained in the follow-up study are in general physically and mentally healthier. Indeed, participants with a lower self-rated health and quality of life and increased levels of psychological distress were 30–40 % less likely to respond to the follow-up survey. In relation to this finding, we also report that responders to the follow-up survey were significantly less likely to have ever been diagnosed with chronic diseases such as diabetes and stroke, less likely to be currently undergoing medical treatments and less likely to have physical functional limitations. It can be speculated that the reasons for attrition among those suffering from chronic disease and disability could include: difficulty in being contacted due to hospitalisation; difficulty in completing the questionnaire; a need to prioritise things other than participating in research; and feeling disengaged due to mental health problems.

Participation in the follow up survey among those people who had less social support (fewer social contacts or single/not-partnered marital status) was significantly lower compared to those with greater social support. Although the exact reasons for this findings is unclear from this study, previous research has also shown associations between greater social support and positive health behaviours such as participating in cardiovascular disease risk screening [38].

The role of formal educational qualifications and income level as mediating factors was also examined. The association between socio-demographic factors and health with participation in the follow-up survey persisted in the fully adjusted model among both Aboriginal and non-Aboriginal participants. However, a number of the associations were found to be attenuated in the fully adjusted model, suggesting that lower levels of formal education and income level are contributing to a small proportion of the observed associations.

This is one of the few studies to date to have examined the factors associated with participation in follow up surveys, particularly among Aboriginal people. However, one of the main limitations of the current study is that the reasons for non-response to the follow up study is not known, which would have provided greater information to understand patterns of non-response. It is also important to note that due to the relatively small sample size in the Aboriginal group compared to the non-Aboriginal group, some of the associations observed may be prone to error and should be interpreted with caution, particularly where the number of participants in the follow-up survey in the specific category was less than ten [39].

Conclusions

The findings of this study are important for future analyses and interpretation of longitudinal data from Aboriginal and non-Aboriginal participants in the 45 and Up cohort, as well as follow-up studies more broadly. Importantly, the results show that follow-up studies among Aboriginal participants can be undertaken through postal surveys. Although loss to follow-up was greater among Aboriginal people (even after taking into account age, sex, annual household income, remoteness of residence, smoking status and number of medical conditions), the factors related to non-participation in the follow-up survey were similar between Aboriginal and non-Aboriginal people which included: disadvantage, ill-health and health risk factors. Aboriginal participants on a low annual household income and those who were current regular smokers had a greater likelihood of non-participation compared to non-Aboriginal participants. In future studies, it is important to identify the barriers to participation among hard-to-reach population groups and devise strategies to minimise attrition.

Consent for publication

Not applicable.

Availability of data and materials

Due to ethical restrictions, the authors are unable to make the raw data set used for this manuscript publicly available. Readers can visit the 45 and Up study website (https://www.saxinstitute.org.au/our-work/45-up-study/) for more information about how to request the raw data, or they can contact either Sandra Eades (Sandra.Eades@bakeridi.edu.au) or Professor Emily Banks (Emily.Banks@anu.edu.au).

Additional file

Additional file 1: Table S1. Follow-up participation in the 45 and Up Study among Aboriginal and non-Aboriginal individuals by socio-demographic factors at baseline. **Table S2.** Follow-up participation in the 45 and Up Study among Aboriginal and non-Aboriginal individuals by health behaviours at baseline. **Table S3.** Follow-up participation in the 45 and Up Study among Aboriginal and non-Aboriginal individuals by psychosocial factors at baseline. **Table S4.** Follow-up participation in the 45 and Up Study among Aboriginal and non-Aboriginal individuals by medical history at baseline. **Table S5.** Follow-up participation in the 45 and Up Study among Aboriginal and non-Aboriginal individuals by current treatments for selected conditions at baseline. (DOCX 39.8 kb)

Abbreviations

ARIA+: Accessibility Remoteness Index of Australia Plus; BMI: body mass index; IRSD: Index of Relative Socio-economic Disadvantage; NSW: New South Wales; PRR: participation rate ratio; WHO: World Health Organisation.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

LG participated in the design of the study, performed the statistical analysis, was involved in the analysis and interpretation of data and drafted the manuscript. EB was involved in data acquisition, conceived of the study, participated in its design and helped to draft the manuscript. RM, BM were involved in interpretation of data and helped to draft the manuscript. GJ helped to perform the statistical analysis, interpretation of data and helped to draft the manuscript. AB was involved in data acquisition, intepretation of data and helped to draft the manuscript. SE participated in the design of the study, interpretation of data and helped to draft the manuscript. All authors read and approved the final manuscript.

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Declarations

The authors of this manuscript have nothing to declare.

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Appendix 2

Physical Functional Limitations among Aboriginal and Non-Aboriginal Older Adults: Associations with Socio-Demographic Factors and Health

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RESEARCH ARTICLE

Physical Functional Limitations among Aboriginal and Non-Aboriginal Older Adults: Associations with Socio-Demographic Factors and Health

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Data Availability Statement: Due to ethical restrictions, the authors are unable to make the minimal data set used for this manuscript publicly available. Readers can visit the 45 and Up study website (http://www.saxinstitute.com.au/our-work/45-up-study/) for more information about how to request the data, or they can contact either Sandra Eades (Sandra.Eades@bakeridi.edu.au) or Professor Emily Banks (Emily.Banks@anu.edu.au).

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Abstract

Background

Australian Aboriginal people are disproportionately affected by physical disability; the reasons for this are unclear. This study aimed to quantify associations between severe physical functional limitations and socio-demographic and health-related factors among older Aboriginal and non-Aboriginal adults.

Methods

Questionnaire data from 1,563 Aboriginal and 226,802 non-Aboriginal participants aged ≥45 years from the Sax Institute's 45 and Up Study (New South Wales, Australia) were used to calculate age- and sex-adjusted prevalence ratios (aPRs) for severe limitation [MOS-PF score <60] according to socio-demographic and health-related factors.

Results

Overall, 26% (410/1563) of Aboriginal participants and 13% (29,569/226,802) of non-Aboriginal participants had severe limitations (aPR 2.8, 95%CI 2.5–3.0). In both Aboriginal and non-Aboriginal participants, severe limitation was significantly associated with: being ≥70 vs <70 years old (aPRs 1.8, 1.3–2.4 and 5.3, 5.0–5.5, within Aboriginal and non-Aboriginal participants, respectively), none vs tertiary educational qualifications (aPRs 2.4, 1.7–3.3 and 3.1, 3.0–3.2), lower vs higher income (aPRs 6.6, 4.2–10.5 and 5.5, 5.2–5.8), current vs never-smoking (aPRs 2.0, 1.6–2.5 and 2.2, 2.1–2.3), obese vs normal weight (aPRs 1.7, 1.3–2.2 and 2.7, 2.7–2.8) and sitting for ≥7 vs <7 hours/day (aPRs 1.6, 1.2–2.0 and 1.6, 1.6–1.7). Severe limitations increased with increasing ill-health, with aPRs rising to 5–6 for ≥5 versus no chronic conditions. It was significantly higher in those with few vs

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many social contacts (aPRs 1.7, 1.4–2.0 and 1.4, 1.4–1.4) and with very high vs low psychological distress (aPRs 4.4, 3.6–5.4 and 5.7, 5.5–5.9).

Conclusions

Although the prevalence of severe physical limitation among Aboriginal people in this study is around three-fold that of non-Aboriginal people, the factors related to it are similar, indicating that Aboriginal people have higher levels of risk factors for and consequences of severe limitations. Effective management of chronic disease and reducing the prevalence of obesity and smoking are important areas for attention.

Introduction

Australian Aboriginal adults have an average life expectancy approximately 10 years less than non-Aboriginal Australians [1] and have greater levels of ill-health at all stages of life. Colonisation of Australia has had a profound influence on the social, emotional and physical health of Australian Aboriginal people. It is likely that the consequent disempowerment and dramatic shift in diet and lifestyle have played a major role in the deteriorating physical and emotional wellbeing of generations of Aboriginal people [2].

Over the years, although there have been some important improvements in the health of Australian Aboriginal people, little change in the high prevalence of chronic disease and disability has occurred [3]. The proportion of 45–64 year old people living with severe disability requiring assistance with core activities such as mobility, self-care or communication among Aboriginal Australians is estimated to be almost three times that of non-Aboriginal Australians [4]. Physical disability is the most common type of disability among Aboriginal people, affecting 82% of those with a severe/profound disability [4]. It has been hypothesised that the observed levels of severe physical disability among Aboriginal people are largely due to the complications resulting from chronic diseases such as diabetes, heart disease and chronic kidney disease, rates of which are significantly higher among Aboriginal people [4, 5].

Currently, population level data on the prevalence of chronic disease and disability is the major source of information on physical functioning among Aboriginal people. Investigation of physical functional limitations among Aboriginal and non-Aboriginal older adults and an understanding of its relationship to socio-demographic factors and health indicators is important in targeting appropriate types of support to those in greatest need, and hence should contribute to "closing the gap" in health outcomes between Aboriginal and non-Aboriginal Australians. However, there is little direct evidence of the factors associated with physical functional limitations in Aboriginal Australians, nor are direct comparisons of how these relationships compare with those in non-Aboriginal Australians. The aim of this study was to assess the relationship between severe physical functional limitations and a range of socio-demographic, health and psychosocial factors and chronic disease among Aboriginal and non-Aboriginal people. This is in keeping with the 'differential vulnerability hypothesis', which suggests that the factors associated with physical functional limitations differ among Aboriginal people compared to non-Aboriginal people.

Materials and Methods

Participant recruitment

The Sax Institute's 45 and Up Study is a large prospective cohort study of people aged 45 years and older [6] residing in New South Wales (NSW), Australia, which includes periodic health

questionnaires and large-scale data linkage. Potential study participants were randomly selected from the Medicare Australia database, with oversampling in regional areas and of those aged 80 years and older. Residents in remote areas were completely enumerated. Baseline self-administered postal questionnaires were distributed from 1 January 2006 to 31 December 2008. Joining the study comprised of completing the baseline questionnaire and providing written informed consent for follow up through repeat questionnaires and linkage of participant data to health-related datasets. Further information about the 45 and Up Study can be found at https://www.saxinstitute.org.au/our-work/45-up-study.

Ethical Approval

Ethical approval of the 45 and Up Study as a whole was granted by the University of New South Wales Human Research Ethics Committee. Ethical approval for the current study has also been received from the Aboriginal Health and Medical Research Council of NSW (Reference 912/13). Written informed consent was obtained from all participants of this study.

Data collection

The analyses described in this paper used data collected in the baseline postal questionnaire of the 45 and Up Study, apart from remoteness of residence (see below). Details of the variables collected and a summary of the characteristics of Aboriginal and non-Aboriginal participants of the study have been previously published [7].

Aboriginal origin was determined by self-identification. The questionnaire contained the item "Are you of Aboriginal or Torres Strait Islander origin?" Participants who checked the boxes "Yes, Aboriginal" or "Yes, Torres Strait Islander" were included as Aboriginal and/or Torres Strait Islander. Data on Aboriginal and Torres Strait Islander participants have been combined due to the small number of participants who identified as Torres Strait Islander. The term 'Aboriginal' refers to both Aboriginal and/or Torres Strait Islander participants in keeping with advice from the Aboriginal Health and Medical Research Council of New South Wales.

The degree of physical functional limitation was determined using the Medical Outcomes Study–Physical Functioning (MOS-PF) scale [8, 9] that asks participants 10 questions based on whether their health limits them in performing daily activities to vigorous activities (Fig 1). Participants were given a choice of three responses for each question with a score allocated for each response: 1) Yes, limited a lot (score = 1) 2) Yes, limited a little (score = 2) and 3) No, not limited at all (score = 3). Participants could score a minimum of 10 points and a maximum of 30 points which were then re-scaled to a score between 0–100 (10 = 0 and 30 = 100) with higher scores indicative of better physical functioning. Scores from this scale were categorized as follows: no limitation (score of 100); minor limitation (score 90–99); moderate limitation (60–89); and severe limitation (score 0–59).

The Accessibility Remoteness Index of Australia Plus (ARIA+) score [10] and the Index of Relative Socio-economic Disadvantage (IRSD) [11] were derived for each participant's postcode of residence at the time of recruitment as recorded by Medicare Australia. Participants were grouped into quintiles of the IRSD score, with quintile 1 being the most disadvantaged, and quintile 5 the least disadvantaged. The ARIA+ score was used to identify participant's place of residence, categorized as: 'Major City', Inner Regional', 'Outer Regional', 'Remote' and 'Very Remote.' Other socio-demographic information included: age, sex, marital status, highest formal educational qualification, household annual pre-tax income and current employment status. Educational qualifications were categorised as follows: None (No school certificate or other qualification), High School (School or intermediate certificate/Higher school or leaving

Does your health now LIMIT YOU in any of the following activities?	Yes, limited a lot	Yes, limited a little	No, not limited at all
VIGOROUS activities (e.g running, strenuous sports)			
MODERATE activities (e.g pushing a vacuum cleaner, playing golf)			
Lifting or carrying shopping			
Climbing several flights of stairs			
Climbing one flight of stairs			
Walking one kilometre			
Walking half a kilometre			
Walking 100 metres			
Bending, kneeling or stooping			
Bathing or dressing yourself			

Fig 1. Questions included in the Medical Outcomes Study–Physical Functioning (MOS-PF) scale.

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certificate), Technical (Trade or apprenticeship/Certificate or diploma) and University degree or higher.

Variables related to health behaviours included smoking, alcohol consumption, body mass index (BMI), screen time, hours spent sitting, physical activity and diet. Self-reported weight and height measurements were used to calculate participant's BMI, as their weight in kilograms divided by the square of their height in metres (kg/m^2). BMI was categorized according to the World Health Organization (WHO) criteria as underweight ($<18.5 kg/m^2$), normal weight ($18.5 kg/m^2$-$24.99 kg/m^2$), overweight ($25.0–29.99 kg/m^2$), obese class I ($30.0–34.99 kg/m^2$), obese class II (35.0–39.99) and obese class III ($\geq 40.0 kg/m^2$) [12]. Participants' overall level of physical activity was classified according to their responses to questions on the number of weekly sessions (of any duration) of moderate and vigorous physical activity and episodes of walking for longer than 10 min, using items from the validated Australian Institute of Health and Welfare's (AIHW) Active Australia questionnaire [13]. A weighted weekly average number of sessions were calculated for each participant by adding the total number of sessions, with vigorous activity sessions receiving twice the weighting of moderate activity or walking sessions. Physical activity was classified as either 'sufficient' (150 min of physical activity in 5 or more sessions a week) or 'insufficient' (greater than 1 but less than or equal to 149 min), based on the guidelines from the AIHW [13]. Sedentary time was assessed based on 'screen time' which was the number of hours spent per day watching television or using the computer and 'sitting time' which was the number of hours per day spent sitting. Fruit and vegetable (including both raw and cooked vegetables) intake was assessed as servings per day and classified as adequate ($\geq$ 2 servings of fruit and $\geq$ 5 servings of vegetables per day) or inadequate (less than these amounts) according to the National Health and Medical Research Council guidelines [14].

The Kessler-10 (K-10) scale was used to measure psychological distress [15, 16]. The scale contains a series of ten questions related to signs and symptoms of distress in the past 4 weeks with response options of "none of the time", "a little of the time", "some of the time", "most of

the time", or "all of the time". Kessler-10 scores were classified into 4 groups: low psychological distress (score 10–15), moderate psychological distress (score 16–21), high psychological distress (score 22–29) and very high psychological distress (score 30 or higher). Self-rated health and quality of life were categorised into the following: Excellent/very good, good/fair and poor. In order to determine the level of social support provided by close contacts, participants were asked "How many people outside your home, but within 1 hour of travel, do you feel you can depend on or you feel very close to?" Based on the responses the social support variable was categorised as follows: none, 1–3 people, 4–6 people and 7 or more people. Social interaction was also measured with the questions, "How many times in the last week did you spend time with friends or family who do not live with you?" and "How many times in the last week did you go to meetings of social clubs, religious groups or other groups you belong to?" These variables were categorised as follows: none, 1–2 times, 3–4 times and 5 or more times.

Prevalence of chronic diseases was assessed based on the participant's response to the questions "Has the doctor ever told you that you have. . ." followed by a list of conditions that the participant could select. Number of chronic conditions were categorised as: 0, 1–2 conditions, 3–4 conditions, 5–6 conditions and 7 or more conditions.

Statistical analysis

To assess the internal consistency of the 10 items included in the MOS-PF scale, Cronbach's alpha coefficients were assessed, with a criterion of 0.7 used to define adequate internal consistency. To assess the factor structure of the MOS-PF scale, an exploratory factor analyses was undertaken in the Aboriginal and non-Aboriginal participants separately (PROC FACTOR). The number of factors to retain in the final analysis was determined by examining eigenvalues (>1.0) [17].

Modified Poisson regression which combines a log Poisson regression model with robust variance estimation [18] was used to obtain age- and sex- adjusted prevalence ratios (aPR) for severe physical functional limitations (MOS-PF score of 0–59) for a range of socio-demographic and health indicators for Aboriginal and non-Aboriginal participants separately. A modified Poisson regression model was chosen over other log binomial regression and logistic regression models since it has been previously reported that use of the binomial regression model have limitations such as convergence difficulties [19]. Furthermore, a logistic regression model is known to produce odds ratios which are overestimated especially when the outcome is common [19]. Effect modification of the relationship between each specific factor (e.g sex) and severe physical functional limitation by Aboriginal status was assessed separately by comparing the model with and without the interaction term.

The MOS-PF score was also analysed as a continuous variable. Given the skewed distribution of the MOS-PF scores (as shown by the Kolmogorov-Smirnov test [$P<0.01$]), group medians and interquartile ranges are reported along with means and standard deviations. Non-parametric Kruskal-Wallis statistical tests were utilised to examine significant variation in median scores within categories of the exposure variables (for example to examine variation in MOS-PF scores by age groups, median scores within age group categories [45–49 years, 50–59 years, 60–69 years, 70+ years] were compared). All statistical analyses were undertaken using SAS software version 9.3 (SAS Institute Inc, Cary, NC, USA). Statistical significance was accepted at the $P<0.05$ level.

Inclusion/Exclusion criteria

Participants without a valid age or date of entry into the study or an invalid response to the question on Aboriginal origin (n = 4741), or without a valid MOS-PF score following the

logical backfilling (n = 386 Aboriginal, n = 33614 non-Aboriginal) were excluded from the analysis.

Results

The study population available for analyses included 1563 Aboriginal and 226802 non-Aboriginal participants. Baseline socio-demographic and health characteristics of these participants are given in Table 1. The proportion of participants in the younger age groups was higher among Aboriginal people compared to non-Aboriginal people.

The MOS-PF scale demonstrated very high levels of internal consistency among both the Aboriginal and non-Aboriginal group with Cronbach's alphas of 0.98 and 0.99, respectively. Exploratory factor analysis showed a similar one-dimensional factor structure among Aboriginal and non-Aboriginal participants based on eigenvalues greater than one. Only one factor among both Aboriginal and non-Aboriginal participants showed eigenvalues greater than one (6.64 and 6.12, respectively). All ten items included on the MOS-PF scale were shown to have a moderate to high loading (>0.50) onto that single factor (S2 Table).

Median MOS-PF scores were lower among Aboriginal participants compared to non-Aboriginal participants (Table 1). Overall, 26% of Aboriginal participants and 13% of non-Aboriginal participants had scores consistent with severe limitation (Score <60). After adjusting for age and sex, the prevalence of severe limitation among Aboriginal people was around three times that of non-Aboriginal people (aPR: 2.8, 95% CI 2.5–3.0).

Socio-demographic factors

In both Aboriginal and non-Aboriginal participants, the prevalence of severe limitation increased with increasing age (Fig 2), with a steeper gradient in the prevalence ratio among non-Aboriginal participants ($P_{interaction}<0.001$), but similar differences in absolute prevalence according to age within the two groups. Overall, 19% of Aboriginal participants aged between 45–49 years were severely limited compared to 5% of non-Aboriginal participants.

The prevalence of severe limitation was generally greater in females compared to males. In both Aboriginal and non-Aboriginal participants, severe limitation was significantly higher among participants who had fewer educational qualifications, not married or partnered, not in paid employment, low income earners, and among those living in remote areas and areas with greater social disadvantage, compared to those without these characteristics (Fig 2). It is to be noted that among those in paid employment, the absolute prevalence of severe limitation was higher among Aboriginal participants (8%) versus non-Aboriginal participants (3%). Although the relationship between socio-demographic factors and severe limitation were generally similar between Aboriginal and non-Aboriginal participants, significant statistical interaction with Aboriginal status was found with age ($P_{interaction}<0.001$), sex ($P_{interaction} = 0.05$), marital status ($P_{interaction} <0.001$) and work status ($P_{interaction}<0.001$).

Health behaviours

Among both Aboriginal and non-Aboriginal participants, those who were overweight or obese were more likely to be severely limited compared to those with normal weight (Fig 3). The prevalence of severe functional limitation also increased with increasing severity of obesity (class I–class II); with a steeper gradient in prevalence ratio among non-Aboriginal vs Aboriginal people ($P_{interaction}<0.001$). The prevalence of severe functional limitation was greater among those with higher versus lower levels of sedentary time (screen time and sitting time) and lower (50%-60%) among those people who achieved the recommended levels of physical

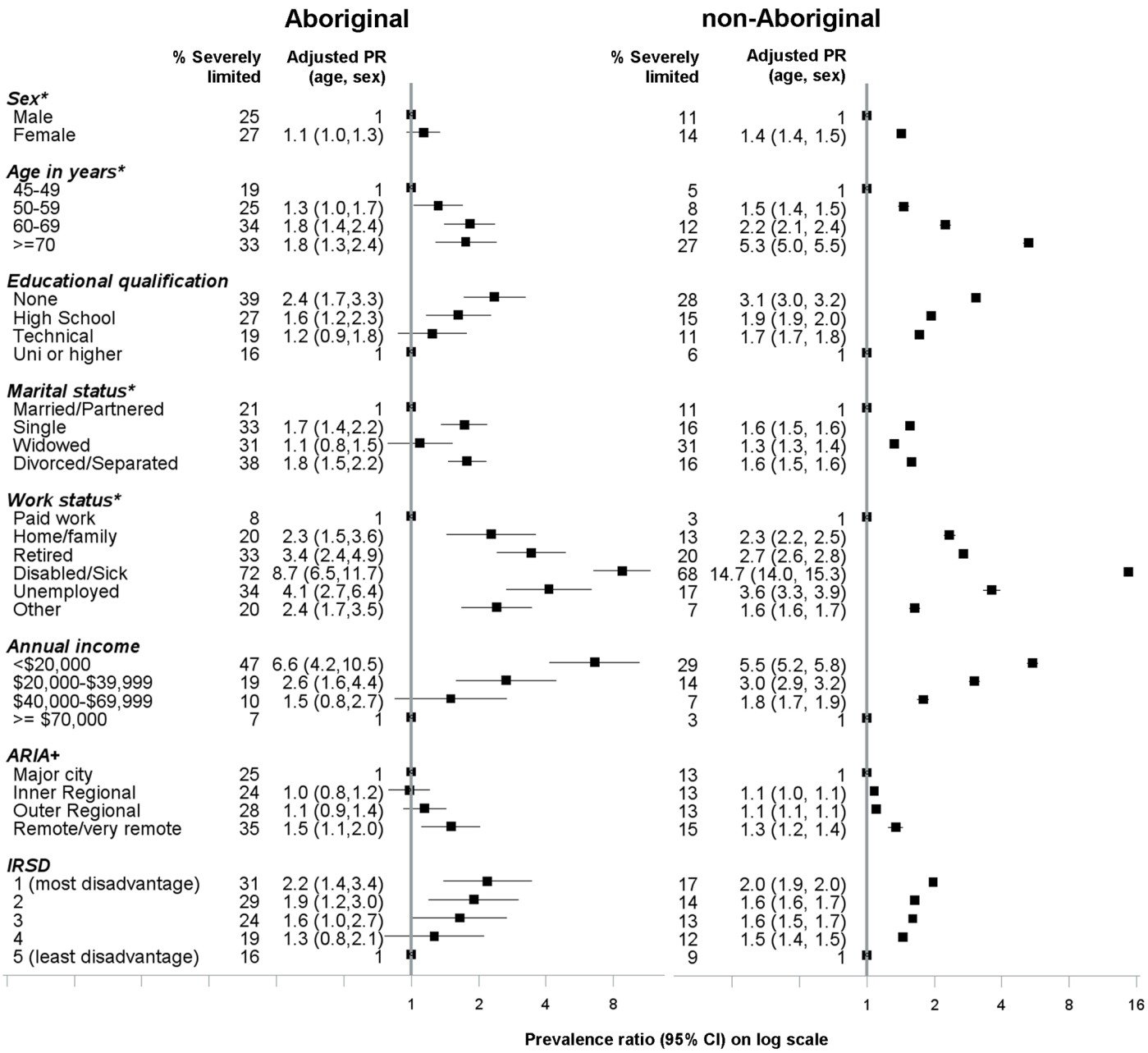
Table 1. Characteristics of Aboriginal and non-Aboriginal participants of the 45 and Up study examined in the current study and overall MOS-PF score and level of physical functional limitations.

	Aboriginal	Non-Aboriginal
	(n = 1563)	(n = 226802)
	% (n)	% (n)
Sex		
Male	44 (690)	47 (107413)
Female	56 (873)	53 (119389)
Age (years)		
45–49	24 (373)	14 (31618)
50–59	45 (701)	35 (78927)
60–69	21 (336)	28 (63658)
≥70	10 (153)	23 (52599)
Educational qualifications		
None	27 (415)	10 (23314)
High school	29 (453)	31 (70858)
Technical (Trade/Diploma/Certificate)	27 (427)	33 (73930)
Uni or higher	15 (236)	25 (56134)
Work Status		
Paid work	36 (565)	33 (74416)
Home/Family	8 (118)	7 (15419)
Retired	20 (307)	35 (78304)
Disabled/sick	14 (214)	3 (7662)
Unemployed	4 (68)	1 (3110)
Other	18 (277)	21 (46771)
Annual household income		
<$20,000	31 (480)	18 (41624)
$20,000-$39,000	18 (279)	18 (40449)
$40,000-$69,000	16 (251)	19 (42617)
≥$70,000	17 (263)	26 (58808)
Marital status		
Married/Partnered	62 (974)	76 (171859)
Single	13 (197)	6 (12582)
Widowed	6 (98)	8 (17262)
Divorced/Separated	18 (277)	11 (23926)
Smoking status		
Never	40 (630)	56 (126539)
Former	37 (583)	37 (83640)
Current	22 (339)	7 (16034)
Body mass index		
Underweight (<18.5 kg/m^2)	1 (21)	1 (2689)
Normal weight (18.5–24.99 kg/m^2)	20 (317)	34 (78014)
Overweight (25.0 kg/m^2-29.99m^2)	33 (518)	37 (83939)
Obese (≥30 kg/m^2)	34 (535)	21 (46526)
Median (IQR) MOS-PF score	85 (55–100)	95 (80–100)
Level of physical functional limitation		
None (100)	29 (451)	34 (77476)
Minor (90–99)	20 (316)	29 (65438)
Moderate (60–89)	25 (386)	24 (54319)
Severe (0–59)	26 (410)	13 (29569)

Percentages may not equal to 100 due to missing/invalid data

MOS-PF = Medical Outcomes Study Physical Functioning

doi:10.1371/journal.pone.0139364.t001



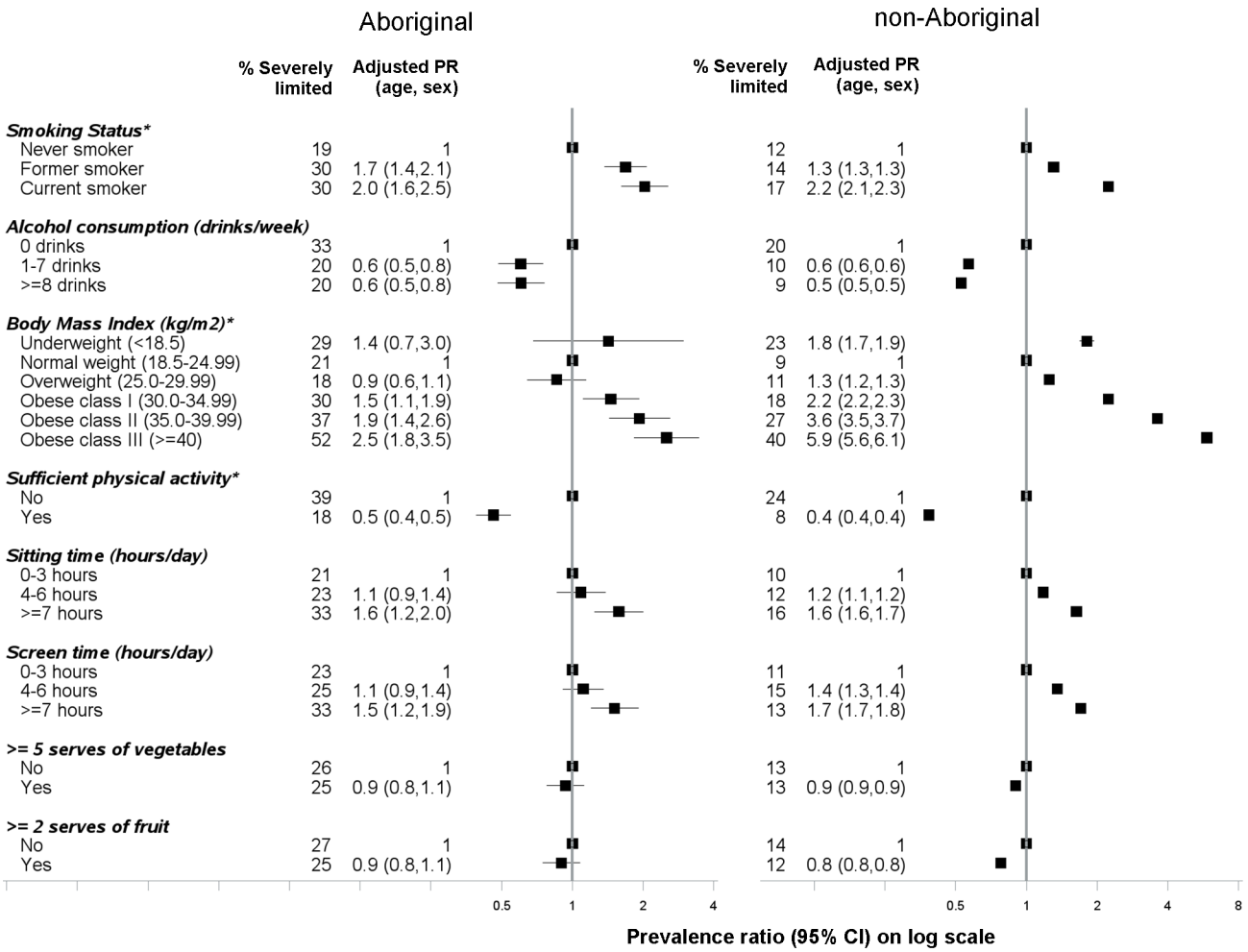
*Statistically significant interaction ($P_{interaction}$<0.05) between Aboriginal and non-Aboriginal participants

Fig 2. Association between *severe physical functional limitations* (MOS-PF score 0–59) and socio-demographic factors among Aboriginal and non-Aboriginal participants from the 45 and Up study.

doi:10.1371/journal.pone.0139364.g002

activity compared to those people who did not. Significant statistical interaction with Aboriginal status was found with meeting the physical activity recommendations ($P_{interaction}$ = 0.02).

Among both Aboriginal and non-Aboriginal participants, current smokers had twice the prevalence of severe limitation compared to non-smokers. Among non-Aboriginal participants the absolute proportions of participants severely limited was lower among former smokers compared to current smokers (14% vs 17%); however, the proportion was similar among Aboriginal participants (30%). Furthermore, the absolute proportion of participants who were



*Statistically significant interaction ($P_{interaction}$<0.05) between Aboriginal and non-Aboriginal participants

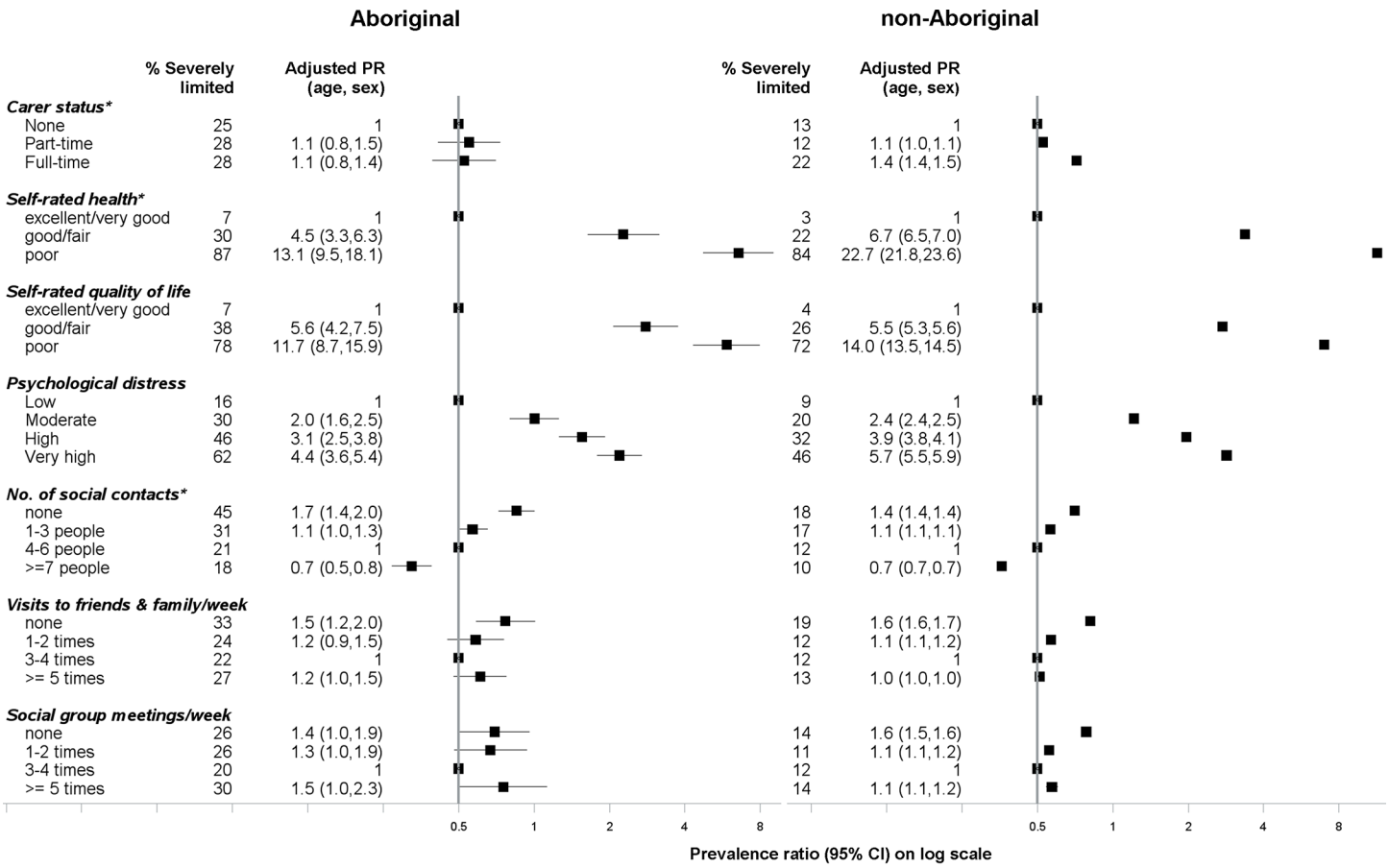
Fig 3. Association between *severe physical functional limitations* (MOS-PF score 0–59) and health behaviours among Aboriginal and non-Aboriginal participants from the 45 and Up study.

doi:10.1371/journal.pone.0139364.g003

severely limited was 10% higher among Aboriginal current smokers compared to non-smokers whereas among non-Aboriginal participants, the difference in proportions was 5%. Significant statistical interaction with Aboriginal status was found with smoking status ($P_{interaction}$ = 0.02). Participants who consumed more alcohol were less likely to be severely limited compared to those who were non-drinkers or consumed less than 1 drink/week.

Psychosocial factors

Among Aboriginal and non-Aboriginal participants who rated their health as poor, 87% and 84%, respectively, had scores consistent with severe limitation (Fig 4). The prevalence of severe limitation increased with increasing levels of psychological distress among both Aboriginal and non-Aboriginal participants with prevalence ratios of 2.0 among those with moderate distress and as high as 5.7 among those with very high levels of distress. Aboriginal and non-Aboriginal participants with very high levels of psychological distress had scores consistent with severe limitations (62% and 46%, respectively).

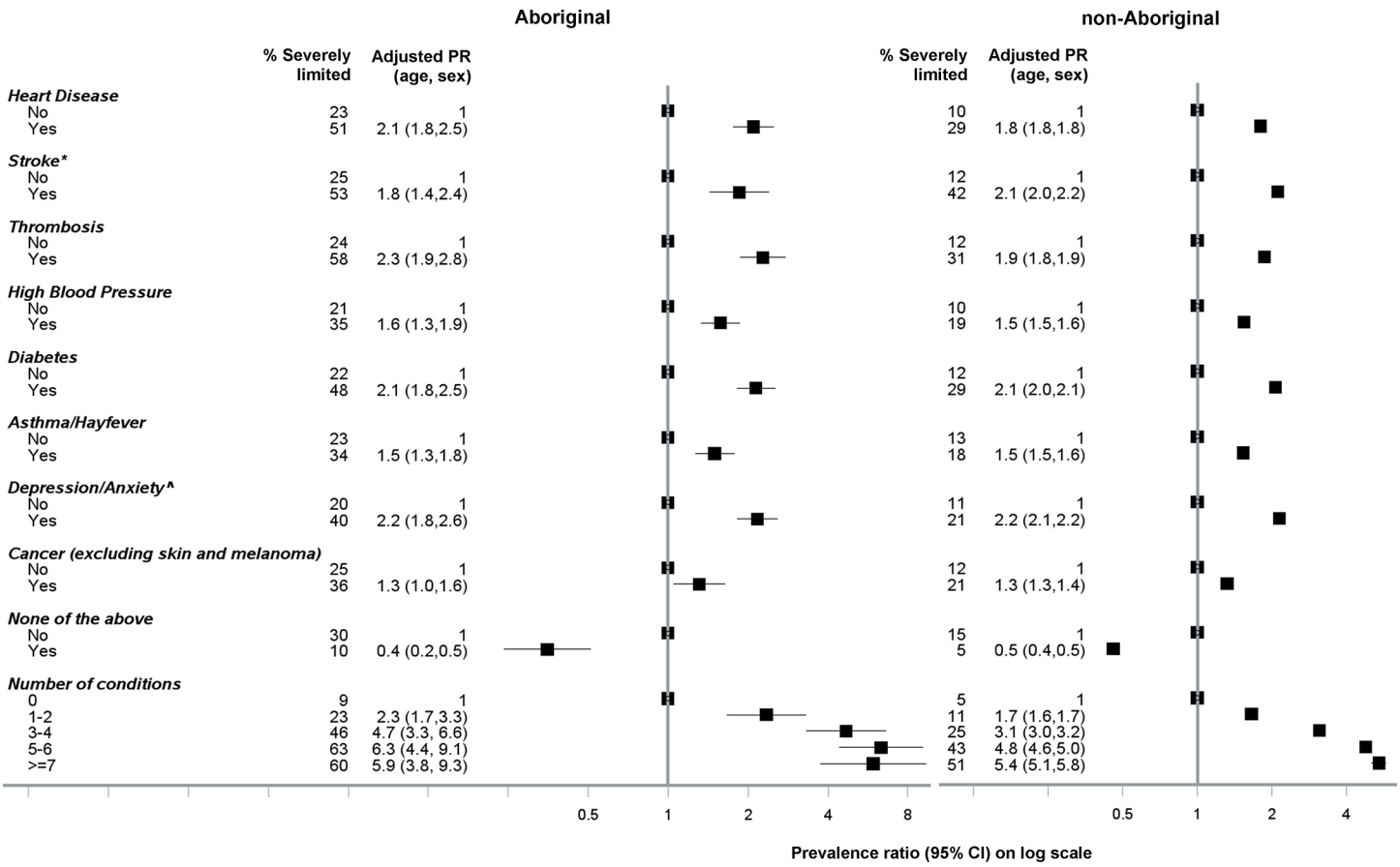


*Statistically significant interaction ($P_{interaction}<0.05$) between Aboriginal and non-Aboriginal participants

Fig 4. Association between *severe physical functional limitations* (MOS-PF Score 0–59) and psychosocial factors among Aboriginal and non-Aboriginal participants from the 45 and Up study.

doi:10.1371/journal.pone.0139364.g004

Having no one to depend on (outside of home) was associated with a higher prevalence of severe limitation among Aboriginal and non-Aboriginal people, with a much higher absolute prevalence among Aboriginal people (45% vs 18%). Accordingly, prevalence ratios of 0.7 were found among both Aboriginal and non-Aboriginal people who responded having seven or more people who they could depend on compared to those with no social contacts. Prevalence of severe limitation was significantly higher among those who spent no time with friends or family who did not live with them compared to those that spent 3–4 times per week, among both Aboriginal and non-Aboriginal people. In terms of meetings of social clubs, religious groups and other groups, prevalence of severe limitation was high among those who attended none or only 1–2 meetings per week and those who attended many meetings (5 or more) per week compared to those attending 3–4 times per week. Furthermore, prevalence of severe limitation was higher among those participants who had full-time carer responsibilities compared to those who had no carer responsibilities. Significant statistical interaction with Aboriginal status was found with carer status ($P_{interaction}<0.001$), social contacts ($P_{interaction} = 0.03$) and self-rated health ($P_{interaction} = 0.03$).



*Statistically significant interaction ($P_{interaction}<0.05$) between Aboriginal and non-Aboriginal participants
^Not included in Version 1 questionnaire (excludes 31,222 participants)

Fig 5. Association between *severe physical functional limitations* (MOS-PF score 0–59) and chronic disease among Aboriginal and non-Aboriginal participants from the 45 and Up study.

doi:10.1371/journal.pone.0139364.g005

Chronic diseases

A higher prevalence of severe limitation was found among individuals diagnosed with a specific medical condition in comparison to those that did not have the condition. Absolute baseline prevalence of severe limitation was consistently high among Aboriginal people: approximately 20–25% of Aboriginal people who responded as not being diagnosed with the specific condition were severely limited. Among those who responded to not being diagnosed with *any* of the conditions listed, 10% of Aboriginal people were severely limited compared to 5% of non-Aboriginal people. Aboriginal and non-Aboriginal participants who had ever been told by a doctor that they had diabetes had 2.1 times the prevalence of severe limitation, respectively, compared to those that did not have diabetes (Fig 5). The prevalence of severe functional limitation among participants who had thrombosis, heart disease, depression/anxiety and stroke was also twice that of those without those conditions. Prevalence of severe limitation increased steadily with increasing number of chronic conditions; compared to those with no chronic conditions, a prevalence ratio of 2.3 (95% CI 1.7–3.3) was observed among Aboriginal participants with one to two conditions; rising to 5.9 (95% CI 3.8–9.3) among those with seven or more conditions. Significant statistical interaction with Aboriginal status was found for the relationship between severe limitation and stroke ($P_{interaction} = 0.01$).

Differences in median MOS-PF score (S2 Table)

Differences in median MOS-PF score among Aboriginal and non-Aboriginal people according to socio-demographic factors, health behaviours, psychosocial factors and chronic disease and disability showed similar results to those from the prevalence ratios described above (S2 Table).

Discussion

The prevalence of severe limitation among middle-aged and older Aboriginal people in this study was approximately three times that of non-Aboriginal people, such that over one-quarter of Aboriginal participants had severe physical limitations. Among both Aboriginal and non-Aboriginal participants, severe limitation was associated with older age, socio-economic disadvantage, being a former or current smoker, obesity, sedentary behaviour (screen time and sitting time), poor self-rated health and quality of life, high psychological distress and fewer social contacts. Prevalence of severe limitation also increased steadily with increasing number of chronic conditions. Although Aboriginal people had a consistently higher absolute prevalence of severe limitation, in general the factors relating to severe limitation were similar for Aboriginal and non-Aboriginal participants. This suggests that Aboriginal people may not have differential vulnerability to physical functional limitations, but experience a higher prevalence of the factors that are related to higher levels of physical disability in the population as a whole.

The prevalence of severe limitations increased with age among both Aboriginal and non-Aboriginal participants. However, the gradient of increasing physical limitation with increasing age was less steep for Aboriginal compared to non-Aboriginal participants, both in relative and absolute terms. A contributing factor is likely to be the very high prevalence of severe limitation among younger Aboriginal participants compared to their non-Aboriginal counterparts, with 19% of Aboriginal participants aged 45–49 having severe limitations; this may reflect the premature morbidity and earlier onset of chronic conditions among Aboriginal people [20, 21]. It has previously been reported that 84% of Aboriginal people who access disability support services are less than 50 years of age [22]. Appropriate management of risk factors (social disadvantage, health risk factors) and chronic disease associated with severe limitation, as identified in the current study, at a younger age may avoid further age-related impairment among Aboriginal people.

In accordance with previous findings, socio-economic disadvantage (low levels of formal education, non-paid work status and low annual household income) were important correlates of severe limitation [4, 23]. Our study has shown that the relationship between socio-demographic factors and severe limitations to be very similar between Aboriginal and non-Aboriginal people, suggesting socio-economic disadvantage to be a common factor on the causal pathway to physical limitations, as well as being a consequence of physical limitation/disability. However, the proportion severely limited was consistently higher among Aboriginal people in each category. In particular, 47% of Aboriginal participants with a low annual household income (<$20,000) were severely limited compared to 29% of non-Aboriginal participants. This finding is in accordance to previous literature that has shown the strong relationship between social disadvantage and ill health among Aboriginal people [24, 25]. Among people in paid employment or looking after their home/family, a higher absolute proportion of Aboriginal people were severely limited compared to non-Aboriginal people (8% vs 3% and 20% vs 13%, respectively). This suggests that, despite physical limitations, Aboriginal people persist with work and home duties, suggestive of resilience to physical ailments.

The prevalence of severe limitation was significantly higher among both former and current smokers compared to never smokers, particularly for Aboriginal participants. Smoking is a

known risk factor for a number of chronic diseases and has previously been shown to be a significant contributor to the difference in the disability-adjusted life years between Aboriginal and non-Aboriginal people [21]. Although smoking rates in the general population have declined over recent years, 41% of Aboriginal people are still daily smokers [22] and 51% of Aboriginal people who responded as being severely disabled in a national survey have been daily smokers [26]. Therefore, the findings of this study further support existing efforts to reduce smoking among Aboriginal people, which is likely to be a key intervention for reducing the causes and consequences of disease and disability. Interestingly, the current study showed that both Aboriginal and non-Aboriginal participants who reported consuming more than 1 drink per week were less likely to have severe physical functional limitations compared to non-drinkers. This may be because those participants who suffer from poor physical health have been advised to abstain from alcohol; similar findings have been reported in previous health surveys whereby the prevalence of medium-to-high risk level drinking was lower among those with severe/profound disability compared to those with no disability [4].

The current study showed that prevalence of severe physical functional limitations increased with increasing BMI; importantly, we found a graded increase in the prevalence of severe limitation with increasing severity of obesity (class I–class III). Our findings are supported by a recent systematic review and meta-analysis that also demonstrated a graded increase in the risk of disability (limitations in activities of daily living) among overweight and obese relative to normal weight [27]. The strong association between obesity and chronic disease is also likely to be contributing to the relationship between obesity and physical functional limitations. The gradient of the relationship between severity of obesity and functional limitations was less steep among Aboriginal people; this may be due to the already high prevalence of functional limitations among those who were normal weight compared to their non-Aboriginal counterparts (21% vs 9%).

In agreement with previous reports [28–30], there was a significant association between prevalence and number of chronic diseases and severe physical functional limitations. It is important to note that baseline prevalence of severe limitation among Aboriginal people was high (20–25% among those that were not diagnosed with the specific medical condition) even though adjusted prevalence ratios for severe limitation were similar between Aboriginal and non-Aboriginal people. Furthermore, even among Aboriginal people who responded to having none of the conditions listed, 10 percent were still severely limited; double the prevalence among non-Aboriginal participants, which suggests an important contributory role of other factors and conditions.

The relationship between physical and psychological wellbeing has been explored in a number of recent studies [31–35]. In this study, there was a significant association between severe limitations and history of depression/anxiety and also a significant gradient in the prevalence of severe limitation among those with increasing levels of psychological distress in both Aboriginal and non-Aboriginal participants. Interestingly, a higher proportion of Aboriginal people who self-rated their health as excellent/very good were severely limited compared to non-Aboriginal people (7% vs. 3%) suggesting that Aboriginal people's perception of their health may include factors other than their physical state.

It has recently been reported that Australians with disabilities were less likely to belong to networks and to have social support [36]. In the current study, people with severe physical limitations had generally lower levels of social contact compared to those with fewer limitations, as measured by number of social contacts, visits to family and friends and membership of social groups. It should be noted that the Duke Social Support Scale used in the 45 and Up Study focuses on social contacts outside the home, which may not capture social support within the

household or family; such household and family support may be of greater importance to Aboriginal people.

This study has a number of strengths including the large population-based sample of Aboriginal people aged 45 years and older from New South Wales, which has the largest number of Aboriginal people in Australia. The MOS-PF scale is a well-validated tool that has been widely used in many population based studies and the cross-cultural validity of the whole Short Form-36 tool has also been assessed [37]. The current study further confirms that the uni-dimensional factor structure of the MOS-PF scale which was shown among both Aboriginal and non-Aboriginal people. To date, severe limitations have mainly been examined through the prevalence of chronic disease and disability; which does not clearly show the level of physical impairments among the population. Hence, use of the MOS-PF scale allows a more detailed examination of physical limitations among older adults.

There are also some limitations to this study which need to be acknowledged. The approximately 18% response rate for participation in the 45 and Up Study (which is in keeping with other studies of its kind) means there is likely to be a "healthy cohort effect" such that participants are likely to be healthier and less physically limited compared to the general population. However, this effect has been shown not to materially affect within-cohort comparisons, such as those presented here [38]. In this regard, high levels of severe limitation among these Aboriginal participants suggest that the true burden is likely to be even greater. Furthermore, given that the study was based on self-reported data, it is possible that the physical functional limitation score in Aboriginal and non-Aboriginal groups may have been affected by response style bias (socially desirable responding) [39] which has been shown to be more common among ethnic minorities [40] and therefore may have differed by Aboriginal status in the current study.The current analyses were based on the cross-sectional baseline survey data; therefore, temporal relationships between the risk factors and severe limitations could not be established. However, the longitudinal design of the overall 45 and Up Study will allow future analyses of temporal relationships and also an examination of the changes in physical functional limitations among study participants.

This study presents both absolute prevalence of severe physical functional limitation–to demonstrate absolute differences across various factors and between Aboriginal and non-Aboriginal participants–and prevalence ratios, to illustrate relative differences. In addition, effect modification with Aboriginal status on the relationships of factors with physical limitations has also been assessed. Therefore, it is important that all three measures are considered in interpreting the relationships of factors with physical impairment among Aboriginal and non-Aboriginal people. Due to the very high absolute prevalence of severe limitations among the Aboriginal participants, potential ceiling effects limit the magnitude of the prevalence ratios in Aboriginal participants to a greater extent than non-Aboriginal participants. For example, if the prevalence of severe limitation is 20% in the non-exposed group, it is not possible to have relative risks above 5. Similarly, when baseline prevalence is high, prevalence ratios may not appear particularly dramatic but absolute differences can be large. For example, for both Aboriginal and non-Aboriginal participants, those aged 60–69 years have around double the prevalence of severe physical limitations of those aged 45–49 years. However, the absolute difference between these groups is around 15% (19% vs 34%) in Aboriginal participants and 7% (5% vs 12%) in non-Aboriginal participants.

In terms of the relationship between functional limitations and chronic disease, conditions that participants selected from a list on the questionnaire were used in this study; this means that common conditions were captured, but other less common conditions that were listed as free text by participants were not included. Finally, this study focuses on the more proximal "upstream" factors relating to disability and functional limitations, including poverty, illness,

and health behaviours. It does not capture the broader societal and cultural determinants of these factors, such as colonisation and its related consequences including disempowerment, racism and discrimination.

Conclusions

Aboriginal people in the 45 and Up Study have a significantly greater burden from physical functional limitations compared to non-Aboriginal people. The relationships of socio-economic, health and psychosocial factors to severe limitation among Aboriginal and non-Aboriginal people were very similar. Taken together, these indicate that Aboriginal people have greater levels of risk factors for and consequences of severe physical limitation, and these occur at younger ages. The major role of ill health in disability highlights the importance of continuing efforts in chronic disease management and the need to address the smoking and obesity epidemics.

Supporting Information

S1 Table. Loading of the 10 items of the MOS-PF on the single factor retained by the exploratory factor analysis among Aboriginal and non-Aboriginal participants.
(DOCX)

S2 Table. Mean and median MOS-PF score in Aboriginal and non-Aboriginal participants stratified by groups according to socio-demographic factors, health behaviours, psychosocial factors and chronic diseases.
(DOCX)

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Author Contributions

Conceived and designed the experiments: LG EB SJE AB. Analyzed the data: LG BM RM. Wrote the paper: LG EB RM BM GJ SJE AB. Acquisition of data: EB AB.

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Appendix 3

Thursday Island Running Festival Questionnaire, 2016

Sign here if you consent……..

RUNNING EVALUATION SURVEY

Complete for a chance to win a prize!

BIB NUMBER _____

1. TRIF 2016 Event 1k ❑ 5k ❑ 10k ❑ 21.1k ❑ none ❑
2. Age ____ years
3. Male ❑ Female ❑
4. Language at home: ❑ English ❑ Other: _____
5. Where do you live? ❑ Thursday Island ❑ Other: _____
6. Are you Torres Strait Islander or Aboriginal? Yes ❑ No ❑

7. Have you heard of the Indigenous Marathon Program (IMP)? Yes ❑ No ❑ Not sure ❑

8. What activities have you participated in during the last year?

❑ TI DEADLY RUNNERS
❑ ***2015*** THURSDAY ISLAND RUNNING FESTIVAL
❑ IMP DEADLY FUN RUN SERIES
❑ TEAM SPORTS e.g. RUGBY, BASKETBALL
❑ PERSONAL EXERCISE e.g.WALK/RUN WITH FRIEND
❑ OTHER RUNNING EVENTS e.g. HORN HALF

9. Compared to 1 year ago, are you running (or walking):

MUCH MORE❑ MORE ❑ ABOUT THE SAME ❑ LESS ❑ MUCH LESS ❑

10. Why do you run/walk?

❑ FITNESS
❑ MENTAL WELL-BEING
❑ HEALTH PROBLEMS
❑ SENSE OF COMMUNITY
❑ WEIGHT CONTROL
❑ FUN

11. Who inspires you to run/walk?

IMP RUNNERS ❑ DEADLY RUNNERS ❑ FAMILY ❑ FRIENDS ❑
(Elsie, Harold, Alicia, Saliman)

12. There are lots of adults in my community who run regularly:

Strongly disagree ❑ Disagree ❑ Neutral ❑ Agree ❑ Strongly agree ❑

13. Running has become more popular in my community in the past 3 years:

Strongly disagree ❑ Disagree ❑ Neutral ❑ Agree ❑ Strongly agree ❑

14. IMP has had an impact on my community:

Strongly disagree ❑ Disagree ❑ Neutral ❑ Agree ❑ Strongly agree ❑

15. Overall, how would you rate your health during the <u>past 4 weeks</u>?

EXCELLENT ❑ VERY GOOD ❑ GOOD ❑ FAIR ❑ POOR ❑ VERY POOR ❑

16. What is your highest level of education?

Below year 10 ❑ Year 10 ❑ Year 12 ❑ TAFE certificate or diploma ❑ University ❑

Appendix 4

Thursday Island Deadly Runners Questionnaire, 2016

RUNNING EVALUATION SURVEY

This survey is about your running and health. It will take 15-20 minutes and your responses are confidential

1. Age ____ years Name_____
2. Male ❑ Female ❑
3. Language at home: ❑ English ❑ Other: _____
4. Where do you live? ❑ Thursday Island ❑ Other: _____
5. Are you Torres Strait Islander or Aboriginal? Yes ❑ No ❑

6. How long have you been a Deadly Runner?
   LESS THAN 2 MONTHS ❑ 2-6 MONTHS ❑ 6 -12 MONTHS ❑ OVER 1 YEAR ❑

7. What activities have you participated in during the last year?

❑ TI DEADLY RUNNERS ❑ THURSDAY ISLAND RUNNING FESTIVAL

❑ IMP DEADLY FUN RUN SERIES ❑ TEAM SPORTS e.g. RUGBY, BASKETBALL

❑ PERSONAL EXERCISE e.g.WALK/RUN WITH FRIEND ❑ OTHER RUNNING EVENTS e.g. HORN HALF

8. How many TIMES did you do each of these activities LAST WEEK?

Walking continuously, for at least 10 minutes
(for recreation or exercise or to get to or from places) _____ times

Vigorous physical activity
(that made you breathe harder or puff and pant, like jogging, cycling, aerobics, competitive tennis, but not household chores or gardening _____ times

Moderate physical activity
(like gentle swimming, social tennis, vigorous gardening or work around the house) _____ times

9. If you add up all the time you spent doing each activity LAST WEEK, how much time did you spend ALTOGETHER doing each type of activity?

Walking continuously, for at least 10 minutes
(for recreation or exercise or to get to or from places) _____ hours _____ mins

Vigorous physical activity
(that made you breathe harder or puff and pant, like jogging, cycling, aerobics, competitive tennis, but not household chores or gardening _____ hours _____ mins

Moderate physical activity
(like gentle swimming, social tennis, vigorous gardening or work around the house) _____ hours _____ mins

10. There are lots of adults in my community who run regularly:

Strongly disagree ❑ Disagree ❑ Neutral ❑ Agree ❑ Strongly agree ❑

11. Compared to 12 months ago, are you running:

MUCH MORE❑ MORE ❑ ABOUT THE SAME ❑ LESS ❑ MUCH LESS ❑

12. Who inspires you to run/walk?
IMP RUNNERS ❑ DEADLY RUNNERS ❑ FAMILY ❑ FRIENDS ❑

SURVEY # ____

RUNNING EVALUATION SURVEY

For Deadly Runners: Compared to before I joined Deadly Runners					
13. I am eating **vegetables:**					
MUCH MORE❑	MORE ❑	ABOUT THE SAME ❑	LESS ❑	MUCH LESS ❑	
14. I am eating **fruit:**					
MUCH MORE❑	MORE ❑	ABOUT THE SAME ❑	LESS ❑	MUCH LESS ❑	
15. I am eating meals or snacks such as burgers, pizza, chicken or chips from take-away places:					
MUCH MORE❑	MORE ❑	ABOUT THE SAME ❑	LESS ❑	MUCH LESS ❑	
16. I am drinking soft drink, cordials or sports drink, (eg Coke, Gatorade):					
MUCH MORE❑	MORE ❑	ABOUT THE SAME ❑	LESS ❑	MUCH LESS ❑	
17. I am drinking alcohol:					
MUCH MORE❑	MORE ❑	ABOUT THE SAME ❑	LESS ❑	MUCH LESS ❑	N/A ❑
18. I am smoking:					
MUCH MORE❑	MORE ❑	ABOUT THE SAME ❑	LESS ❑	MUCH LESS ❑	N/A ❑

RUNNING EVALUATION SURVEY

For EVERYONE:

19.	How many cups of **vegetables** do you usually eat each day?	0	1	2	3	4	5	More
20.	How many cups of **fruit** do you usually eat each day?	0	1	2	3	4	5	More

21. How often do you have meals or snacks such as burgers, pizza, chicken or chips from take-away places?

_____ **times per week** _____ **times per month**

22. How many cups of soft drink, cordials or sports drink, (eg Coke, Gatorade), do you usually drink in a day/week? 1 cup=250ml. One can of soft drink = 1.5 cups. One 500ml bottle of Gatorade = 2 cups

____**Cups per day** ____**Cups per week** **Don't drink soft drink** ❑

23. Do you currently smoke at least once a day? **Yes** ❑ **No** ❑

If YES, how many times do you smoke on a usual day? _____ times

24. How many days a week do you usually drink alcohol? (circle one)

0 1 2 3 4 5 6 7

25. On a day when you drink alcohol, how many drinks do you usually have? (circle one)

0 1 2 3 4 5 6 7

26. Please indicate how you have been feeling over the last two weeks.

Over the last two weeks……	All of the time	Most of the time	More than ½ of the time	Less than ½ of the time	Some of the time	At no Time
I have felt cheerful and in good spirits	❑ 5	❑ 4	❑ 3	❑ 2	❑ 1	❑ 0
I have felt calm and relaxed	❑ 5	❑ 4	❑ 3	❑ 2	❑ 1	❑ 0
I have felt active and vigorous	❑ 5	❑ 4	❑ 3	❑ 2	❑ 1	❑ 0
I woke up feeling fresh and rested	❑ 5	❑ 4	❑ 3	❑ 2	❑ 1	❑ 0
My daily life has been filled with things that interest me	❑ 5	❑ 4	❑ 3	❑ 2	❑ 1	❑ 0

27. Overall, how would you rate your health during the past 4 weeks?

EXCELLENT ❑ VERY GOOD ❑ GOOD ❑ FAIR ❑ POOR ❑ VERY POOR ❑

28. What is your highest level of education?

Below year 10 ❑ Year 10 ❑ Year 12 ❑ TAFE certificate or diploma ❑ University ❑

29. Height _____ centimetres

30. Weight _____ kilograms

Thank you!

SURVEY # ____

Appendix 5

Chapter 4 Many Rivers community results flyer

Many Rivers

Diabetes Prevention Project

The Many Rivers Diabetes Prevention Project (MRDPP) delivered health promotion strategies on healthy food, physical activity and diabetes knowledge to Aboriginal and non-Aboriginal rural children between 2008-2010. We then evaluated these strategies.

1620 children (251 were Aboriginal children) took part in the 1st survey, and 1035 (240 were Aboriginal children) took part in the second survey.

This flyer describes the physical activity results.

The MRDPP project also undertook a number of other studies – see the time line below.

We set up an Aboriginal community governance structure including community reference groups and a steering committee, and employed a lot of local people.

This project was a partnership between Biripi ACMS, Durri ACMS (from the Mid-North Coast at NSW) and The University of Newcastle. The MRDPP began in 2002 when Mr Steve Blunden, then CEO at Durri ACMS, asked for a research and education program which would help to prevent children from developing diabetes later in life.

Physical Activity Health Promotion Strategies:

Supporting Physical Activity

Traditional Indigenous Games

Midnight Basketball (Taree only)

Mapping of Local Food & Activity Venues

As one of only 4 studies like this in Australia, the MRDPP has provided information about rural children's healthy eating and physical activity.

STRATEGIC PROJECT PHASES:

2002

Consultation, development & funding

2005

Survey development and describing nutrition and physical activity

2007

MRDPP Community Consultations on Barriers / Enablers

Health Promotion Strategies delivered and evaluated

2012

Data Analysis, Report Writing and Results Dissemination

2016

What the community said ...

128 people (55% were Aboriginal people) from the Mid-North Coast and the Hunter Region of NSW took part in Focus Groups.

Barriers to children's physical activity:

- few sporting facilities
- the high cost of participating in organised sport
- lack/cost of private transport
- poor public transport
- and concerns around the safety of community play areas for children.

Enablers of children's physical activity:

- engaging Aboriginal people in local programs
- assisting parents to support their children to be more active
- increasing the availability and accessibility of physical activity facilities in rural areas.

For more detailed information about the results of the MRDPP project please contact:

Josephine Gwynn
043117 2883

What we found ...

after the strategies were delivered:

1. All children need to increase their physical activity levels
2. Non-Aboriginal children increased their physical activity at school and on weekends (but only during summer)
3. Aboriginal children decreased their physical activity in winter. There was no change in physical activity levels during summer or at weekends
4. Aboriginal children were more active in the summer than in the winter.
5. We still need to find the best ways to support Aboriginal children to be more active.

The following may have influenced our results.

The MRDPP spent less time on the physical activity strategies than healthy food or diabetes knowledge strategies.

Also, there were lots of programs on physical activity conducted across NSW at the same time as the Many Rivers project.

Grants from the National Health and Medical Research Council of Australia and the Ministry of Health New South Wales Centre for Aboriginal Health supported this study.

THE UNIVERSITY OF NEWCASTLE AUSTRALIA

Centre for Rural & Remote Mental Health

THE UNIVERSITY OF SYDNEY

WE ACKNOWLEDGE THE TRADITIONAL OWNERS OF THE LANDS ON WHICH THIS PROGRAM OF RESEARCH AND HEALTH PROMOTION WAS CONDUCTED, THE BIRIPI AND DUNGHUTTI PEOPLES AND THEIR ELDERS PAST AND PRESENT. WE THANK THEM FOR THEIR GUIDANCE AND SUPPORT AND FOR ALLOWING THE MANY RIVERS PROJECT TO BE CARRIED OUT ON THEIR LAND.