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Physical activity and risk of behavioural and mental health disorders in Kindergarten children: analysis of a series of cross-sectional complete enumeration surveys

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Article title

Physical activity and risk of behavioural and mental health disorders in Kindergarten children:
analysis of a series of cross-sectional complete enumeration surveys

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ABSTRACT

Objectives There is mixed evidence on the relationship between exercise and mental health. We aimed to estimate the association between physical activity and risk of behavioural and mental health disorders in early childhood.

Design A series of cross-sectional complete enumeration surveys.

Settings All public and private primary schools in the Australian Capital Territory (ACT), 2014 to 2016.

Participants Of the 16,662 children enrolled in their first year of primary education in the ACT in 2014-2016, 15,040 completed the survey for the first time.

Outcome measures Demographic characteristics, physical activity participation, risk of behavioural and mental health disorders as measured using the Strengths and Difficulties Questionnaire (SDQ).

Results 15,040 children completed the survey for the first time in 2014–2016. 8,340 (61.7%) children met physical activity targets and 709 (4.8%) were at clinically significant risk of behavioural and mental health disorders.

Predictors for risk of behavioural and mental health disorders (*Total difficulties*) were Aboriginal and Torres Strait Islander status (OR 2.72, 95% CI 1.78-4.16), relative socioeconomic disadvantage (most disadvantaged versus least disadvantaged, OR 1.86, 95% CI 1.38-2.50), and male sex (OR 1.80, 95% CI 1.49-2.17). Average daily exercise was not significant, despite the highest levels of physical activity being reported in boys, Aboriginal and Torres Strait Islander children, and those from more disadvantaged areas.

Male sex was associated with increased risk of conduct problems, hyperactivity & inattention, peer problems and prosocial behaviour difficulties. Aboriginal and Torres Strait Islander children were at increased risk of emotional difficulties, conduct problems, and hyperactivity & inattention.

Conclusions Aboriginal and Torres Strait Islander children, boys, and those from the most disadvantaged socioeconomic group were at greatest risk of clinically significant mental health problems, despite having the highest levels of reported physical activity.

ARTICLE SUMMARY

- Studies exploring the relationship between physical activity and mental health in children have returned mixed results.
- Australian data have found that less than half of primary school-aged children are meeting exercise targets.
- The burden of behavioural and mental health disorders is increasing.

Strengths and limitations of this study

- **Strengths:** The Kindergarten Health Check has been conducted for several years, and has excellent response rates, providing a large sample for analysis. It includes well-validated questions including the SDQ and measured anthropometric data.
- **Limitations:** The KHC is a series of cross-sectional surveys so we can demonstrate relationships between variables, but inference cannot be made about causality.

INTRODUCTION

Physical inactivity is associated with many potentially preventable chronic diseases[1] and childhood is a key time for increasing participation in exercise.[2] The benefits of exercise start in childhood with protective effects on cardiovascular and metabolic health.[3] The importance of exercise has been emphasised in the Australian Capital Territory (ACT) through activity targets for primary school children as part of the government's *Healthy Weight Initiatives*. [4]

The evidence on the association between physical activity and mental wellbeing in young children is mixed. Several studies have associated physical activity participation with lower rates of depression and anxiety, and improved self-esteem.[5-8] A study of Australian children aged 10-16 years, found 60 minutes or more of moderate to vigorous activity on at least five days per week was associated with lower odds for depressive symptoms.[9] However, contradictory results have been found and there is a paucity of information for younger children.[5,6,9] In their systematic review of early childhood physical activity and psychosocial wellbeing, Hinkley et al.[8] found supportive, null and even adverse associations between physical activity and a range of psychosocial wellbeing outcomes. Nevertheless, physical activity may have a role in mitigating the increasing burden of mental health disorders in children. Anxiety, autism spectrum disorder, conduct disorder, and depressive disorders ranked among the six largest contributors to the burden of disease for Australian boys and girls aged 5-14 years in 2011.[1] The 2013-14 *Australian Child and Adolescent Survey of Mental Health and Wellbeing (Young Minds Matter)* survey reported a mental disorder in 14% of boys and 7% of girls in Kindergarten or pre-primary.[10]

Despite the importance of physical activity, few children are meeting recommended targets. Australian primary school-aged children are advised to get at least 60 minutes of exercise daily.[11] The 2011-12 Australian Health Survey found 36% of children aged 5-8 years met the recommended 60 minutes or more of physical activity on all seven days prior to interview, with a further 34% meeting this target on 5-6 of the preceding seven days.[12] The ACT General Health Survey found 44% of children aged 5-12 years were active for at least 60 minutes each day in 2015-2016.[13]

We know that fewer than half of young Australian children meet physical activity targets, including primary school-aged children in the ACT. It is also well known that sociodemographic characteristics play an important part in health and wellbeing. However, we lack information about children in early childhood, how their exercise levels may relate to risk of mental and behavioural health outcomes, and how sociodemographic factors may influence these for young children in the ACT.

The ACT Kindergarten Health Check (KHC) is offered to all children in the ACT in their first year of primary school and collects information on risk of mental health and behavioural disorders and physical activity. Our study aimed to estimate the association between physical activity and risk of mental health and behavioural disorders and how this may differ for Aboriginal and Torres Strait Islander children, and those from different socioeconomic backgrounds.

METHODS

The KHC is an annual cross-sectional survey of all children in the ACT in their first year of full-time primary education (Kindergarten). It consists of a questionnaire completed by parents at the start of the school year, and a physical health check performed by the School Health Nurses. Our study analyses data from the 2014 to 2016 surveys. Children who were identified as repeating Kindergarten within the ACT were excluded from the analysis for their second year. The data collection and consent process has been granted ethics approval through the ACT Health Human

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3 Research Ethics Committee (ETHLR.13.316). Ethics approval for our study was granted by the ACT
4 Health Human Research Ethics Committee's Low Risk Sub-Committee (ETHLR.17.080).

5
6 The KHC collects demographic data and information on selected conditions and behaviours. Parents
7 were asked to report on their child's physical activity outside of school hours in terms of the number
8 of school days and hours/minutes of activity on these days, and similar for weekend days. These
9 were combined to determine the average daily activity of children and were assessed against the
10 Physical Activity Guidelines for Australian children.

11
12
13 The parent-completed questionnaire includes the Strengths and Difficulties Questionnaire (SDQ).
14 The SDQ contains 25 questions asking parents to assess their child's behaviour and psychological
15 traits over the previous six months. It is a well-validated behavioural screening questionnaire for
16 children, adapted for use in Australia from the original developed by Goodman[14]. The questions
17 ask about positive and negative attributes which are used to calculate scores for emotional
18 difficulties, conduct problems, hyperactivity & inattention, peer relationship problems, and prosocial
19 behaviour. A *Total difficulties* score is calculated from all subscales except prosocial behaviour.
20 Children are scored as close to average, slightly raised, and high risk.

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22
23 The physical health check includes measurement of height and weight by School Health Nurses.
24 Body mass index was calculated and classified into weight categories based on age- and sex-specific
25 cutoffs.[15] Health concerns from either the questionnaire or health screen are communicated to
26 the child's primary carer and nominated general practitioner.

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28
29 We linked the KHC with an indicator of socioeconomic disadvantage—the 2016 Index of Relative
30 Socio-Economic Disadvantage (IRSD), one of the Socio-Economic Indexes for Areas (SEIFA) produced
31 by the Australian Bureau of Statistics (ABS).[16] IRSD was mapped to geocoded home addresses at
32 the finest geographic level available, the Statistical Area Level 1 (SA1). We created quintiles of
33 socioeconomic disadvantage for the ACT by ranking the IRSD scores for ACT SA1 regions and dividing
34 them into five equal cohorts. These quintiles are specific to the ACT, and differ from those based on
35 the national profile. The ACT is relatively advantaged compared to the national average, with 78% of
36 the ACT in the least disadvantaged quintile based on the national IRSD profile.[16]

37 38 39 **Statistical analysis**

40
41 Our analysis comprised producing unweighted prevalence estimates and logistic regression analysis.
42 Confidence intervals for prevalence estimates were calculated using binomial sampling. Logistic
43 regression was performed with dependent variable *Total difficulties* (high versus slightly
44 raised/average risk) and independent variables sex, Aboriginal and Torres Strait Islander status,
45 relative socioeconomic disadvantage, total daily exercise (minutes), body mass index, and age
46 (months). Average daily exercise was skewed, so the cube root transformation was used. Analysis
47 was also run with SDQ subscales as the dependent variable.

48
49
50 Analysis was conducted in SPSS Version 24. Missing data were excluded from the analysis.

51 52 **RESULTS**

53
54 Of the 16,662 children enrolled in Kindergarten in ACT schools during the study period, 15,146
55 (90.9%) participated in the KHC. Data for 106 children who were identified as repeating Kindergarten
56 within the ACT were excluded from the analysis for their second year of participation. Of the
57 remaining 15,040 children, 94.0% participated in the health screen (Figure 1). Overall, 14,136 (84.8%
58 of enrolled children) participated in the KHC parent-completed questionnaire and physical health
59 check for the first time.
60

Baseline characteristics of study participants are shown in Table 1. Over 75% of children were of a healthy weight with 3.6% in the obese weight range and 6.0% considered underweight. Nearly two-thirds (61.7%) met physical activity targets of 60 minutes or more on average daily, however 13% averaged less than 30 minutes daily. Five per cent of children had a high risk *Total difficulties* score; that is, they were at significantly increased risk of clinically significant mental health and behavioural problems. Analysis of the SDQ subscales showed that a higher proportion of children had high risk scores for hyperactivity & inattention than for the other domains, and peer problems was the domain with the lowest proportion of high risk scores.

Table 1: Characteristics of children in the Kindergarten Health Check, 2014–2016

Characteristic		Number	Per cent (95% CI)
Mean (SD) age on commencement (years)		5.27 (0.31)	
Age at 30 April of enrolment year	< 5 years	91	0.6 (0.5-0.7)
	5 to <6 years	13,947	92.7 (92.3-93.1)
	6 years or more	1,002	6.7 (6.3-7.1)
Sex	Male	7,754	51.6 (50.8-52.4)
	Female	7,286	48.4 (47.6-49.2)
Indigenous status ^(a)	Aboriginal or Torres Strait Islander	348	2.3 (2.1-2.6)
	Not Aboriginal or Torres Strait Islander	14,649	97.7 (97.4-97.9)
Socioeconomic status ^(b)	Most disadvantaged (Q1)	2,676	18.5 (17.9-19.2)
	Q2	2,915	20.2 (19.5-20.8)
	Q3	3,166	21.9 (21.2-22.6)
	Q4	2,881	19.9 (19.3-20.6)
	Least disadvantaged (Q5)	2,805	19.4 (18.8-20.1)
School sector	Government school	9,773	65.0 (64.2-65.7)
	Non-government school	5,267	35.0 (34.3-35.8)
Body mass index ^(c)	Underweight	851	6.0 (5.6-6.4)
	Healthy weight	11,023	78.1 (77.4-78.7)
	Overweight	1,736	12.3 (11.8-12.8)
	Obese	511	3.6 (3.3-3.9)
Mean (SD) daily physical activity participation (minutes) ^(d)		85.6 (66.51)	
Average daily physical activity participation ^(d)	< 30 minutes	1,782	13.2 (12.6-13.8)
	30 to <60 minutes	3,382	25.0 (24.3-25.8)
	60 to <90 minutes	3,392	25.1 (24.4-25.8)
	≥ 90 minutes	4,948	36.6 (35.8-37.8)
Strengths and Difficulties Questionnaire high risk subscale scores ^(e)	Emotional difficulties	915	6.1 (5.8-6.5)
	Conduct problems	1,019	6.8 (6.4-7.3)
	Hyperactivity & inattention	1,232	8.3 (7.8-8.7)
	Peer problems	101	0.7 (0.5-0.8)
	<i>Total difficulties</i>	709	4.8 (4.4-5.1)
	Prosocial	421	2.8 (2.6-3.1)
All children		15,040	100.0

Notes:

(a) Excludes children for whom Indigenous status was not available.

(b) Socioeconomic status based on ACT quintiles of relative disadvantage from IRSD at SA1 level. Excludes children for whom socioeconomic status was not available.

(c) Excludes those for whom body mass index not available.

(d) Excludes those for whom physical activity participation not available.

(e) Each category excludes those children for which the reported measure is not available.

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3 Figure 2 shows that children meeting exercise target of 60 minutes or more daily were more likely to
4 be of Aboriginal and Torres Strait Islander origin, or boys. Children who were underweight were less
5 likely than other children to exercise for 60 minutes or more daily. Aboriginal and Torres Strait
6 Islander children had the highest level of reported activity, with half averaging 90 minutes a day or
7 more.
8
9

10 The attributes of children with high risk *Total difficulties* scores is shown in Table 2. These children
11 were more likely to be boys, of Aboriginal and Torres Strait Islander origin, or from the most
12 disadvantaged socioeconomic groups. No increase in risk was seen based on average daily physical
13 activity (Figure 2).
14

15 Boys were more likely than girls to be rated high risk for conduct problems, hyperactivity &
16 inattention, and prosocial behaviour difficulties (Table 2). Very few children (<1%) were rated high
17 risk for peer problems. Aboriginal and Torres Strait Islander children were more likely than other
18 children to be rated high risk for all subscales excluding peer problems. Children in the most
19 disadvantaged two quintiles were more likely to be at high risk for emotional difficulties, conduct
20 problems and hyperactivity & inattention.
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23 Of the 15,040 children in the study, 12,097 (80.4%) were included in the main logistic regression
24 model (Table 3). Aboriginal and Torres Strait Islander background was the strongest predictor of
25 being at substantial risk of clinically significant problems (OR 2.73, 95% CI 1.79–4.17). Being from the
26 most disadvantaged socioeconomic quintile was the next highest predictor of risk (OR 1.87, 95% CI
27 1.39–2.51). The risk of significant problems decreased with relative socioeconomic disadvantage,
28 however the odds ratios were significantly different for the two most disadvantaged quintiles (Table
29 3). Boys were more likely to be at high risk than girls (OR 1.78, 95% CI 1.48–2.15). Age at enrolment
30 was weakly significant with a small impact on risk. Total daily exercise and body mass index were not
31 significant predictors in the model.
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34 Logistic regression was also undertaken for the SDQ subscales (Table 3). Odds ratios were significant
35 for boys for all domains other than emotional difficulties. Aboriginal and Torres Strait Islander
36 children were at increased risk for emotional difficulties, conduct problems, and hyperactivity &
37 inattention, however they were not at increased risk for peer problems or prosocial behaviour
38 difficulties. Being from the most disadvantaged socioeconomic quintile was associated with
39 increased odds of conduct problems and hyperactivity & inattention. Physical activity was associated
40 with lower odds of peer problems and prosocial behaviour difficulties.
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Table 2: Characteristics of children rated high risk for strengths and difficulties subscales, 2014–2016

SDQ Subscale ^(e)	Sex		Indigenous status ^(a)		Socioeconomic status ^(b)					Body mass index ^(c)			
	Male	Female	Aboriginal or Torres Strait Islander	Not Indigenous	Q1	Q2	Q3	Q4	Q5	Under- weight	Healthy weight	Over- weight	Obese
	number (per cent)												
Total difficulties	471 (6.1)	238 (3.3)	43 (12.5)	663 (4.6)	179 (6.8)	165 (5.7)	132 (4.2)	130 (4.6)	87 (3.1)	35 (4.2)	495 (4.5)	79 (4.6)	41 (8.1)
Emotional difficulties	473 (6.2)	442 (6.1)	41 (11.9)	871 (6.0)	204 (7.7)	196 (6.8)	177 (5.6)	153 (5.4)	158 (5.7)	52 (6.2)	662 (6.1)	100 (5.8)	53 (10.5)
Conduct problems	626 (8.2)	393 (5.5)	42 (12.2)	976 (6.7)	234 (8.8)	228 (7.9)	198 (6.3)	172 (6.0)	157 (5.6)	35 (4.2)	726 (6.6)	135 (7.8)	40 (7.9)
Hyperactivity & inattention	827 (10.8)	405 (5.6)	59 (17.2)	1,167 (8.1)	275 (10.4)	276 (9.6)	219 (7.0)	217 (7.6)	203 (7.3)	57 (6.8)	880 (8.1)	145 (8.4)	52 (10.3)
Peer problems	77 (1.0)	24 (0.3)	n.p.	n.p.	22 (0.8)	21 (0.7)	20 (0.6)	22 (0.8)	13 (0.5)	10 (1.2)	59 (0.5)	16 (0.9)	6 (1.2)
Prosocial	296 (3.9)	125 (1.7)	15 (4.4)	405 (2.8)	80 (3.0)	73 (2.5)	95 (3.0)	90 (3.1)	68 (2.4)	26 (3.1)	299 (2.7)	44 (2.5)	17 (3.4)

n.p. not published due to small cell size

Notes:

(a) Excludes children for whom Indigenous status was not available.

(b) Socioeconomic status based on ACT quintiles of relative disadvantage from IRSD at SA1 level. Excludes children for whom socioeconomic status was not available.

(c) Excludes those for whom body mass index not available.

(e) Each category excludes those children for which the reported measure is not available.

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Table 3: Odds ratios from logistic regression analyses

SDQ Subscale ^(b)	Logistic regression independent variables ^(a)							
	Sex	Indigenous status	Socio-economic status ^(c) Q1	Physical activity	Underweight ^(d)	Overweight ^(d)	Obese ^(d)	Age
	Odds Ratio (95% CI)							
<i>Total difficulties</i>	1.80 (1.49-2.17)	2.72 (1.78-4.16)	1.86 (1.38-2.50)	n.s.	n.s.	n.s.	1.86 (1.27-2.72)	1.03 (1.00-1.05)
Emotional difficulties	n.s.	1.98 (1.30-3.01)	n.s.	n.s.	n.s.	n.s.	1.78 (1.28-2.47)	1.03 (1.01-1.06)
Conduct problems	1.57 (1.35-1.82)	1.66 (1.09-2.54)	1.48 (1.17-1.87)	n.s.	0.58 (0.39-0.85)	1.29 (1.05, 1.59)	n.s.	n.s.
Hyperactivity & inattention	2.02 (1.75-2.33)	1.85 (1.26-2.72)	1.35 (1.09-1.67)	n.s.	n.s.	n.s.	1.41 (1.02-1.94)	n.s.
Peer problems	2.73 (1.61-4.64)	n.s.	n.s.	0.78 (0.62-0.98)	2.42 (1.18-4.98)	1.90 (1.02-3.52)	n.s.	n.s.
Prosocial	2.49 (1.94-3.19)	n.s.	n.s.	0.78 (0.70-0.87)	n.s.	n.s.	n.s.	n.s.

n.s. not significant at p=0.05.

(a) Reference categories: girls, non-Indigenous, Q5 - least disadvantaged, healthy weight (BMI); physical activity and age are continuous.

(b) Each category excludes those children for which the reported measure is not available.

(c) Socioeconomic status based on ACT quintiles of relative disadvantage from IRSD at SA1 level. Q1 – most disadvantaged; Q5 – least disadvantaged. Q2-Q5 not shown. Q2 significant for *Total difficulties*, conduct problems, and hyperactivity & inattention.

(d) Based on BMI.

DISCUSSION

Nearly two-thirds of ACT Kindergarten children were meeting physical activity targets. These children were more likely to be boys, of Aboriginal or Torres Strait Islander background, or from the most disadvantaged socioeconomic areas.

The groups of children with higher daily exercise also had a higher risk of behavioural and mental health disorders, with boys having double the rate of high risk *Total difficulties* scores as girls (6.1% vs 3.3%). Aboriginal and Torres Strait Islander children had more than double the proportion compared to non-Indigenous children (12.5% versus 4.6%), and children from the most disadvantaged socioeconomic group also over-represented. Children who were obese were more likely to have high risk *Total difficulties* score, but there was no significant difference in their physical activity participation compared to other children.

Boys were more likely to be at high risk for conduct problems, hyperactivity & inattention, peer problems, and prosocial behaviour difficulties. They were equally likely as girls to be high risk for emotional problems.

Children of Aboriginal and Torres Strait Islander background and children with relative socioeconomic disadvantage were more likely to be at high risk for emotional problems, conduct problems, and hyperactivity & inattention.

We did not demonstrate an association between exercise and high risk *Total difficulties* score, despite research linking physical activity participation with reduced depressive symptoms. Our study considered all physical activity together and it may be that different forms of physical activity provide different benefits. For example, Eime et al.[7] propose that participation in sport may have psychological benefits beyond that from other forms of exercise. We did find that increased exercise participation was associated with lower odds of peer problems and prosocial behaviour difficulties. In their systematic review, Hinkley et al.[8] found supportive associations between physical activity with conduct problems, emotional competence, emotional symptoms, hyperactivity/inattention and peer relationships, but conversely found studies with adverse associations between physical activity with conduct problems and hyperactivity/inattention. Many more had no significant associations.

The ratio of boys to girls at high risk for *Total difficulties* is consistent with findings from *Young Minds Matter*, however our estimates are lower than their reported prevalence of mental health disorders (13.6% of boys and 7.1% of girls).[10] Two factors that may explain the difference are the survey scope and survey tools used. The KHC surveys children attending schools in the ACT only, and uses the SDQ to assign risk of mental health disorders. *Young Minds Matter* assessed children across Australia and used the Diagnostic Interview Schedule for Children Version IV to identify mental health disorders.[10]

Boys were at higher risk than girls for all subscales of the SDQ other than emotional difficulties. Boys in Kindergarten or pre-primary in *Young Minds Matter* had a higher prevalence of all and different types of mental disorders, compared to girls of the same age.[10] Among primary school-aged children they found a higher prevalence of anxiety disorders, ADHD and conduct disorders for boys, and a higher prevalence of major depressive disorder for girls. However, for high school-aged children, males had higher rates of ADHD and conduct disorders, but females had a greater prevalence of major depressive disorder and anxiety disorders. The 2017-18 National Health Survey found that amongst adults, females report higher rates of psychological distress than men.[17] This begs the question as to whether risks and prevalence of behavioural and mental health disorders are

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3 becoming more common for males, whether males are more vulnerable only in the younger age
4 groups, or whether risk varies for different conditions.
5

6 Aboriginal and Torres Strait Islander children in our study had the highest reported levels of physical
7 activity. Despite the potential benefits of physical activity, these children also had the highest levels
8 of risk for behavioural and mental health disorders overall (*Total difficulties*), emotional difficulties,
9 conduct problems, and hyperactivity & inattention. Aboriginal and Torres Strait Islander children
10 have been shown elsewhere to have higher SDQ scores than the Australian average.[18] High risk of
11 mental illness has been reprimed elsewhere and has in part been attributed to the impacts of
12 intergenerational trauma.[19] It is well known that Aboriginal and Torres Strait Islanders have poorer
13 health outcomes than other Australians, and these data have been extensively reported
14 elsewhere.[20]
15

16
17 Despite the ACT being a fairly homogenous jurisdiction with respect to socioeconomic advantage,
18 degrees of relative disadvantage were found in our study. Children from the two most
19 disadvantaged quintiles were significantly more likely to be at high risk of behavioural and mental
20 health disorders than those from less disadvantaged areas. The relationship between lower
21 socioeconomic status and poorer health outcomes has been seen in numerous settings. The World
22 Health Organization's report *Closing the gap in a generation* presents comprehensive and
23 compelling data demonstrating poorer health outcomes both between and within countries based
24 on different elements of social and economic disadvantage.[21] In all countries, people in the least
25 socioeconomically advantaged groups have poorer health outcomes. An independent report
26 commissioned by the British Government—*The Marmot Review*—noted that health inequalities
27 arise secondary to societal inequalities, and that to reduce health inequality society needs to reduce
28 social gradients affecting children.[22] The Australian Children's Headlines Indicators show that
29 across the board children of the least socioeconomic advantage have poorer outcomes than those
30 from the highest.[23]
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35 **Strengths and Limitations**

36
37 The KHC has a number of strengths. It has been conducted for several years, and has excellent
38 response rates, providing a large sample for analysis. It includes well-validated questions including
39 the SDQ. It includes measured anthropometric data, which is known to be more accurate than self-
40 reported data.[24]
41

42
43 The KHC is a series of cross-sectional surveys; we can therefore demonstrate relationships between
44 variables, but inference cannot be made about causality. Despite the high overall response rate,
45 some questions were subject to lower participation. This includes physical activity, which was one of
46 the key variables in our study.
47

48
49 Our study did not measure screen time, which is a proxy measure for inactivity, and it may be that
50 high screen time negates the benefits of physical activity or may be an independent risk
51 factor.[25,26] The evidence in early childhood around physical activity, sedentary behaviour and
52 wellbeing remains mixed.[8] The KHC questionnaire will include parental report of screen time from
53 2019.
54

55
56 A potential limitation of using the area-based Index of Relative Socioeconomic Disadvantage to
57 create quintiles of socioeconomic disadvantage for our analysis is that this reflects the area children
58 live in rather than their personal attributes.
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3 Disadvantage in the ACT is found when looking at very small areas, which area-based measures such
4 as SEIFA may miss.[27,28] An alternative school-based measure, the Index of Community Socio-
5 Educational Advantage (ICSEA), was considered as the school a child attends may better reflect their
6 level of socioeconomic disadvantage than the suburb they live in. However, its derivation includes
7 the proportion of Indigenous students at the school.[29] If a sub-population of interest is used in the
8 creation of an area-based measure, it may introduce bias into the results.[30] We had geocoded
9 data and we were able to use IRSD at the finest available level – SA1 – which overcomes some of the
10 limitations of using area-based measures.
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13 CONCLUSION

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15 Increased risk of clinically significant behavioural and mental health problems was seen for boys,
16 Aboriginal and Torres Strait Islander children, and those from socioeconomically disadvantaged
17 areas. Despite evidence that physical activity is protective for mental health, we did not find that
18 children who exercised more had different levels of overall risk than other children. Physical activity
19 was associated with reduced risk of peer relationship problems or prosocial behaviour difficulties.
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22 Boys in early childhood are at higher risk of developing clinically significant behavioural and mental
23 health problems, compared to girls of the same age. Programs or tailored supports may be needed
24 for boys in this age group.
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26 Health inequalities due to socioeconomic disadvantage are evident from a young age. Interventions
27 that focus on addressing inequity and the impacts of intergenerational trauma, rather than
28 promoting healthy lifestyles, are likely to have greater impact on young children's mental wellbeing.
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17 FOOTNOTES

18
19 **Contributors:** KO, JA and KD conceived the original idea and structure of the paper. KO, JA, KC and
20 KD planned the analysis. KO undertook the data analysis. KO wrote the paper with significant
21 structural and content input from JA, KC and KD. All authors approved submission of the manuscript
22 for publication.
23

24
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28 Division of Women, Youth & Children).
29

30
31 **Competing interests:** None declared.
32

33
34 **Ethics approval:** The data collection and consent process has been granted ethics approval through
35 the ACT Health Human Research Ethics Committee (ETHLR.13.316). Ethics approval for our study was
36 granted by the ACT Health Human Research Ethics Committee's Low Risk Sub-Committee
37 (ETHLR.17.080).
38

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40 **Word count:** 2,992
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42 FIGURE LEGENDS

43
44 **Figure 1** Participation rates for the Kindergarten Health Check, 2014–2016
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46 *Source:* ACT Education and Training Directorate 2014; ACT Education and Training Directorate 2015; ACT Education
47 Directorate 2016; KHC 2014-2016.

48 *Note:* Enrolment data derived from the February census within each year.
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51 **Figure 2** Characteristics of children by average daily physical activity participation, 2014-2016
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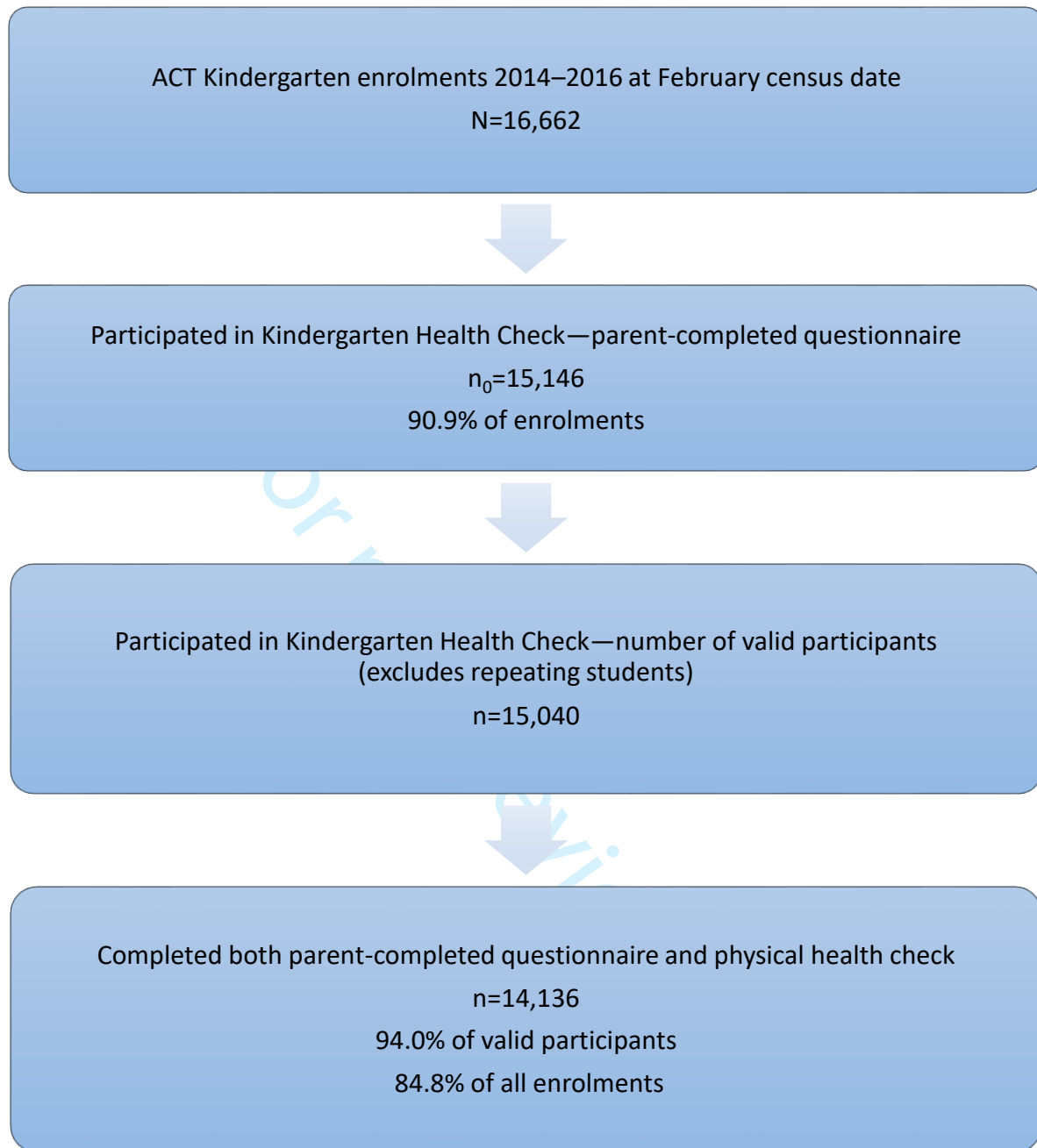
53 *Notes:*

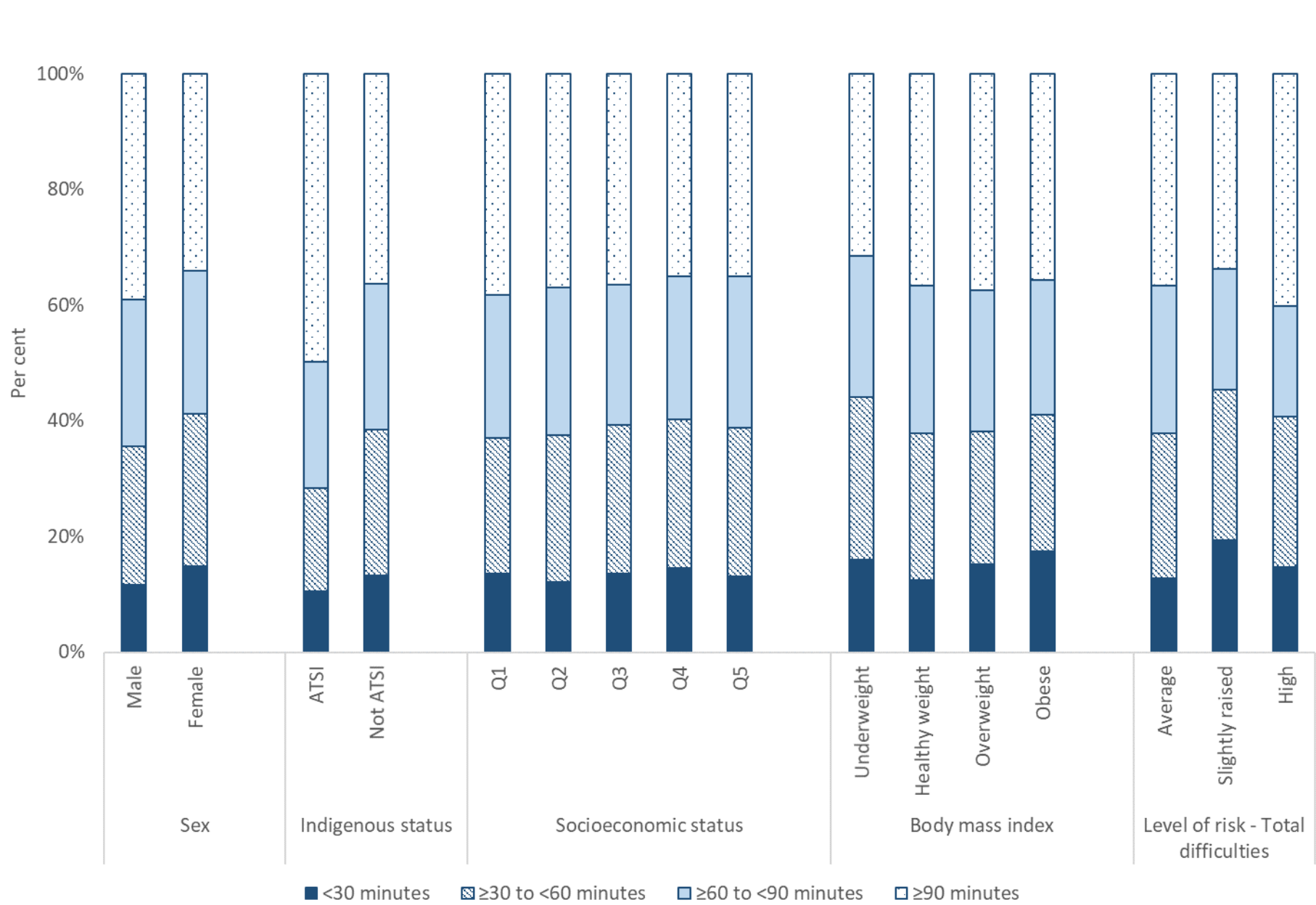
54 (a) Excludes children for whom Indigenous status was not available.

55 (b) Socioeconomic status based on ACT quintiles of relative disadvantage from IRSD at SA1 level. Excludes children for whom
56 socioeconomic status was not available.

57 (c) Excludes those for whom body mass index not available.

58 (d) Excludes those for whom physical activity participation not available.
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Physical activity and risk of behavioural and mental health disorders in Kindergarten children: analysis of a series of cross-sectional complete enumeration (census) surveys

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Article title

Physical activity and risk of behavioural and mental health disorders in Kindergarten children:
analysis of a series of cross-sectional complete enumeration (census) surveys

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ABSTRACT

Objectives There is mixed evidence on the relationship between physical activity and behavioural and mental health. We aimed to estimate the association between physical activity and risk of behavioural and mental health disorders in early school-aged children.

Design A series of cross-sectional complete enumeration (census) surveys.

Settings All primary schools in the Australian Capital Territory (ACT), 2014 to 2016.

Participants All children enrolled in their first year of full-time primary education (Kindergarten) were invited to participate. Of the 16,662 eligible Kindergarten children, 15,040 completed the survey for the first time.

Outcome measures Average daily physical activity participation and prevalence of risk of behavioural and mental health disorders derived from parent-reported data and the Strengths and Difficulties Questionnaire (SDQ). Characteristics associated with SDQ *Total difficulties* and subscales were estimated using logistic regression.

Results 8,340 (61.7%) children met physical activity targets (60 minutes or more daily) and 709 (4.8%) were at clinically significant risk of behavioural and mental health disorders (*Total difficulties*).

Known sociodemographic correlates were also those variables associated with high risk of behavioural and mental health disorders (*Total difficulties*): Aboriginal and Torres Strait Islander status (OR 2.72, 95% CI 1.78-4.16), relative socioeconomic disadvantage (most disadvantaged versus least disadvantaged, OR 1.86, 95% CI 1.38-2.50), and male sex (OR 1.80, 95% CI 1.49-2.17). Average daily physical activity was not significant, despite the highest levels of physical activity (90 minutes or more daily) being reported in boys, Aboriginal and Torres Strait Islander children, and those from more disadvantaged areas.

Conclusions Our study provides comprehensive cross-sectional data on the relationship between physical activity participation and the risk of behavioural and mental health disorders in a large cohort of early school-aged Australian children. Aboriginal and Torres Strait Islander children, boys, and those from the most disadvantaged socioeconomic group were at greatest risk of clinically significant behavioural and mental health disorders.

Strengths and limitations of this study

- The Kindergarten Health Check has been conducted for several years, and has excellent response rates.
- There is a large sample for analysis.
- The survey includes well-validated questions including the Strengths and Difficulties Questionnaire and measured anthropometric data.
- The KHC is a series of cross-sectional surveys so we can demonstrate relationships between variables, but inference cannot be made about causality.
- The survey includes parent-reported data on physical activity. The questions on physical activity had a lower response rate than other variables.

INTRODUCTION

Physical inactivity is associated with many potentially preventable chronic diseases[1] and childhood is a key time for increasing participation in physical activity.[2] The benefits of physical activity start in childhood with protective effects on cardiovascular and metabolic health.[3,4] The importance of

1
2
3 physical activity for school-aged children has been recognised by the World Health Organization, and
4 within Australia through the *Australian 24-hour movement guidelines for children and young people*
5 *(5 to 17 years)*.^[5,6]
6

7
8 The evidence on the association between physical activity and mental wellbeing and behavioural
9 disorders in young children is mixed. Several studies have associated physical activity participation
10 with lower rates of depression and anxiety, and improved self-esteem.^[7-8] However, mixed and
11 contradictory results have been found and there is a paucity of information for younger
12 children.^[7,9,10] In their systematic review of early childhood physical activity and psychosocial
13 wellbeing, Hinkley et al.^[11] found supportive, null and even adverse associations between physical
14 activity and a range of psychosocial wellbeing and behavioural outcomes. More recent systematic
15 reviews continue to find mixed evidence. Carson et al. ^[12] showed a favourable relationship
16 between physical activity and psychosocial health in preschool aged children based on an
17 experimental study, while observational studies gave mixed results. Poitras et al. ^[13] assessed the
18 relationship between objectively measured physical activity and indicators such as behavioural
19 conduct/prosocial behaviour, psychological distress and self-esteem in 5-17-year-olds, however
20 none of the included studies were for primary school-aged children. Nevertheless, physical activity
21 may have a role in mitigating the increasing burden of mental health disorders in children. Anxiety,
22 autism spectrum disorder, conduct disorder, and depressive disorders ranked among the six largest
23 contributors to the burden of disease for Australian boys and girls aged 5-14 years in 2011.^[1] The
24 *2013-14 Australian Child and Adolescent Survey of Mental Health and Wellbeing (Young Minds*
25 *Matter)* survey reported a mental disorder in 14% of boys and 7% of girls in Kindergarten or pre-
26 primary.^[14]
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30
31 Despite the importance of physical activity, few children are meeting recommended targets. The *24-*
32 *hour movement guidelines* recommend Australian primary school-aged children get at least 60
33 minutes of moderate to vigorous intensity physical activity daily.^[6] The 2011-12 Australian Health
34 Survey (AHS) found 36% of children aged 5-8 years met the recommended 60 minutes or more of
35 physical activity on all seven days prior to interview, with a further 34% meeting this target on 5-6
36 of the preceding seven days.^[15] The Australian Capital Territory (ACT) General Health Survey found
37 44% of children aged 5-12 years were active for at least 60 minutes each day in 2015-2016.^[16]
38
39

40 We know that fewer than half of young Australian children meet physical activity targets, including
41 primary school-aged children in the ACT. It is also well known that sociodemographic characteristics
42 play an important part in health and wellbeing. However, we lack information about children in early
43 childhood, how their physical activity levels may relate to risk of mental and behavioural health
44 disorders, and how sociodemographic factors may influence these for young children in the ACT.
45
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47 The ACT Kindergarten Health Check (KHC) is offered to all children in the ACT in their first year of
48 full-time primary school and collects information on risk of mental health and behavioural disorders
49 and physical activity. Our study aimed to estimate the association between physical activity and risk
50 of mental health and behavioural disorders and how this may differ for Aboriginal and Torres Strait
51 Islander children, and those from different socioeconomic backgrounds.
52

53 **METHODS**

54
55 The KHC is an annual cross-sectional survey of all children in the ACT in their first year of full-time
56 primary education (Kindergarten). All eligible children enrolled in ACT Kindergartens are invited to
57 participate in the survey; participation is voluntary. The KHC consists of a paper questionnaire
58 completed by parents at the start of the school year, and a physical health check performed by the
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2
3 School Health Nurses during the school year for all children whose parents consent to their
4 participation. More information on the KHC is included in Supplementary File 1. Our study analyses
5 data from the 2014 to 2016 surveys. Children who were identified as repeating Kindergarten within
6 the ACT were excluded from the analysis for their second year. The data collection and consent
7 process has been granted ethics approval through the ACT Health Human Research Ethics
8 Committee (ETHLR.13.316). Ethics approval for our study was granted by the ACT Health Human
9 Research Ethics Committee's Low Risk Sub-Committee (ETHLR.17.080).

10
11
12 The KHC collects demographic data (date of birth, sex, Aboriginal or Torres Strait Islander status,
13 home address) and information on selected conditions and behaviours. Parents were asked to report
14 on their child's physical activity outside of school hours in terms of the number of school days and
15 hours/minutes of activity on these days, and similar for weekend days. These were combined to
16 determine the average daily activity of children and were assessed against the targets for moderate
17 to vigorous physical activity from the *Australian 24-hour movement guidelines for children aged 5-17*
18 *years*.^[6] As our study population are children at school, we used the guidelines for school-aged
19 children (5-17-year-olds), rather than those in early years including pre-school (0-5-year-olds). The
20 KHC physical activity survey questions are included within the survey instrument, which is included
21 as Supplementary File 2.

22
23
24 The parent-completed questionnaire includes the Strengths and Difficulties Questionnaire (SDQ).
25 The SDQ contains 25 questions asking parents to assess their child's behaviour and psychological
26 traits over the previous six months. It is a well-validated behavioural screening questionnaire for
27 children, adapted for use in Australia from the original developed by Goodman^[17]. The questions
28 ask about positive and negative attributes which are used to calculate scores for emotional
29 difficulties, conduct problems, hyperactivity & inattention, peer relationship problems, and prosocial
30 behaviour. A *Total difficulties* score is calculated from all subscales except prosocial behaviour.
31 Children are scored as close to average, slightly raised, or high risk.

32
33
34 The physical health check includes measurement of height and weight by School Health Nurses.
35 Body mass index was calculated and classified into weight categories based on age- and sex-specific
36 cutoffs.^[18] Health concerns from either the questionnaire or health screen are communicated to
37 the child's primary carer and nominated general practitioner.

38
39
40 We linked the KHC with an indicator of socioeconomic disadvantage—the 2016 Index of Relative
41 Socio-Economic Disadvantage (IRSD), one of the Socio-Economic Indexes for Areas (SEIFA) produced
42 by the Australian Bureau of Statistics.^[19] IRSD was mapped to geocoded home addresses at the
43 finest geographic level available, the Statistical Area Level 1 (SA1). We created quintiles of
44 socioeconomic disadvantage for the ACT by ranking the IRSD scores for ACT SA1 regions and dividing
45 them into five equal cohorts. These quintiles are specific to the ACT, and differ from those based on
46 the national profile. The ACT is relatively advantaged compared to the national average, with 78% of
47 the ACT in the least disadvantaged quintile based on the national IRSD profile.^[19]

51 **Statistical analysis**

52
53 The KHC is a census and thus there is no sampling error associated with it. Our analysis comprised
54 producing unweighted prevalence estimates and logistic regression analysis. Confidence intervals for
55 prevalence estimates were calculated using binomial sampling. Logistic regression was performed
56 with dependent variable *Total difficulties* (high versus slightly raised/average risk) and independent
57 variables sex, Aboriginal and Torres Strait Islander status, relative socioeconomic disadvantage, total
58 daily physical activity (minutes), body mass index, and age (months). Average daily physical activity
59
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was skewed, so the cube root transformation was used. A sensitivity analysis was conducted with categories of physical activity participation in lieu of continuous data. Analysis was also run with SDQ subscales as the dependent variable.

Analysis was conducted in SPSS Version 24. Missing data were excluded from the analysis.

Patient and public involvement

Patients and the public were not involved in the design of the study.

RESULTS

Of the 16,662 children enrolled in Kindergarten in ACT schools during the study period, 15,146 (90.9%) participated in the KHC. Data for 106 children who were identified as repeating Kindergarten within the ACT were excluded from the analysis for their second year of participation. Of the remaining 15,040 children, 94.0% participated in the health screen (Figure 1). Overall, 14,136 (84.8% of enrolled children) participated in the KHC parent-completed questionnaire and physical health check for the first time.

Baseline characteristics of study participants are shown in Table 1. Over 75% of children were of a healthy weight with 3.6% in the obese weight range and 6.0% considered underweight. Nearly two-thirds (61.7%) met physical activity targets of 60 minutes or more on average daily, however 13% averaged less than 30 minutes daily. Five per cent of children had a high risk *Total difficulties* score; that is, they were at significantly increased risk of clinically significant mental health and behavioural disorders. Analysis of the SDQ subscales showed that a higher proportion of children had high risk scores for hyperactivity & inattention than for the other domains, and peer problems was the domain with the lowest proportion of high risk scores.

Table 1: Characteristics of children in the Kindergarten Health Check, 2014–2016

Characteristic		Number	Per cent (95% CI)
Mean (SD) age on commencement (years)		5.27	(0.31)
Age at 30 April of enrolment year	< 5 years	91	0.6 (0.5-0.7)
	5 to <6 years	13,947	92.7 (92.3-93.1)
	6 years or more	1,002	6.7 (6.3-7.1)
Sex	Male	7,754	51.6 (50.8-52.4)
	Female	7,286	48.4 (47.6-49.2)
Indigenous status ^(a)	Aboriginal or Torres Strait Islander	348	2.3 (2.1-2.6)
	Not Aboriginal or Torres Strait Islander	14,649	97.7 (97.4-97.9)
Socioeconomic status ^(b)	Most disadvantaged (Q1)	2,676	18.5 (17.9-19.2)
	Q2	2,915	20.2 (19.5-20.8)
	Q3	3,166	21.9 (21.2-22.6)
	Q4	2,881	19.9 (19.3-20.6)
	Least disadvantaged (Q5)	2,805	19.4 (18.8-20.1)
School sector	Government school	9,773	65.0 (64.2-65.7)
	Non-government school	5,267	35.0 (34.3-35.8)
Body mass index ^(c)	Underweight	851	6.0 (5.6-6.4)
	Healthy weight	11,023	78.1 (77.4-78.7)
	Overweight	1,736	12.3 (11.8-12.8)
	Obese	511	3.6 (3.3-3.9)
Mean (SD) daily physical activity participation (minutes) ^(d)		85.6	(66.51)
Average daily physical	< 30 minutes	1,782	13.2 (12.6-13.8)

activity participation ^(d)	30 to <60 minutes	3,382	25.0 (24.3-25.8)
	60 to <90 minutes	3,392	25.1 (24.4-25.8)
	≥ 90 minutes	4,948	36.6 (35.8-37.8)
Strengths and Difficulties Questionnaire high risk subscale scores ^(e)	Emotional difficulties	915	6.1 (5.8-6.5)
	Conduct problems	1,019	6.8 (6.4-7.3)
	Hyperactivity & inattention	1,232	8.3 (7.8-8.7)
	Peer problems	101	0.7 (0.5-0.8)
	<i>Total difficulties</i>	709	4.8 (4.4-5.1)
	Prosocial	421	2.8 (2.6-3.1)
All children		15,040	100.0

Notes:

(a) Excludes children for whom Indigenous status was not available.

(b) Socioeconomic status based on ACT quintiles of relative disadvantage from IRSD at SA1 level. Excludes children for whom socioeconomic status was not available.

(c) Excludes those for whom body mass index not available.

(d) Excludes those for whom physical activity participation not available.

(e) Each category excludes those children for which the reported measure is not available.

Figure 2 shows that children meeting physical activity target of 60 minutes or more daily were more likely to be of Aboriginal and Torres Strait Islander origin, or boys. Children who were underweight were less likely than other children to participate in 60 minutes or more of physical activity daily. Aboriginal and Torres Strait Islander children had the highest level of reported activity, with half averaging 90 minutes or more daily.

The attributes of children with high risk *Total difficulties* scores is shown in Table 2. These children were more likely to be boys, of Aboriginal and Torres Strait Islander origin, or from the most disadvantaged socioeconomic groups. No increase in risk was seen based on average daily physical activity (Figure 2).

Boys were more likely than girls to be rated high risk for conduct problems, hyperactivity & inattention, and prosocial behaviour difficulties (Table 2). Very few children (<1%) were rated high risk for peer problems. Aboriginal and Torres Strait Islander children were more likely than other children to be rated high risk for all subscales excluding peer problems. Children in the most disadvantaged two quintiles were more likely to be at high risk for emotional difficulties, conduct problems and hyperactivity & inattention.

Of the 15,040 children in the study, 12,097 (80.4%) were included in the main logistic regression model (dependent variable, high risk *Total difficulties* score) (Table 3). Aboriginal and Torres Strait Islander background was the strongest predictor of being at substantial risk of clinically significant problems (OR 2.73, 95% CI 1.79–4.17). Being from the most disadvantaged socioeconomic quintile was the next highest predictor of risk (OR 1.87, 95% CI 1.39–2.51). The risk of significant problems decreased with relative socioeconomic disadvantage, however the odds ratios were significantly different for the two most disadvantaged quintiles (Table 3). Boys were more likely to be at high risk than girls (OR 1.78, 95% CI 1.48–2.15). Age at enrolment was weakly significant with a small impact on risk. Total daily physical activity and body mass index were not significant predictors in the model.

Logistic regression was also undertaken for the SDQ subscales (Table 3). Odds ratios were significant for boys for all domains other than emotional difficulties. Aboriginal and Torres Strait Islander children were at increased risk for emotional difficulties, conduct problems, and hyperactivity & inattention, however they were not at increased risk for peer problems or prosocial behaviour difficulties. Being from the most disadvantaged socioeconomic quintile was associated with

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3 increased odds of conduct problems and hyperactivity & inattention. Physical activity was associated
4 with lower odds of peer problems and prosocial behaviour difficulties.
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6 Logistic regression analyses for *Total difficulties* and the SDQ subscales where physical activity was
7 included as a categorical variable were done as part of a sensitivity analysis (Supplementary File 3).
8 Odds ratios for independent variables, other than physical activity, showed only minor differences
9 from those in the models where physical activity was included as a continuous variable. For *Total*
10 *difficulties* and hyperactivity & inattention, 60 to <90 minutes of daily physical activity was significant
11 in the models (baseline, <30 minutes daily). For prosocial behaviour, all categories were significant
12 compared to baseline. Physical activity was not significant for the remaining SDQ subscales.
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Table 2: Characteristics of children rated high risk for strengths and difficulties subscales, 2014–2016

SDQ Subscale ^(e)	Sex		Indigenous status ^(a)		Socioeconomic status ^(b)					Body mass index ^(c)			
	Male	Female	Aboriginal or Torres Strait Islander	Not Indigenous	Q1	Q2	Q3	Q4	Q5	Under-weight	Healthy weight	Over-weight	Obese
	number (per cent)												
Total difficulties	471 (6.1)	238 (3.3)	43 (12.5)	663 (4.6)	179 (6.8)	165 (5.7)	132 (4.2)	130 (4.6)	87 (3.1)	35 (4.2)	495 (4.5)	79 (4.6)	41 (8.1)
Emotional difficulties	473 (6.2)	442 (6.1)	41 (11.9)	871 (6.0)	204 (7.7)	196 (6.8)	177 (5.6)	153 (5.4)	158 (5.7)	52 (6.2)	662 (6.1)	100 (5.8)	53 (10.5)
Conduct problems	626 (8.2)	393 (5.5)	42 (12.2)	976 (6.7)	234 (8.8)	228 (7.9)	198 (6.3)	172 (6.0)	157 (5.6)	35 (4.2)	726 (6.6)	135 (7.8)	40 (7.9)
Hyperactivity & inattention	827 (10.8)	405 (5.6)	59 (17.2)	1,167 (8.1)	275 (10.4)	276 (9.6)	219 (7.0)	217 (7.6)	203 (7.3)	57 (6.8)	880 (8.1)	145 (8.4)	52 (10.3)
Peer problems	77 (1.0)	24 (0.3)	n.p.	n.p.	22 (0.8)	21 (0.7)	20 (0.6)	22 (0.8)	13 (0.5)	10 (1.2)	59 (0.5)	16 (0.9)	6 (1.2)
Prosocial	296 (3.9)	125 (1.7)	15 (4.4)	405 (2.8)	80 (3.0)	73 (2.5)	95 (3.0)	90 (3.1)	68 (2.4)	26 (3.1)	299 (2.7)	44 (2.5)	17 (3.4)

n.p. not published due to small cell size

Notes:

(a) Excludes children for whom Indigenous status was not available.

(b) Socioeconomic status based on ACT quintiles of relative disadvantage from IRSD at SA1 level. Excludes children for whom socioeconomic status was not available.

(c) Excludes those for whom body mass index not available.

(e) Each category excludes those children for which the reported measure is not available.

Table 3: Odds ratios from logistic regression analyses

SDQ Subscale ^(b)	Logistic regression independent variables ^(a)										
	Sex	Indigenous status	Socio-economic status ^(c) Q1	SES Q2	SES Q3	SES Q4	Physical activity	Under-weight ^(d)	Over-weight ^(d)	Obese ^(d)	Age
	Odds Ratio (95% CI)										
<i>Total difficulties</i>	1.80 (1.49-2.17)	2.72 (1.78-4.16)	1.86 (1.38-2.50)	1.50 (1.11-2.03)	1.30 (0.96-1.77)	1.29 (0.95-1.76)	0.96 (0.88-1.04)	1.05 (0.72-1.53)	1.05 (0.79-1.38)	1.86 (1.27-2.72)	1.03 (1.00-1.05)
Emotional difficulties	0.97 (0.83-1.13)	1.98 (1.30-3.01)	1.26 (0.99-1.60)	1.09 (0.86-1.38)	0.96 (0.86-1.38)	0.91 (0.71-1.16)	0.94 (0.87-1.01)	0.98 (0.70-1.36)	0.94 (0.74-1.20)	1.78 (1.28-2.47)	1.03 (1.01-1.06)
Conduct problems	1.57 (1.35-1.82)	1.66 (1.09-2.54)	1.48 (1.17-1.87)	1.32 (1.05-1.67)	1.08 (0.85-1.37)	0.98 (0.77-1.25)	0.99 (0.93-1.07)	0.58 (0.39-0.85)	1.29 (1.05, 1.59)	1.15 (0.79-1.68)	1.02 (1.00-1.04)
Hyperactivity & inattention	2.02 (1.75-2.33)	1.85 (1.26-2.72)	1.35 (1.09-1.67)	1.27 (1.03-1.57)	0.91 (0.73-1.13)	1.05 (0.84-1.30)	0.97 (0.91-1.04)	0.91 (0.67-1.22)	1.09 (0.89-1.34)	1.41 (1.02-1.94)	1.01 (0.99-1.02)
Peer problems	2.73 (1.61-4.64)	1.43 (0.35-5.91)	1.67 (0.74-3.73)	1.22 (0.53-2.84)	1.70 (0.78-3.70)	1.78 (0.82-3.86)	0.78 (0.62-0.98)	2.42 (1.18-4.98)	1.90 (1.02-3.52)	1.93 (0.69-5.41)	1.03 (0.97-1.10)
Prosocial	2.49 (1.94-3.19)	0.66 (0.24-1.80)	1.27 (0.87-1.85)	1.14 (0.78-1.66)	1.36 (0.95-1.93)	1.28 (0.89-1.84)	0.78 (0.70-0.87)	1.07 (0.68-1.68)	1.13 (0.81-1.58)	1.03 (0.56-1.91)	1.00 (0.97-1.03)

(a) Reference categories: girls, non-Indigenous, Q5 - least disadvantaged, healthy weight (BMI); physical activity and age are continuous.

(b) Each category excludes those children for which the reported measure is not available.

(c) Socioeconomic status based on ACT quintiles of relative disadvantage from IRSD at SA1 level. Q1 – most disadvantaged; Q5 – least disadvantaged.

(d) Based on BMI.

DISCUSSION

Our study found nearly two-thirds of ACT Kindergarten children were meeting physical activity targets of 60 minutes or more daily. These children were more likely to be boys, of Aboriginal or Torres Strait Islander background, or from the most disadvantaged socioeconomic areas.

The 2011-12 AHS found similar proportions of boys (36%) and girls (35%) aged 5-8 years met the recommended 60 minutes or more of physical activity on all seven days prior to interview.[15] However similar to our study, boys undertook more daily exercise. Boys aged 5-17 years spent an average of 78 minutes in moderate to vigorous activity daily, compared to 67 minutes for girls. There were no statistically significant differences in the proportion of children aged 5-17 years meeting physical activity targets based on socioeconomic status (IRSD).

In our study, the groups of children with higher daily physical activity also had a higher risk of behavioural and mental health disorders, with boys having double the rate of high risk *Total difficulties* scores as girls (6.1% vs 3.3%). Aboriginal and Torres Strait Islander children had more than double the proportion at high risk compared to non-Indigenous children (12.5% versus 4.6%), and children from the most disadvantaged socioeconomic group also over-represented. Children who were obese were more likely to have high risk *Total difficulties* score, but there was no significant difference in their physical activity participation compared to other children.

Our results are consistent with SDQ data for Australian children aged 4-12 years; higher rates of high risk *Total difficulties* were seen for boys compared to girls (12.7% versus 7.7%) and children in the most disadvantaged socioeconomic groups (15.6% in the lowest SES quintile versus 7.2% in the highest SES quintile).[20] Aboriginal and Torres Strait Islander children have also been shown elsewhere to have higher SDQ scores than the Australian average.[21]

Boys in our study were more likely to be at high risk for conduct problems, hyperactivity & inattention, peer problems, and prosocial behaviour difficulties. They were equally likely as girls to be high risk for emotional problems.

Children of Aboriginal and Torres Strait Islander background and children with relative socioeconomic disadvantage were more likely to be at high risk for emotional problems, conduct problems, and hyperactivity & inattention.

The Australian Early Development Census (AEDC) is a three-yearly census of children in their first year of full-time primary education. Data from the 2018 AEDC found similar patterns to our study. Boys were more likely to be developmentally vulnerable than girls; including the social competence and emotional maturity domains.[22] Aboriginal and Torres Strait Islander children were more likely to be developmentally vulnerable than other children, as were children from the most disadvantaged socioeconomic groups.

We did not demonstrate an association between physical activity and high risk *Total difficulties* score in our study, despite other research linking physical activity participation with reduced depressive symptoms. Our study considered all physical activity together and it may be that different forms of physical activity provide different benefits. For example, Eime et al.[23] propose that participation in sport may have psychological benefits beyond that from other forms of physical activity. We did find that increased physical activity participation was associated with lower odds of peer problems and prosocial behaviour difficulties. In their systematic review, Hinkley et al.[11] found supportive associations between physical activity with conduct problems, emotional competence, emotional symptoms, hyperactivity/inattention and peer relationships, but conversely

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3 found studies with adverse associations between physical activity with conduct problems and
4 hyperactivity/inattention. Many more had no significant associations.
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6 The ratio of boys to girls at high risk for *Total difficulties* in our study is consistent with findings from
7 *Young Minds Matter*, however our estimates are lower than their reported prevalence of mental
8 health disorders (13.6% of boys and 7.1% of girls).[14] Two factors that may explain the difference
9 are the survey scope and survey tools used. The KHC surveys children attending schools in the ACT
10 only, and uses the SDQ to assign risk of mental health disorders. *Young Minds Matter* assessed
11 children across Australia and used the Diagnostic Interview Schedule for Children Version IV to
12 identify mental health disorders.[14]
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15 In our study, boys were at higher risk than girls for all subscales of the SDQ other than emotional
16 difficulties. Boys in Kindergarten or pre-primary in *Young Minds Matter* had a higher prevalence of
17 all and different types of mental disorders, compared to girls of the same age.[14] Among primary
18 school-aged children they found a higher prevalence of anxiety disorders, ADHD and conduct
19 disorders for boys, and a higher prevalence of major depressive disorder for girls. However, for high
20 school-aged children, males had higher rates of ADHD and conduct disorders, but females had a
21 greater prevalence of major depressive disorder and anxiety disorders. The 2017-18 National Health
22 Survey found that amongst adults, females report higher rates of psychological distress than
23 men.[24] This begs the question as to whether risks and prevalence of behavioural and mental
24 health disorders are becoming more common for males, whether males are more vulnerable only in
25 the younger age groups, or whether risk varies for different conditions.
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29 Aboriginal and Torres Strait Islander children in our study had the highest reported levels of physical
30 activity. Despite the potential benefits of physical activity, these children also had the highest levels
31 of risk for behavioural and mental health disorders overall (*Total difficulties*), emotional difficulties,
32 conduct problems, and hyperactivity & inattention. High risk of mental illness has been reprinted
33 elsewhere and has in part been attributed to the impacts of intergenerational trauma.[25] It is well
34 known that Aboriginal and Torres Strait Islanders have poorer health outcomes than other
35 Australians, and these data have been extensively reported elsewhere.[26]
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38 Despite the ACT being a fairly homogenous jurisdiction with respect to socioeconomic advantage,
39 degrees of relative disadvantage were found in our study. Children from the two most
40 disadvantaged quintiles were significantly more likely to be at high risk of behavioural and mental
41 health disorders than those from less disadvantaged areas. The relationship between lower
42 socioeconomic status and poorer health outcomes has been seen in numerous settings. The World
43 Health Organization's report *Closing the gap in a generation* presents comprehensive and
44 compelling data demonstrating poorer health outcomes both between and within countries based
45 on different elements of social and economic disadvantage.[27] In all countries, people in the least
46 socioeconomically advantaged groups have poorer health outcomes. An independent report
47 commissioned by the British Government—*The Marmot Review*—noted that health inequalities
48 arise secondary to societal inequalities, and that to reduce health inequality society needs to reduce
49 social gradients affecting children.[28] The Australian Children's Headlines Indicators show that
50 across the board children of the least socioeconomic advantage have poorer outcomes than those
51 from the highest.[20]
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56 **Strengths and Limitations**

57 The KHC has a number of strengths. It has been conducted for several years, is offered to all children
58 and thus not subject to sampling error, and has excellent response rates, providing a large sample
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3 for analysis. It includes well-validated questions including the SDQ. It includes measured
4 anthropometric data, which is known to be more accurate than self-reported data.[29]
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6 The KHC is a series of cross-sectional surveys; we can therefore demonstrate relationships between
7 variables, but inference cannot be made about causality. Despite the high overall response rate,
8 some questions were subject to lower participation. This includes physical activity, which was one of
9 the key variables in our study.
10

11 While not subject to sampling error, the data are subject to non-sampling error. For example, the
12 physical activity measure is derived from parent-reported data. As with anthropometric data,
13 measured, objective, physical activity data is more accurate than parent-reported activity.[30]
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16 Our study did not measure screen time, which is a proxy measure for inactivity, and it may be that
17 high screen time negates the benefits of physical activity or may be an independent risk
18 factor.[31,32] The *Australian 24-hour movement guidelines for children and young people (5 to 17*
19 *years)* recommend limiting sedentary recreational screen time to no more than two hours per day,
20 and breaking up long periods of sitting as often as possible.[6] The Canadian review of evidence for
21 5-17-year-olds found that increased sedentary behaviour was associated with unfavourable health
22 outcomes a range of indicators.[33] The KHC questionnaire will include parental report of screen
23 time from 2019.
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26 We undertook the logistic regression using standard categories for degree of risk from the SDQ. It is
27 possible that different relationships may have been observed if the raw scores were used, as was
28 done in the study by Griffiths et al.[9]
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30 A potential limitation of using the area-based Index of Relative Socioeconomic Disadvantage to
31 create quintiles of socioeconomic disadvantage for our analysis is that this reflects the area children
32 live in rather than their personal attributes.
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35 Disadvantage in the ACT is found when looking at very small areas, which area-based measures such
36 as SEIFA may miss.[34,35] An alternative school-based measure, the Index of Community Socio-
37 Educational Advantage (ICSEA), was considered as the school a child attends may better reflect their
38 level of socioeconomic disadvantage than the suburb they live in. However, its derivation includes
39 the proportion of Indigenous students at the school.[36] If a sub-population of interest is used in the
40 creation of an area-based measure, it may introduce bias into the results.[37] We had geocoded
41 data and we were able to use IRSD at the finest available level – SA1 – which overcomes some of the
42 limitations of using area-based measures.
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45 CONCLUSION

46 Increased risk of clinically significant behavioural and mental health disorders was seen for boys,
47 Aboriginal and Torres Strait Islander children, and those from socioeconomically disadvantaged
48 areas. Despite evidence that physical activity is protective for mental health, we did not find that
49 children who participated in more physical activity had different levels of overall risk than other
50 children. Lower levels of physical activity were associated with being at high risk for peer
51 relationship problems or prosocial behaviour difficulties.
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54 Boys in early childhood are at higher risk of developing clinically significant behavioural and mental
55 health disorders, compared to girls of the same age. Programs or tailored supports may be needed
56 for boys in this age group.
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3 Health inequalities due to socioeconomic disadvantage are evident from a young age. Interventions
4 that focus on addressing inequity and the impacts of intergenerational trauma, rather than
5 promoting healthy lifestyles, are likely to have greater impact on young children's mental wellbeing.
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22 FOOTNOTES

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Contributors: KO, JA and KD conceived the original idea and structure of the paper. KO, JA, KC and KD planned the analysis. KO undertook the data analysis. KO wrote the paper with significant structural and content input from JA, KC and KD. All authors approved submission of the manuscript for publication.

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Competing interests: None declared.

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Ethics approval: The data collection and consent process has been granted ethics approval through the ACT Health Human Research Ethics Committee (ETHLR.13.316). Ethics approval for our study was granted by the ACT Health Human Research Ethics Committee's Low Risk Sub-Committee (ETHLR.17.080).

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Data sharing statement: No additional data available for this study. The Kindergarten Health Check is an ACT Health database. Access can be applied for by emailing: augp@anu.edu.au.

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Word count: 3,725

50 FIGURE LEGENDS

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Figure 1 Participation rates for the Kindergarten Health Check, 2014–2016

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Source: ACT Education and Training Directorate[38-40] and KHC 2014-2016.

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Note: Enrolment data derived from the February census within each year.

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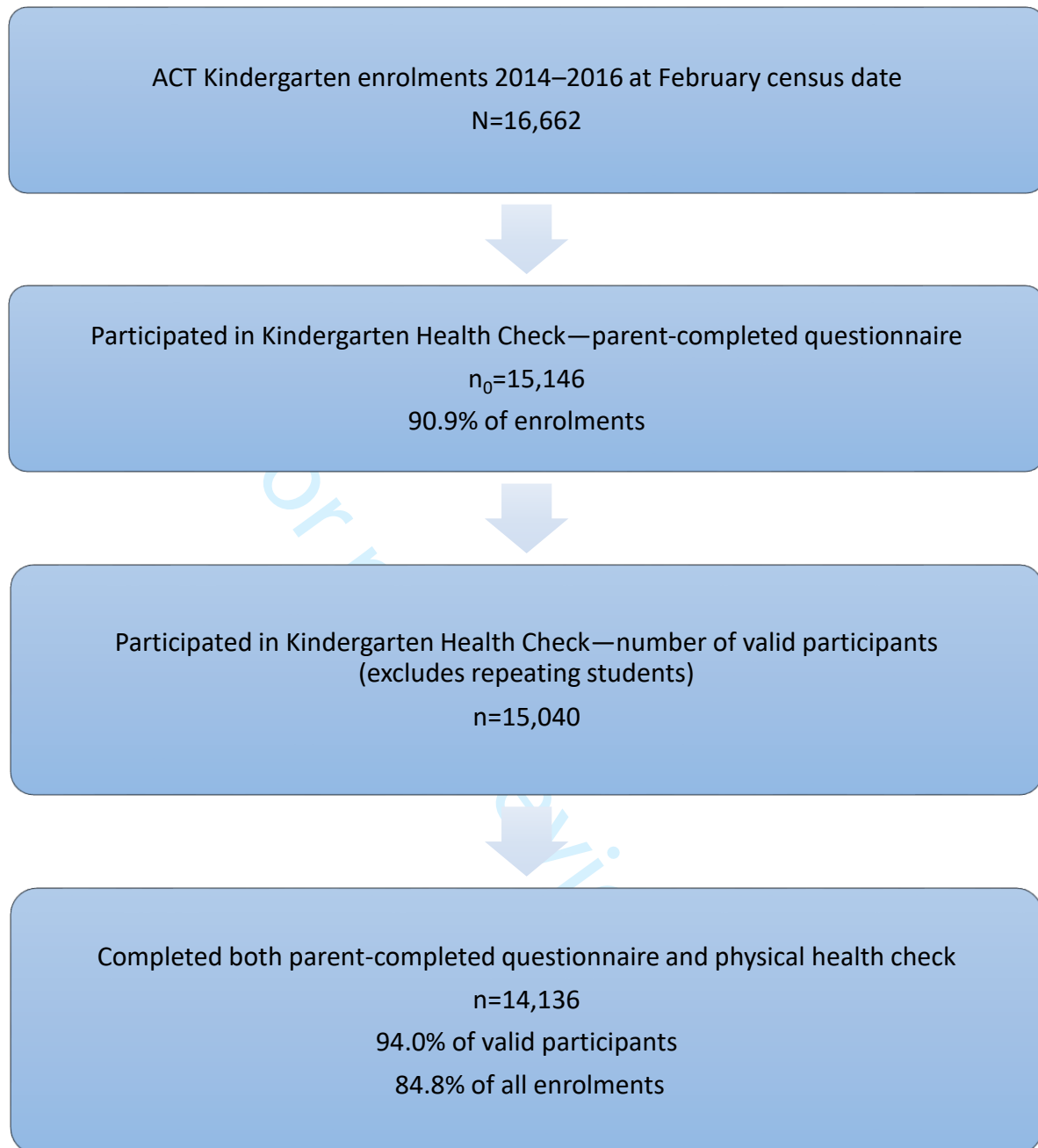
Figure 2 Characteristics of children by average daily physical activity participation, 2014-2016

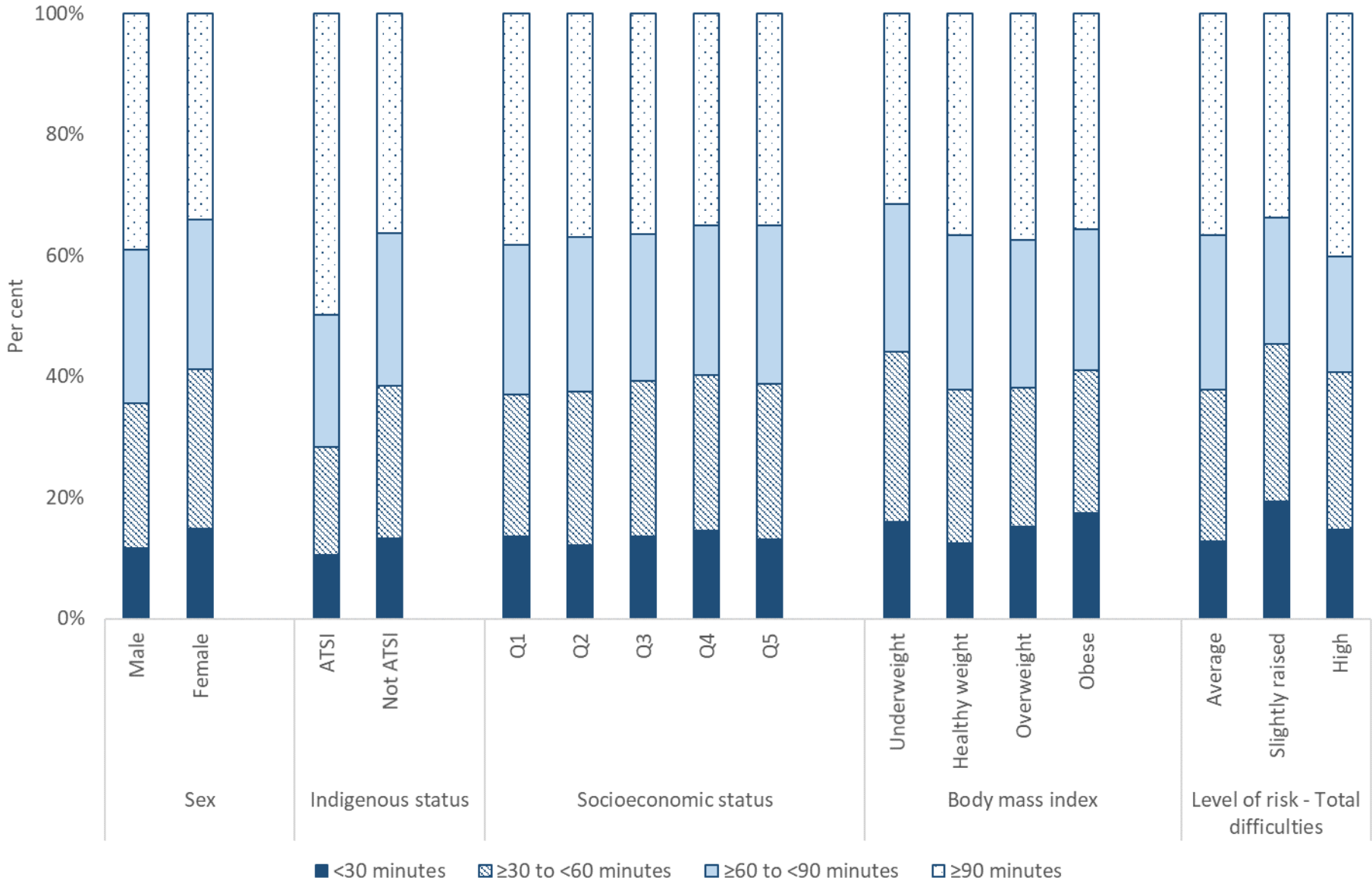
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- (a) Excludes children for whom Indigenous status was not available.
- (b) Socioeconomic status based on ACT quintiles of relative disadvantage from IRSD at SA1 level. Excludes children for whom socioeconomic status was not available.
- (c) Excludes those for whom body mass index not available.
- (d) Excludes those for whom physical activity participation not available.

For peer review only





Supplement 1: Kindergarten Health Check methods

The Kindergarten Health Check (KHC) is conducted annually in the Australian Capital Territory (ACT). See: <https://health.act.gov.au/services-and-programs/women-youth-and-children/children-and-youth/school-health>

All children in their first year of full-time primary education (Kindergarten) in the ACT are invited to participate. Participation is voluntary. Paper survey forms are distributed to parents/guardians of eligible children via their schools in early February of the school year. Parent-completed questionnaires are collected by schools a few weeks later.

Physical health checks are conducted by School Health Nurses between April and October of that year for all children whose parents/guardians' consent to their participation. The physical health check includes body measurements (height, weight), vision check and hearing check. Results are recorded on a paper survey form. The KHC is conducted using best practice protocols as informed by recent literature, including protocols for measuring height and weight.

Denominator data is derived from The ACT Education Directorate census data.

The same survey instrument was used for 2014-2016. A copy of the 2016 survey instrument is included as Supplementary File 2.

These questions ask you about your child's vision and hearing. Please tick ✓ the required boxes.

VISION

1. Do you have any concerns about your child's vision? Yes No

If yes, please describe: _____

2. Has your child been prescribed glasses? Yes No

If yes, when should they be worn? (e.g. when reading): _____

3. Has your child ever received, or are they receiving medical care for their eyes or vision? Yes No

If yes, please describe: _____

HEARING

1. Do you have any concerns about your child's hearing or airways? Yes No

If yes, please describe: _____

2. Has your child had any of the following? Tick all that apply.

Repeated ear infections Yes No

Discharging ears Yes No

Hearing Loss Yes No

Grommets Yes No If yes, when were these inserted? _____

Snoring Yes No

3. Has your child ever received or are they receiving medical care for their ears, hearing or airways?

Yes No

If yes, please describe: _____

Would you like information on any of the following? Tick all that apply.

Wetting pants Yes No

Wetting the bed Yes No

Soiling pants Yes No

This completes the questions relating to the health check conducted by the School Health Nurses.

The results will be posted to your nominated address.

Please continue answering the questions about your child's development on the following pages.

If you have any concerns about your child's health, please see your GP.

These questions ask you about your child's strengths and difficulties.

Instructions: For each item, please tick the box for Not True, Somewhat True or Certainly True. It would help us if you answered all items as best you can, even if you are not absolutely certain. Please give your answers on the basis of your child's behaviour over the last 6 months.

STRENGTHS AND DIFFICULTIES QUESTIONNAIRE	Not True	Somewhat True	Certainly True
1. Considerate of other people's feelings	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Restless, overactive, cannot sit still for long	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Often complains of headaches, stomach-aches or sickness	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. Shares readily with other children for example toys, treats, pencils	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. Often loses temper	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. Rather solitary, prefers to play alone	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. Generally well behaved, usually does what adults request	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. Many worries, or often seems worried	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. Helpful if someone is hurt, upset, or feeling ill	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10. Constantly fidgeting or squirming	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11. Has at least one good friend	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12. Often fights with other children or bullies them	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
13. Often unhappy, depressed or tearful	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
14. Generally liked by other children	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
15. Easily distracted, concentration wanders	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
16. Nervous or clingy in new situations, easily loses confidence	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
17. Kind to younger children	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
18. Often lies or cheats	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
19. Picked on or bullied by other children	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20. Often volunteers to help others (parents, teachers, other children)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
21. Thinks things out before acting	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
22. Steals from home, school or elsewhere	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
23. Gets along better with adults than with other children	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
24. Many fears, easily scared	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
25. Good attention span, sees chores or homework through to the end	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

SDQ (P) 04-10 Self-Report Measure © Robert Goodman 2002

These questions ask you about asthma, eczema and hay fever.

RESPIRATORY SYMPTOMS

1. Has your child ever had wheezing or whistling in the chest? Yes No
2. Has your child ever had asthma? Yes No
3. In the last 12 months has your child experienced any of the following respiratory symptoms?
- Wheezing or whistling in the chest Yes No
- A dry cough at night not associated with a cold or chest infection Yes No
- Wheezing with coughs or colds Yes No
- Shortness of breath when exercising or playing games or participating in sports Yes No
4. In the last 12 months how often, *on average*, have the following respiratory symptoms been present?
Please tick one box on EACH line

Wheeze or whistle in the chest	<input type="checkbox"/> Never	<input type="checkbox"/> Less than 1 day / wk	<input type="checkbox"/> 1 – 3 days / wk	<input type="checkbox"/> 4 or more days / wk
Night cough or night wheeze	<input type="checkbox"/> Never	<input type="checkbox"/> Less than 1 night / wk	<input type="checkbox"/> 1 – 3 nights / wk	<input type="checkbox"/> 4 or more nights / wk
Shortness of breath (when exercising or playing)	<input type="checkbox"/> Never	<input type="checkbox"/> Less than 1 day / wk	<input type="checkbox"/> 1 – 3 days / wk	<input type="checkbox"/> 4 or more days / wk

ECZEMA

5. Has your child ever had an itchy rash that was coming and going for at least 6 months? Yes No
6. Has the itchy rash ever affected the following places? Yes No
(the fold of the elbows, behind the knees, in front of the ankles, under the buttocks, or around the neck, ears or eyes)
7. Has your child ever had eczema? Yes No

HAY FEVER

8. In the past 12 months has your child had a problem with sneezing, or a runny or blocked nose when he / she did not have a cold or the flu? Yes No
9. In the past 12 months has this nose problem been accompanied by itchy / watery eyes? Yes No
10. Has your child ever had hay fever? Yes No
11. Do any close members of the family have any of the following conditions?
- Asthma Yes No
- Eczema Yes No
- Hay fever Yes No

Adapted from The International Study of Asthma and Allergies in Childhood (ISAAC): Core questionnaire

For peer review only - <http://bmjopen.bmj.com/site/about/guidelines.xhtml>

These questions ask about your child's food intake and physical activity.

WEIGHT PERCEPTION

1. How would you describe your child's weight?

- Underweight
 Healthy weight
 Overweight
 Obese
 Don't know

2. Do you have any concerns about your child's weight?

Yes No

3. Do you have any concerns about your child's height?

Yes No

Comments: _____

DIET

The following questions are about the food your child eats.

4. How many serves of vegetables does your child usually eat each day?

(1 serve = ½ cup cooked vegetables, or ½ medium potato, or 1 medium tomato, or 1 cup salad vegetables)

- ___ serves per day *(write number of serves) OR*
 ___ serves per week *(write number of serves)*
 my child doesn't eat vegetables
 don't know

5. How many serves of fruit does your child usually eat each day?

(1 serve = 1 medium piece, or 2 small pieces of fruit, or 1 cup of diced pieces with no added sugar, or 30 grams of dried fruit such as 4 dried apricots or 1½ tablespoons sultanas)

- ___ serves per day *(write number of serves) OR*
 ___ serves per week *(write number of serves)*
 my child doesn't eat fruit
 don't know

6. Do you have any concerns about your child's eating habits?

Yes No

Comments: _____

PHYSICAL ACTIVITY

The following questions are about your child's physical activity. Physical activity is any activity that increases your heart rate and makes you get out of breath some of the time.

7. On about how many days during the school week does your child usually do physical activity outside of school hours? This includes before and after school sports, playing with friends, walking/ riding to and from school.

- ___ number of school days per week
 none
 don't know

8. On these days, about how many hours does your child usually do physical activity? *(in hours and minutes)*

- ___ hours ___ minutes (average time on each school day)
 don't know

9. On about how many days during the weekend does your child usually do physical activity?

- ___ number of weekend days
 none
 don't know

10. On a typical weekend day, about how many hours does your child usually do physical activity?

- ___ hours ___ minutes (average time on each weekend day)
 don't know

Thank you. Please return the completed form to your child's school in a sealed envelope.
 The results of the Kindergarten Health Check will be posted to your nominated address

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Supplementary Table 1: Odds ratios from logistic regression analyses, sensitivity analysis using categorical physical activity

SDQ Subscale ^(b)	Logistic regression independent variables ^(a)												
	Sex	Indigenous status	Socio-economic status ^(c)				Physical activity (minutes)			Under-weight ^(d)	Over-weight ^(d)	Obese ^(d)	Age
			Q1	Q2	Q3	Q4	30 to <60	60 to <90	≥90				
	Odds Ratio (95% CI)												
Total difficulties	1.80 (1.49-2.17)	2.69 (1.76-4.11)	1.85 (1.37-2.48)	1.50 (1.11-2.02)	1.29 (0.96-1.75)	1.28 (0.94-1.75)	0.95 (0.71-1.28)	0.67 (0.49-0.91)	0.93 (0.71-1.22)	1.06 (0.73-1.54)	1.04 (0.79-1.37)	1.85 (1.27-2.70)	1.03 (1.00-1.05)
Emotional difficulties	0.97 (0.83-1.13)	1.96 (1.29-2.98)	1.25 (0.99-1.59)	1.09 (0.85-1.38)	0.95 (0.75-1.21)	0.90 (0.71-1.16)	0.90 (0.70-1.15)	0.81 (0.63-1.04)	0.84 (0.66-1.06)	0.98 (0.70-1.36)	0.94 (0.74-1.20)	1.77 (1.28-2.46)	1.04 (1.01-1.06)
Conduct problems	1.56 (1.35-1.82)	1.65 (1.08-2.52)	1.48 (1.17-1.86)	1.32 (1.05-1.67)	1.08 (0.85-1.37)	0.98 (0.77-1.25)	1.05 (0.82-1.35)	0.91 (0.71-1.18)	1.08 (0.86-1.37)	0.58 (0.39-0.86)	1.29 (1.05-1.59)	1.15 (0.79-1.68)	1.02 (1.00-1.04)
Hyperactivity & inattention	2.03 (1.76-2.34)	1.84 (1.25-2.70)	1.34 (1.08-1.66)	1.27 (1.03-1.57)	0.90 (0.73-1.13)	1.04 (0.84-1.29)	0.87 (0.70-1.08)	0.69 (0.55-1.87)	0.88 (0.71-1.08)	0.91 (0.67-1.22)	1.09 (0.89-1.33)	1.39 (1.01-1.93)	1.01 (0.99-1.02)
Peer problems	2.72 (1.60-4.61)	1.41 (0.34-5.82)	1.65 (0.74-3.69)	1.21 (0.52-2.81)	1.68 (0.77-3.65)	1.76 (0.81-3.83)	0.91 (0.46-1.81)	0.64 (0.30-1.33)	0.60 (0.30-1.20)	2.42 (1.18-4.98)	1.89 (1.02-3.51)	1.96 (0.70-5.49)	1.03 (0.97-1.10)
Prosocial	2.48 (1.94-3.18)	0.65 (0.24-1.76)	1.25 (0.86-1.82)	1.13 (0.78-1.64)	1.34 (0.94-1.91)	1.27 (0.88-1.82)	0.70 (0.50-0.97)	0.54 (0.38-0.77)	0.52 (0.38-0.73)	1.07 (0.68-1.68)	1.12 (0.80-1.57)	1.03 (0.56-1.91)	1.00 (0.97-1.03)

(a) Reference categories: girls, non-Indigenous, Q5 - least disadvantaged, healthy weight (BMI), physical activity < 30 minutes daily; age is continuous.
 (b) Each category excludes those children for which the reported measure is not available.
 (c) Socioeconomic status based on ACT quintiles of relative disadvantage from IRSd at SA1 level. Q1 – most disadvantaged; Q5 – least disadvantaged.
 (d) Based on BMI.

STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract Page 1, Line 2; Page 2, Line 5 (b) Provide in the abstract an informative and balanced summary of what was done and what was found Page 2, Lines 11-33
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported Page 3, Lines 2-43
Objectives	3	State specific objectives, including any prespecified hypotheses Page 3, Lines 41-43
Methods		
Study design	4	Present key elements of study design early in the paper Page 4, Lines 2-9
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection Page 4, Lines 2-41
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants Page 4, Lines 2-4
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable Page 4, Lines 2-41
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group Page 4, Lines 2-41
Bias	9	Describe any efforts to address potential sources of bias <i>n/a</i>
Study size	10	Explain how the study size was arrived at Page 4, Lines 2-4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why Page 4, Lines 2-41
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding Page 4, Line 42 to Page 5, Line 8 (b) Describe any methods used to examine subgroups and interactions Page 4, Line 42 to Page 5, Line 8 (c) Explain how missing data were addressed Page 5, Lines 5-6 (d) If applicable, describe analytical methods taking account of sampling strategy Page 4, Line 42 to Page 5, Line 8 (e) Describe any sensitivity analyses Page 5, Line 8
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed Figure 1 (b) Give reasons for non-participation at each stage Figure 1 (c) Consider use of a flow diagram Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders Table 1, Table 2, Figure 2 (b) Indicate number of participants with missing data for each variable of interest Table 1, Table 2
Outcome data	15*	Report numbers of outcome events or summary measures Table 1, Table 2, Figure 2
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were

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adjusted for and why they were included [Table 1](#), [Table 2](#), [Table 3](#)

(b) Report category boundaries when continuous variables were categorized [Table 1](#), [Table 2](#), [Table 3](#)

(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period [n/a](#)

Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses Supplementary Table S2.1
Discussion		
Key results	18	Summarise key results with reference to study objectives Page 10, Lines 2-4, 11-17, 23-28
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias Page 12, Lines 3-31
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence Page 12, Lines 43-51; Page 13, Lines 1-3
Generalisability	21	Discuss the generalisability (external validity) of the study results Page 12, Lines 43-51; Page 13, Lines 1-3
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based Page 15, Lines 22-25

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Physical activity and risk of behavioural and mental health disorders in Kindergarten children: analysis of a series of cross-sectional complete enumeration (census) surveys

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Secondary Subject Heading:	Paediatrics, Sports and exercise medicine, Mental health
Keywords:	PUBLIC HEALTH, PRIMARY CARE, Community child health < PAEDIATRICS, MENTAL HEALTH

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Article title

Physical activity and risk of behavioural and mental health disorders in Kindergarten children:
analysis of a series of cross-sectional complete enumeration (census) surveys

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ABSTRACT

Objectives There is mixed evidence on the relationship between physical activity and behavioural and mental health. We aimed to estimate the association between physical activity and risk of behavioural and mental health disorders in early school-aged children.

Design A series of cross-sectional complete enumeration (census) surveys.

Settings All primary schools in the Australian Capital Territory (ACT), 2014 to 2016.

Participants All children enrolled in their first year of full-time primary education (Kindergarten) were invited to participate. Of the 16,662 eligible Kindergarten children, 15,040 completed the survey for the first time.

Outcome measures Average daily physical activity participation and prevalence of risk of behavioural and mental health disorders derived from parent-reported data and the Strengths and Difficulties Questionnaire (SDQ). Characteristics associated with SDQ *Total difficulties* and subscales were estimated using logistic regression.

Results 8,340 (61.7%) children met physical activity targets (60 minutes or more daily) and 709 (4.8%) were at clinically significant risk of behavioural and mental health disorders (*Total difficulties*).

Known sociodemographic correlates were also those variables associated with high risk of behavioural and mental health disorders (*Total difficulties*): Aboriginal and Torres Strait Islander status (OR 2.72, 95% CI 1.78-4.16), relative socioeconomic disadvantage (most disadvantaged versus least disadvantaged, OR 1.86, 95% CI 1.38-2.50), and male sex (OR 1.80, 95% CI 1.49-2.17). Average daily physical activity was not significant, despite the highest levels of physical activity (90 minutes or more daily) being reported in boys, Aboriginal and Torres Strait Islander children, and those from more disadvantaged areas.

Conclusions Our study provides comprehensive cross-sectional data on the relationship between physical activity participation and the risk of behavioural and mental health disorders in a large cohort of early school-aged Australian children. Aboriginal and Torres Strait Islander children, boys, and those from the most disadvantaged socioeconomic group were at greatest risk of clinically significant behavioural and mental health disorders.

Strengths and limitations of this study

- The Kindergarten Health Check has been conducted for several years and has excellent response rates.
- There is a large sample for analysis.
- The survey includes well-validated questions including the Strengths and Difficulties Questionnaire and measured anthropometric data.
- The KHC is a series of cross-sectional surveys so we can demonstrate relationships between variables, but inference cannot be made about causality.
- The survey includes parent-reported data on physical activity. The questions on physical activity had a lower response rate than other variables.

INTRODUCTION

Physical inactivity is associated with many potentially preventable chronic diseases[1] and childhood is a key time for increasing participation in physical activity.[2] The benefits of physical activity start in childhood with protective effects on cardiovascular and metabolic health.[3,4] The importance of

1
2
3 physical activity for school-aged children has been recognised by the World Health Organization, and
4 within Australia through the *Australian 24-hour movement guidelines for children and young people*
5 *(5 to 17 years)*.^[5,6]
6

7 The evidence on the association between physical activity and mental wellbeing and behavioural
8 disorders in young children is mixed. Several studies have associated physical activity participation
9 with lower rates of depression and anxiety, and improved self-esteem.^[7-8] However, mixed and
10 contradictory results have been found and there is a paucity of information for younger
11 children.^[7,9,10] In their systematic review of early childhood physical activity and psychosocial
12 wellbeing, Hinkley et al.^[11] found supportive, null and even adverse associations between physical
13 activity and a range of psychosocial wellbeing and behavioural outcomes. More recent systematic
14 reviews continue to find mixed evidence. Carson et al. ^[12] showed a favourable relationship
15 between physical activity and psychosocial health in preschool aged children based on an
16 experimental study, while observational studies gave mixed results. Poitras et al. ^[13] assessed the
17 relationship between objectively measured physical activity and indicators such as behavioural
18 conduct/prosocial behaviour, psychological distress and self-esteem in 5-17-year-olds, however
19 none of the included studies were for primary school-aged children. Nevertheless, physical activity
20 may have a role in mitigating the increasing burden of mental health disorders in children. Anxiety,
21 autism spectrum disorder, conduct disorder, and depressive disorders ranked among the six largest
22 contributors to the burden of disease for Australian boys and girls aged 5-14 years in 2011.^[1] The
23 *2013-14 Australian Child and Adolescent Survey of Mental Health and Wellbeing (Young Minds*
24 *Matter)* survey reported a mental disorder in 14% of boys and 7% of girls in Kindergarten or pre-
25 primary.^[14]
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31 Despite the importance of physical activity, few children are meeting recommended targets. The *24-*
32 *hour movement guidelines* recommend Australian primary school-aged children get at least 60
33 minutes of moderate to vigorous intensity physical activity daily.^[6] The 2011-12 Australian Health
34 Survey (AHS) found 36% of children aged 5-8 years met the recommended 60 minutes or more of
35 physical activity on all seven days prior to interview, with a further 34% meeting this target on 5-6
36 of the preceding seven days.^[15] The Australian Capital Territory (ACT) General Health Survey found
37 44% of children aged 5-12 years were active for at least 60 minutes each day in 2015-2016.^[16]
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40 We know that fewer than half of young Australian children meet physical activity targets, including
41 primary school-aged children in the ACT. It is also well known that sociodemographic characteristics
42 play an important part in health and wellbeing. However, we lack information about children in early
43 childhood, how their physical activity levels may relate to risk of mental and behavioural health
44 disorders, and how sociodemographic factors may influence these for young children in the ACT.
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47 The ACT Kindergarten Health Check (KHC) is offered to all children in the ACT in their first year of
48 full-time primary school and collects information on risk of mental health and behavioural disorders
49 and physical activity. Our study aimed to estimate the association between physical activity and risk
50 of mental health and behavioural disorders and how this may differ for Aboriginal and Torres Strait
51 Islander children, and those from different socioeconomic backgrounds.
52

53 **METHODS**

54
55 The KHC is an annual cross-sectional survey of all children in the ACT in their first year of full-time
56 primary education (Kindergarten). All eligible children enrolled in ACT Kindergartens are invited to
57 participate in the survey; participation is voluntary. The KHC consists of a paper questionnaire
58 completed by parents at the start of the school year, and a physical health check performed by the
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3 School Health Nurses during the school year for all children whose parents consent to their
4 participation. More information on the KHC is included in Supplementary File 1. Our study analyses
5 data from the 2014 to 2016 surveys. Children who were identified as repeating Kindergarten within
6 the ACT were excluded from the analysis for their second year. The data collection and consent
7 process has been granted ethics approval through the ACT Health Human Research Ethics
8 Committee (ETHLR.13.316). Ethics approval for our study was granted by the ACT Health Human
9 Research Ethics Committee's Low Risk Sub-Committee (ETHLR.17.080).

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12 The KHC collects demographic data (date of birth, sex, Aboriginal or Torres Strait Islander status,
13 home address) and information on selected conditions and behaviours. Parents were asked to report
14 on their child's physical activity outside of school hours in terms of the number of school days and
15 hours/minutes of activity on these days, and similar for weekend days. These were combined to
16 determine the average daily activity of children and were assessed against the targets for moderate
17 to vigorous physical activity from the *Australian 24-hour movement guidelines for children aged 5-17*
18 *years*.^[6] As our study population are children at school, we used the guidelines for school-aged
19 children (5-17-year-olds), rather than those in early years including pre-school (0-5-year-olds). The
20 KHC physical activity survey questions are included within the survey instrument, which is included
21 as Supplementary File 2.

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23
24 The parent-completed questionnaire includes the Strengths and Difficulties Questionnaire (SDQ).
25 The SDQ contains 25 questions asking parents to assess their child's behaviour and psychological
26 traits over the previous six months. It is a well-validated behavioural screening questionnaire for
27 children, adapted for use in Australia from the original developed by Goodman.^[17] The questions
28 ask about positive and negative attributes which are used to calculate scores for emotional
29 difficulties, conduct problems, hyperactivity & inattention, peer relationship problems, and prosocial
30 behaviour. A *Total difficulties* score is calculated from all subscales except prosocial behaviour.
31 Children are scored as close to average, slightly raised, or high risk.

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34 The physical health check includes measurement of height and weight by School Health Nurses.
35 Body mass index was calculated and classified into weight categories based on age- and sex-specific
36 cut-offs.^[18] Health concerns from either the questionnaire or health screen are communicated to
37 the child's primary carer and nominated general practitioner.

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40 We linked the KHC with an indicator of socioeconomic disadvantage—the 2016 Index of Relative
41 Socio-Economic Disadvantage (IRSD), one of the Socio-Economic Indexes for Areas (SEIFA) produced
42 by the Australian Bureau of Statistics.^[19] IRSD was mapped to geocoded home addresses at the
43 finest geographic level available, the Statistical Area Level 1 (SA1). We created quintiles of
44 socioeconomic disadvantage for the ACT by ranking the IRSD scores for ACT SA1 regions and dividing
45 them into five equal cohorts. These quintiles are specific to the ACT and differ from those based on
46 the national profile. The ACT is relatively advantaged compared to the national average, with 78% of
47 the ACT in the least disadvantaged quintile based on the national IRSD profile.^[19]

51 **Statistical analysis**

52
53 Our analysis comprised producing unweighted prevalence estimates and logistic regression analysis.
54 Confidence intervals for prevalence estimates were calculated using binomial sampling. Logistic
55 regression was performed with dependent variable *Total difficulties* (high versus slightly
56 raised/average risk) and independent variables sex, Aboriginal and Torres Strait Islander status,
57 relative socioeconomic disadvantage, total daily physical activity (minutes), body mass index, and
58 age (months). Average daily physical activity was skewed, so the cube root transformation was used.
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A sensitivity analysis was conducted with categories of physical activity participation in lieu of continuous data. Analysis was also run with SDQ subscales as the dependent variable.

Analysis was conducted in SPSS Version 24. Missing data were excluded from the analysis.

Patient and public involvement

Patients and the public were not involved in the design of the study.

RESULTS

Of the 16,662 children enrolled in Kindergarten in ACT schools during the study period, 15,146 (90.9%) participated in the KHC. Data for 106 children who were identified as repeating Kindergarten within the ACT were excluded from the analysis for their second year of participation. Of the remaining 15,040 children, 94.0% participated in the health screen (Figure 1). Overall, 14,136 (84.8% of enrolled children) participated in the KHC parent-completed questionnaire and physical health check for the first time.

Baseline characteristics of study participants are shown in Table 1. Over 75% of children were of a healthy weight with 3.6% in the obese weight range and 6.0% considered underweight. Nearly two-thirds (61.7%) met physical activity targets of 60 minutes or more on average daily, however 13% averaged less than 30 minutes daily. Five per cent of children had a high-risk *Total difficulties* score; that is, they were at significantly increased risk of clinically significant mental health and behavioural disorders. Analysis of the SDQ subscales showed that a higher proportion of children had high risk scores for hyperactivity & inattention than for the other domains, and peer problems was the domain with the lowest proportion of high-risk scores.

Table 1: Characteristics of children in the Kindergarten Health Check, 2014–2016

Characteristic	Number	Per cent (95% CI)
Mean (SD) age on commencement (years)	5.27 (0.31)	
Age at 30 April of enrolment year		
< 5 years	91	0.6 (0.5-0.7)
5 to <6 years	13,947	92.7 (92.3-93.1)
6 years or more	1,002	6.7 (6.3-7.1)
Sex		
Male	7,754	51.6 (50.8-52.4)
Female	7,286	48.4 (47.6-49.2)
Indigenous status ^(a)		
Aboriginal or Torres Strait Islander	348	2.3 (2.1-2.6)
Not Aboriginal or Torres Strait Islander	14,649	97.7 (97.4-97.9)
Socioeconomic status ^(b)		
Most disadvantaged quintile (Q1)	2,676	18.5 (17.9-19.2)
Q2	2,915	20.2 (19.5-20.8)
Q3	3,166	21.9 (21.2-22.6)
Q4	2,881	19.9 (19.3-20.6)
Least disadvantaged quintile (Q5)	2,805	19.4 (18.8-20.1)
School sector		
Government school	9,773	65.0 (64.2-65.7)
Non-government school	5,267	35.0 (34.3-35.8)
Body mass index ^(c)		
Underweight	851	6.0 (5.6-6.4)
Healthy weight	11,023	78.1 (77.4-78.7)
Overweight	1,736	12.3 (11.8-12.8)
Obese	511	3.6 (3.3-3.9)
Mean (SD) daily physical activity participation (minutes) ^(d)	85.6 (66.51)	
Average daily physical activity participation ^(d)		
< 30 minutes	1,782	13.2 (12.6-13.8)
30 to <60 minutes	3,382	25.0 (24.3-25.8)

	60 to <90 minutes	3,392	25.1 (24.4-25.8)
	≥ 90 minutes	4,948	36.6 (35.8-37.8)
Strengths and Difficulties Questionnaire high-risk subscale scores ^(e)	Emotional difficulties	915	6.1 (5.8-6.5)
	Conduct problems	1,019	6.8 (6.4-7.3)
	Hyperactivity & inattention	1,232	8.3 (7.8-8.7)
	Peer problems	101	0.7 (0.5-0.8)
	<i>Total difficulties</i>	709	4.8 (4.4-5.1)
	Prosocial	421	2.8 (2.6-3.1)
All children		15,040	100.0

Notes:

(a) Excludes children for whom Indigenous status was not available.

(b) Socioeconomic status based on ACT quintiles of relative disadvantage from IRSD at SA1 level. Excludes children for whom socioeconomic status was not available.

(c) Excludes those for whom body mass index not available.

(d) Excludes those for whom physical activity participation not available.

(e) Each category excludes those children for which the reported measure is not available.

Figure 2 shows that children meeting physical activity target of 60 minutes or more daily were more likely to be of Aboriginal and Torres Strait Islander origin, or boys. Children who were underweight were less likely than other children to participate in 60 minutes or more of physical activity daily. Aboriginal and Torres Strait Islander children had the highest level of reported activity, with half averaging 90 minutes or more daily.

The attributes of children with high-risk *Total difficulties* scores is shown in Table 2. These children were more likely to be boys, of Aboriginal and Torres Strait Islander origin, or from the most disadvantaged socioeconomic groups. No increase in risk was seen based on average daily physical activity (Figure 2).

Boys were more likely than girls to be rated high risk for conduct problems, hyperactivity & inattention, and prosocial behaviour difficulties (Table 2). Very few children (<1%) were rated high risk for peer problems. Aboriginal and Torres Strait Islander children were more likely than other children to be rated high risk for all subscales excluding peer problems. Children in the most disadvantaged two quintiles were more likely to be at high risk for emotional difficulties, conduct problems and hyperactivity & inattention.

Of the 15,040 children in the study, 12,097 (80.4%) were included in the main logistic regression model (dependent variable, high-risk *Total difficulties* score) (Table 3). Aboriginal and Torres Strait Islander background was the strongest predictor of being at substantial risk of clinically significant problems (OR 2.72, 95% CI 1.78–4.16). Being from the most disadvantaged socioeconomic quintile was the next highest predictor of risk (OR 1.86, 95% CI 1.38–2.50). The risk of significant problems decreased with decreasing relative socioeconomic disadvantage, however the odds ratios were significantly different for the two most disadvantaged quintiles (Table 3). Boys were more likely to be at high risk than girls (OR 1.80, 95% CI 1.49–2.17). Age at enrolment was weakly significant with a small impact on risk. Total daily physical activity and body mass index were not significant predictors in the model.

Logistic regression was also undertaken for the SDQ subscales (Table 3). Odds ratios were significant for boys for all domains other than emotional difficulties. Aboriginal and Torres Strait Islander children were at increased risk for emotional difficulties, conduct problems, and hyperactivity & inattention, however they were not at increased risk for peer problems or prosocial behaviour difficulties. Being from the most disadvantaged socioeconomic quintile was associated with

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3 increased odds of conduct problems and hyperactivity & inattention. Physical activity was associated
4 with lower odds of peer problems and prosocial behaviour difficulties.
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6 Logistic regression analyses for *Total difficulties* and the SDQ subscales where physical activity was
7 included as a categorical variable were done as part of a sensitivity analysis (Supplementary File 3).
8 Odds ratios for independent variables, other than physical activity, showed only minor differences
9 from those in the models where physical activity was included as a continuous variable. For *Total*
10 *difficulties* and hyperactivity & inattention, 60 to <90 minutes of daily physical activity was significant
11 in the models (baseline, <30 minutes daily). For prosocial behaviour, all categories were significant
12 compared to baseline. Physical activity was not significant for the remaining SDQ subscales.
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Table 2: Characteristics of children rated high risk for strengths and difficulties subscales, 2014–2016

SDQ Subscale ^(e)	Sex		Indigenous status ^(a)		Socioeconomic status ^(b)					Body mass index ^(c)			
	Male	Female	Aboriginal or Torres Strait Islander	Not Indigenous	Q1	Q2	Q3	Q4	Q5	Under-weight	Healthy weight	Over-weight	Obese
	number (per cent)												
Total difficulties	471 (6.1)	238 (3.3)	43 (12.5)	663 (4.6)	179 (6.8)	165 (5.7)	132 (4.2)	130 (4.6)	87 (3.1)	35 (4.2)	495 (4.5)	79 (4.6)	41 (8.1)
Emotional difficulties	473 (6.2)	442 (6.1)	41 (11.9)	871 (6.0)	204 (7.7)	196 (6.8)	177 (5.6)	153 (5.4)	158 (5.7)	52 (6.2)	662 (6.1)	100 (5.8)	53 (10.5)
Conduct problems	626 (8.2)	393 (5.5)	42 (12.2)	976 (6.7)	234 (8.8)	228 (7.9)	198 (6.3)	172 (6.0)	157 (5.6)	35 (4.2)	726 (6.6)	135 (7.8)	40 (7.9)
Hyperactivity & inattention	827 (10.8)	405 (5.6)	59 (17.2)	1,167 (8.1)	275 (10.4)	276 (9.6)	219 (7.0)	217 (7.6)	203 (7.3)	57 (6.8)	880 (8.1)	145 (8.4)	52 (10.3)
Peer problems	77 (1.0)	24 (0.3)	n.p.	n.p.	22 (0.8)	21 (0.7)	20 (0.6)	22 (0.8)	13 (0.5)	10 (1.2)	59 (0.5)	16 (0.9)	6 (1.2)
Prosocial	296 (3.9)	125 (1.7)	15 (4.4)	405 (2.8)	80 (3.0)	73 (2.5)	95 (3.0)	90 (3.1)	68 (2.4)	26 (3.1)	299 (2.7)	44 (2.5)	17 (3.4)

n.p. not published due to small cell size

Notes:

(a) Excludes children for whom Indigenous status was not available.

(b) Socioeconomic status based on ACT quintiles of relative disadvantage from IRSD at SA1 level. Q1 – most disadvantaged; Q5 – least disadvantaged. Excludes children for whom socioeconomic status was not available.

(c) Excludes those for whom body mass index not available.

(e) Each category excludes those children for which the reported measure is not available.

Table 3: Odds ratios from logistic regression analyses

SDQ Subscale ^(b)	Logistic regression independent variables ^(a)										
	Sex	Indigenous status	Socio-economic status ^(c) Q1	SES Q2	SES Q3	SES Q4	Physical activity	Under-weight ^(d)	Over-weight ^(d)	Obese ^(d)	Age
	Odds Ratio (95% CI)										
Total difficulties	1.80 (1.49-2.17)	2.72 (1.78-4.16)	1.86 (1.38-2.50)	1.50 (1.11-2.03)	1.30 (0.96-1.77)	1.29 (0.95-1.76)	0.96 (0.88-1.04)	1.05 (0.72-1.53)	1.05 (0.79-1.38)	1.86 (1.27-2.72)	1.03 (1.00-1.05)
Emotional difficulties	0.97 (0.83-1.13)	1.98 (1.30-3.01)	1.26 (0.99-1.60)	1.09 (0.86-1.38)	0.96 (0.86-1.38)	0.91 (0.71-1.16)	0.94 (0.87-1.01)	0.98 (0.70-1.36)	0.94 (0.74-1.20)	1.78 (1.28-2.47)	1.03 (1.01-1.06)
Conduct problems	1.57 (1.35-1.82)	1.66 (1.09-2.54)	1.48 (1.17-1.87)	1.32 (1.05-1.67)	1.08 (0.85-1.37)	0.98 (0.77-1.25)	0.99 (0.93-1.07)	0.58 (0.39-0.85)	1.29 (1.05, 1.59)	1.15 (0.79-1.68)	1.02 (1.00-1.04)
Hyperactivity & inattention	2.02 (1.75-2.33)	1.85 (1.26-2.72)	1.35 (1.09-1.67)	1.27 (1.03-1.57)	0.91 (0.73-1.13)	1.05 (0.84-1.30)	0.97 (0.91-1.04)	0.91 (0.67-1.22)	1.09 (0.89-1.34)	1.41 (1.02-1.94)	1.01 (0.99-1.02)
Peer problems	2.73 (1.61-4.64)	1.43 (0.35-5.91)	1.67 (0.74-3.73)	1.22 (0.53-2.84)	1.70 (0.78-3.70)	1.78 (0.82-3.86)	0.78 (0.62-0.98)	2.42 (1.18-4.98)	1.90 (1.02-3.52)	1.93 (0.69-5.41)	1.03 (0.97-1.10)
Prosocial	2.49 (1.94-3.19)	0.66 (0.24-1.80)	1.27 (0.87-1.85)	1.14 (0.78-1.66)	1.36 (0.95-1.93)	1.28 (0.89-1.84)	0.78 (0.70-0.87)	1.07 (0.68-1.68)	1.13 (0.81-1.58)	1.03 (0.56-1.91)	1.00 (0.97-1.03)

(a) Reference categories: girls, non-Indigenous, Q5 - least disadvantaged, healthy weight (BMI); physical activity and age are continuous.

(b) Each category excludes those children for which the reported measure is not available.

(c) Socioeconomic status based on ACT quintiles of relative disadvantage from IRSD at SA1 level. Q1 – most disadvantaged; Q5 – least disadvantaged.

(d) Based on BMI.

DISCUSSION

Our study found nearly two-thirds of ACT Kindergarten children were meeting physical activity targets of 60 minutes or more daily. These children were more likely to be boys, of Aboriginal or Torres Strait Islander background, or from the most disadvantaged socioeconomic areas.

The 2011-12 AHS found similar proportions of boys (36%) and girls (35%) aged 5-8 years met the recommended 60 minutes or more of physical activity on all seven days prior to interview.[15] However similar to our study, boys undertook more daily exercise. Boys aged 5-17 years spent an average of 78 minutes in moderate to vigorous activity daily, compared to 67 minutes for girls. There were no statistically significant differences in the proportion of children aged 5-17 years meeting physical activity targets based on socioeconomic status (IRSD).

In our study, the groups of children with higher daily physical activity also had a higher risk of behavioural and mental health disorders, with boys having double the rate of high-risk *Total difficulties* scores as girls (6.1% vs 3.3%). Aboriginal and Torres Strait Islander children had more than double the proportion at high risk compared to non-Indigenous children (12.5% versus 4.6%), and children from the most disadvantaged socioeconomic group also over-represented. Children who were obese were more likely to have high-risk *Total difficulties* score, but there was no significant difference in their physical activity participation compared to other children.

Our results are consistent with SDQ data for Australian children aged 4-12 years; higher rates of high-risk *Total difficulties* were seen for boys compared to girls (12.7% versus 7.7%) and children in the most disadvantaged socioeconomic groups (15.6% in the lowest SES quintile versus 7.2% in the highest SES quintile).[20] Aboriginal and Torres Strait Islander children have also been shown elsewhere to have higher SDQ scores than the Australian average.[21]

Boys in our study were more likely to be at high risk for conduct problems, hyperactivity & inattention, peer problems, and prosocial behaviour difficulties. They were equally likely as girls to be high risk for emotional problems.

Children of Aboriginal and Torres Strait Islander background and children with relative socioeconomic disadvantage were more likely to be at high risk for emotional problems, conduct problems, and hyperactivity & inattention.

The Australian Early Development Census (AEDC) is a three-yearly census of children in their first year of full-time primary education. Data from the 2018 AEDC found similar patterns to our study. Boys were more likely to be developmentally vulnerable than girls; including the social competence and emotional maturity domains.[22] Aboriginal and Torres Strait Islander children were more likely to be developmentally vulnerable than other children, as were children from the most disadvantaged socioeconomic groups.

We did not demonstrate an association between physical activity and high-risk *Total difficulties* score in our study, despite other research linking physical activity participation with reduced depressive symptoms. Our study considered all physical activity together and it may be that different forms of physical activity provide different benefits. For example, Eime et al.[23] propose that participation in sport may have psychological benefits beyond that from other forms of physical activity. We did find that increased physical activity participation was associated with lower odds of peer problems and prosocial behaviour difficulties. In their systematic review, Hinkley et al.[11] found supportive associations between physical activity with conduct problems, emotional competence, emotional symptoms, hyperactivity/inattention and peer relationships, but conversely

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3 also found studies with adverse associations between physical activity with conduct problems and
4 hyperactivity/inattention. Many more studies showed no significant associations.
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6 The ratio of boys to girls at high risk for *Total difficulties* in our study is consistent with findings from
7 *Young Minds Matter*, however our estimates are lower than their reported prevalence of mental
8 health disorders (13.6% of boys and 7.1% of girls).[14] Two factors that may explain the difference
9 are the survey scope and survey tools used. The KHC surveys children attending schools in the ACT
10 only, and uses the SDQ to assign risk of mental health disorders. *Young Minds Matter* assessed
11 children across Australia and used the Diagnostic Interview Schedule for Children Version IV to
12 identify mental health disorders.[14]
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15 In our study, boys were at higher risk than girls for all subscales of the SDQ other than emotional
16 difficulties. Boys in Kindergarten or pre-primary in *Young Minds Matter* had a higher prevalence of
17 all and different types of mental disorders, compared to girls of the same age.[14] Among primary
18 school-aged children they found a higher prevalence of anxiety disorders, ADHD and conduct
19 disorders for boys, and a higher prevalence of major depressive disorder for girls. However, for high
20 school-aged children, males had higher rates of ADHD and conduct disorders, but females had a
21 greater prevalence of major depressive disorder and anxiety disorders. The 2017-18 National Health
22 Survey found that amongst adults, females report higher rates of psychological distress than
23 men.[24] This begs the question as to whether risks and prevalence of behavioural and mental
24 health disorders are becoming more common for males, whether males are more vulnerable only in
25 the younger age groups, or whether risk varies for different conditions.
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29 Aboriginal and Torres Strait Islander children in our study had the highest reported levels of physical
30 activity. Despite the potential benefits of physical activity, these children also had the highest levels
31 of risk for behavioural and mental health disorders overall (*Total difficulties*), emotional difficulties,
32 conduct problems, and hyperactivity & inattention. High risk of mental illness has been reprinted
33 elsewhere and has in part been attributed to the impacts of intergenerational trauma.[25] It is well
34 known that Aboriginal and Torres Strait Islanders have poorer health outcomes than other
35 Australians, and these data have been extensively reported elsewhere.[26]
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38 Despite the ACT being a fairly homogenous jurisdiction with respect to socioeconomic advantage,
39 degrees of relative disadvantage were found in our study. Children from the two most
40 disadvantaged quintiles were significantly more likely to be at high risk of behavioural and mental
41 health disorders than those from less disadvantaged areas. The relationship between lower
42 socioeconomic status and poorer health outcomes has been seen in numerous settings. The World
43 Health Organization's report *Closing the gap in a generation* presents comprehensive and
44 compelling data demonstrating poorer health outcomes both between and within countries based
45 on different elements of social and economic disadvantage.[27] In all countries, people in the least
46 socioeconomically advantaged groups have poorer health outcomes. An independent report
47 commissioned by the British Government—*The Marmot Review*—noted that health inequalities
48 arise secondary to societal inequalities, and that to reduce health inequality society needs to reduce
49 social gradients affecting children.[28] The Australian Children's Headlines Indicators show that
50 across the board children of the least socioeconomic advantage have poorer outcomes than those
51 from the highest.[20]
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56 **Strengths and Limitations**

57 The KHC has a number of strengths. It has been conducted for several years, is offered to all children
58 and thus not subject to sampling error, and has excellent response rates, providing a large sample
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3 for analysis. It includes well-validated questions including the SDQ. It includes measured
4 anthropometric data, which is known to be more accurate than self-reported data.[29]
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6 The KHC is a series of cross-sectional surveys; we can therefore demonstrate relationships between
7 variables, but inference cannot be made about causality. Despite the high overall response rate,
8 some questions were subject to lower participation. This includes physical activity, which was one of
9 the key variables in our study.
10

11 The KHC data are subject to non-response and other non-sampling error. All Kindergarten children in
12 all ACT schools were invited to participate, with an overall response rate of 90.6%. The
13 characteristics of children who did not participate in the survey may have been different to those
14 that did. As the response rates were high, any effects of non-response were considered unlikely to
15 be significant. If outcomes were correlated within schools, this may cause clustering which would
16 impact error estimates. For the purposes of our study, this was considered unlikely to be significant.
17 All data are subject to non-sampling error. An example of this is the physical activity measure, which
18 is derived from parent-reported data. As with anthropometric data, measured, objective, physical
19 activity data is more accurate than parent-reported activity.[30]
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23 Our study did not measure screen time, which is a proxy measure for inactivity, and it may be that
24 high screen time negates the benefits of physical activity or may be an independent risk
25 factor.[31,32] The *Australian 24-hour movement guidelines for children and young people (5 to 17*
26 *years)* recommend limiting sedentary recreational screen time to no more than two hours per day,
27 and breaking up long periods of sitting as often as possible.[6] The Canadian review of evidence for
28 5-17-year-olds found that increased sedentary behaviour was associated with unfavourable health
29 outcomes a range of indicators.[33] The KHC questionnaire will include parental report of screen
30 time from 2019.
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33 We undertook the logistic regression using standard categories for degree of risk from the SDQ. It is
34 possible that different relationships may have been observed if the raw scores were used, as was
35 done in the study by Griffiths et al.[9]
36
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38 A potential limitation of using the area-based Index of Relative Socioeconomic Disadvantage to
39 create quintiles of socioeconomic disadvantage for our analysis is that this reflects the area children
40 live in rather than their personal attributes.
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42 Disadvantage in the ACT is found when looking at very small areas, which area-based measures such
43 as SEIFA may miss.[34,35] An alternative school-based measure, the Index of Community Socio-
44 Educational Advantage (ICSEA), was considered as the school a child attends may better reflect their
45 level of socioeconomic disadvantage than the suburb they live in. However, its derivation includes
46 the proportion of Indigenous students at the school.[36] If a sub-population of interest is used in the
47 creation of an area-based measure, it may introduce bias into the results.[37] We had geocoded
48 data and we were able to use IRSD at the finest available level – SA1 – which overcomes some of the
49 limitations of using area-based measures.
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52 **CONCLUSION**

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54 Increased risk of clinically significant behavioural and mental health disorders was seen for boys,
55 Aboriginal and Torres Strait Islander children, and those from socioeconomically disadvantaged
56 areas. Despite evidence that physical activity is protective for mental health, we did not find that
57 children who participated in more physical activity had different levels of overall risk than other
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children. Lower levels of physical activity were associated with being at high risk for peer relationship problems or prosocial behaviour difficulties.

Boys in early childhood are at higher risk of developing clinically significant behavioural and mental health disorders, compared to girls of the same age. Programs or tailored supports may be needed for boys in this age group.

Health inequalities due to socioeconomic disadvantage are evident from a young age. Interventions that focus on addressing inequity and the impacts of intergenerational trauma, rather than promoting healthy lifestyles, are likely to have greater impact on young children's mental wellbeing.

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FOOTNOTES

Contributors: KO, JA and KD conceived the original idea and structure of the paper. KO, JA, KC and KD planned the analysis. KC cleaned and provided the de-identified data. KO prepared the final dataset and undertook the data analysis. KO wrote the paper with significant structural and content input from JA, KC and KD. All authors approved submission of the manuscript for publication.

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Competing interests: None declared.

Ethics approval: The data collection and consent process has been granted ethics approval through the ACT Health Human Research Ethics Committee (ETHLR.13.316). Ethics approval for our study was granted by the ACT Health Human Research Ethics Committee's Low Risk Sub-Committee (ETHLR.17.080).

Data sharing statement: No additional data available for this study. The Kindergarten Health Check is an ACT Health database. Access can be applied for by emailing: augp@anu.edu.au.

Word count: 3,793

FIGURE LEGENDS

Figure 1 Participation rates for the Kindergarten Health Check, 2014–2016

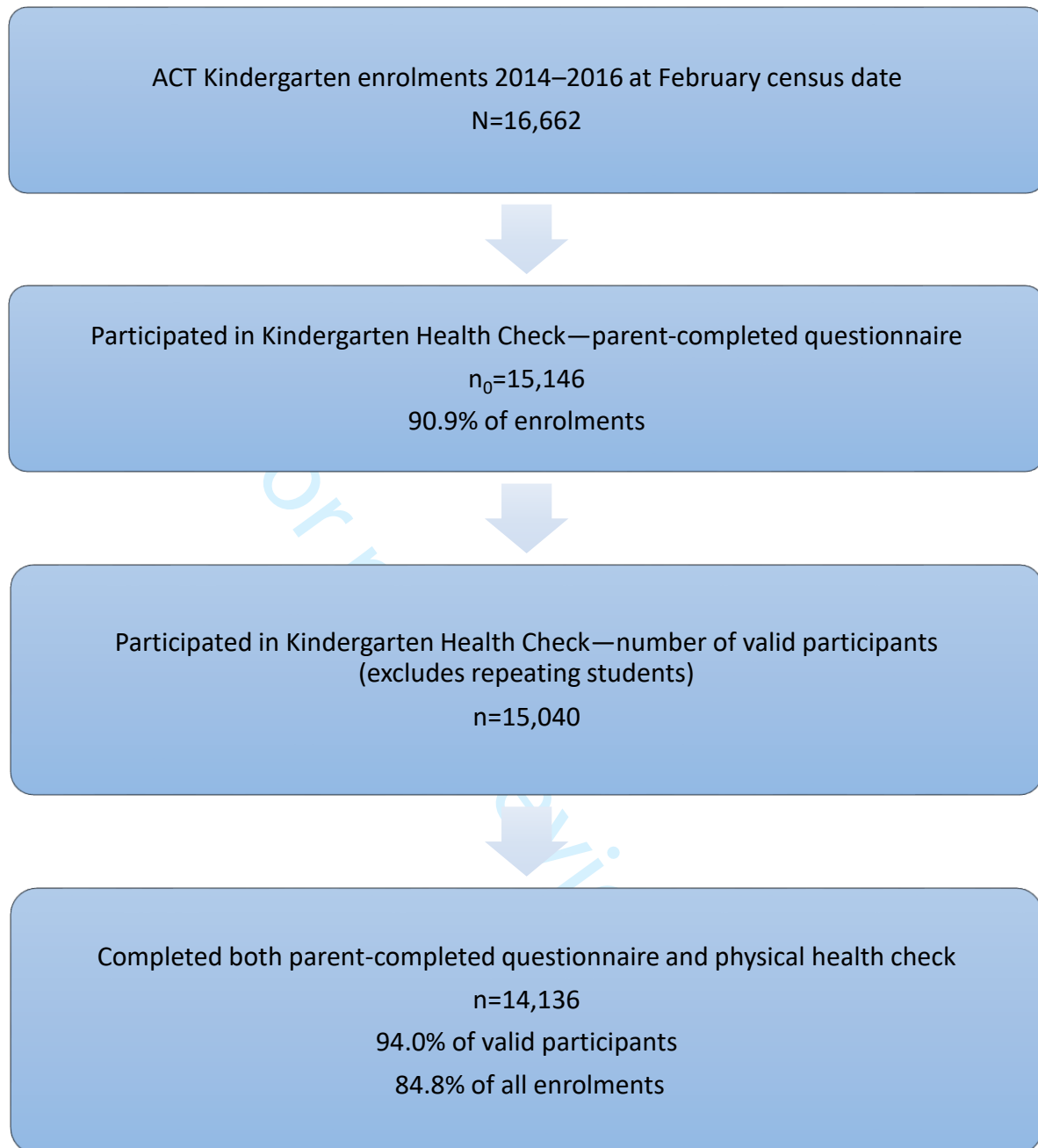
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3 *Source:* ACT Education and Training Directorate[38-40] and KHC 2014-2016.
4 *Note:* Enrolment data derived from the February census within each year.
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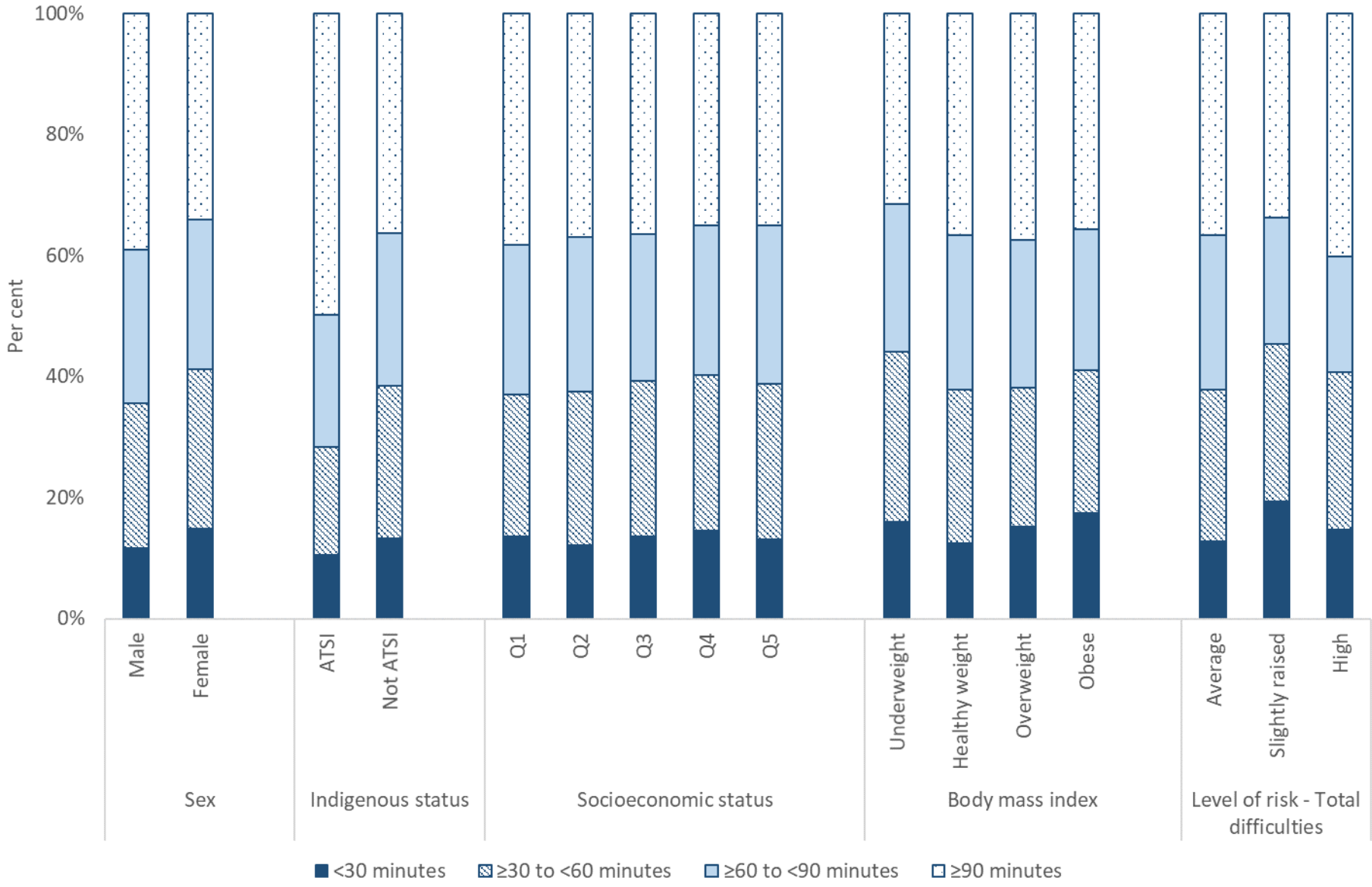
8 **Figure 2** Characteristics of children by average daily physical activity participation, 2014-2016

9 *Notes:*

- 10 (a) Excludes children for whom Indigenous status was not available.
11 (b) Socioeconomic status based on ACT quintiles of relative disadvantage from IRSD at SA1 level. Q1 – most disadvantaged; Q5 – least
12 disadvantaged. Excludes children for whom socioeconomic status was not available.
13 (c) Excludes those for whom body mass index not available.
14 (d) Excludes those for whom physical activity participation not available.
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For peer review only





Supplement 1: Kindergarten Health Check methods

The Kindergarten Health Check (KHC) is conducted annually in the Australian Capital Territory (ACT). See: <https://health.act.gov.au/services-and-programs/women-youth-and-children/children-and-youth/school-health>

All children in their first year of full-time primary education (Kindergarten) in the ACT are invited to participate. Participation is voluntary. Paper survey forms are distributed to parents/guardians of eligible children via their schools in early February of the school year. Parent-completed questionnaires are collected by schools on behalf of the School Health Nurses a few weeks later.

Physical health checks are conducted by School Health Nurses between April and October of that year for all children whose parents/guardians' consent to their participation. The physical health check includes body measurements (height, weight), vision check and hearing check. Results are recorded on a paper survey form. The KHC is conducted using best practice protocols as informed by recent literature, including protocols for measuring height and weight.

Denominator data is derived from The ACT Education Directorate census data.

The same survey instrument was used for 2014-2016. A copy of the 2016 survey instrument is included as Supplementary File 2.

These questions ask you about your child's vision and hearing. Please tick ✓ the required boxes.

VISION

1. Do you have any concerns about your child's vision? Yes No

If yes, please describe: _____

2. Has your child been prescribed glasses? Yes No

If yes, when should they be worn? (e.g. when reading): _____

3. Has your child ever received, or are they receiving medical care for their eyes or vision? Yes No

If yes, please describe: _____

HEARING

1. Do you have any concerns about your child's hearing or airways? Yes No

If yes, please describe: _____

2. Has your child had any of the following? Tick all that apply.

Repeated ear infections Yes No

Discharging ears Yes No

Hearing Loss Yes No

Grommets Yes No If yes, when were these inserted? _____

Snoring Yes No

3. Has your child ever received or are they receiving medical care for their ears, hearing or airways?

Yes No

If yes, please describe: _____

Would you like information on any of the following? Tick all that apply.

Wetting pants Yes No

Wetting the bed Yes No

Soiling pants Yes No

This completes the questions relating to the health check conducted by the School Health Nurses.

The results will be posted to your nominated address.

Please continue answering the questions about your child's development on the following pages.

If you have any concerns about your child's health, please see your GP.

These questions ask you about your child's strengths and difficulties.

Instructions: For each item, please tick the box for Not True, Somewhat True or Certainly True. It would help us if you answered all items as best you can, even if you are not absolutely certain. Please give your answers on the basis of your child's behaviour over the last 6 months.

STRENGTHS AND DIFFICULTIES QUESTIONNAIRE	Not True	Somewhat True	Certainly True
1. Considerate of other people's feelings	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Restless, overactive, cannot sit still for long	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Often complains of headaches, stomach-aches or sickness	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. Shares readily with other children for example toys, treats, pencils	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. Often loses temper	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. Rather solitary, prefers to play alone	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. Generally well behaved, usually does what adults request	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. Many worries, or often seems worried	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. Helpful if someone is hurt, upset, or feeling ill	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10. Constantly fidgeting or squirming	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11. Has at least one good friend	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12. Often fights with other children or bullies them	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
13. Often unhappy, depressed or tearful	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
14. Generally liked by other children	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
15. Easily distracted, concentration wanders	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
16. Nervous or clingy in new situations, easily loses confidence	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
17. Kind to younger children	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
18. Often lies or cheats	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
19. Picked on or bullied by other children	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20. Often volunteers to help others (parents, teachers, other children)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
21. Thinks things out before acting	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
22. Steals from home, school or elsewhere	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
23. Gets along better with adults than with other children	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
24. Many fears, easily scared	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
25. Good attention span, sees chores or homework through to the end	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

SDQ (P) 04-10 Self-Report Measure © Robert Goodman 2002

These questions ask you about asthma, eczema and hay fever.

RESPIRATORY SYMPTOMS

1. Has your child ever had wheezing or whistling in the chest? Yes No
2. Has your child ever had asthma? Yes No
3. In the last 12 months has your child experienced any of the following respiratory symptoms?
- Wheezing or whistling in the chest Yes No
- A dry cough at night not associated with a cold or chest infection Yes No
- Wheezing with coughs or colds Yes No
- Shortness of breath when exercising or playing games or participating in sports Yes No
4. In the last 12 months how often, *on average*, have the following respiratory symptoms been present?
Please tick one box on EACH line

Wheeze or whistle in the chest	<input type="checkbox"/> Never	<input type="checkbox"/> Less than 1 day / wk	<input type="checkbox"/> 1 – 3 days / wk	<input type="checkbox"/> 4 or more days / wk
Night cough or night wheeze	<input type="checkbox"/> Never	<input type="checkbox"/> Less than 1 night / wk	<input type="checkbox"/> 1 – 3 nights / wk	<input type="checkbox"/> 4 or more nights / wk
Shortness of breath (when exercising or playing)	<input type="checkbox"/> Never	<input type="checkbox"/> Less than 1 day / wk	<input type="checkbox"/> 1 – 3 days / wk	<input type="checkbox"/> 4 or more days / wk

ECZEMA

5. Has your child ever had an itchy rash that was coming and going for at least 6 months? Yes No
6. Has the itchy rash ever affected the following places? Yes No
(the fold of the elbows, behind the knees, in front of the ankles, under the buttocks, or around the neck, ears or eyes)
7. Has your child ever had eczema? Yes No

HAY FEVER

8. In the past 12 months has your child had a problem with sneezing, or a runny or blocked nose when he / she did not have a cold or the flu? Yes No
9. In the past 12 months has this nose problem been accompanied by itchy / watery eyes? Yes No
10. Has your child ever had hay fever? Yes No
11. Do any close members of the family have any of the following conditions?
- Asthma Yes No
- Eczema Yes No
- Hay fever Yes No

Adapted from The International Study of Asthma and Allergies in Childhood (ISAAC): Core questionnaire

For peer review only - <http://bmjopen.bmj.com/site/about/guidelines.xhtml>

These questions ask about your child's food intake and physical activity.

WEIGHT PERCEPTION

1. How would you describe your child's weight?

- Underweight
 Healthy weight
 Overweight
 Obese
 Don't know

2. Do you have any concerns about your child's weight?

Yes No

3. Do you have any concerns about your child's height?

Yes No

Comments: _____

DIET

The following questions are about the food your child eats.

4. How many serves of vegetables does your child usually eat each day?

(1 serve = ½ cup cooked vegetables, or ½ medium potato, or 1 medium tomato, or 1 cup salad vegetables)

- ___ serves per day *(write number of serves) OR*
 ___ serves per week *(write number of serves)*
 my child doesn't eat vegetables
 don't know

5. How many serves of fruit does your child usually eat each day?

(1 serve = 1 medium piece, or 2 small pieces of fruit, or 1 cup of diced pieces with no added sugar, or 30 grams of dried fruit such as 4 dried apricots or 1½ tablespoons sultanas)

- ___ serves per day *(write number of serves) OR*
 ___ serves per week *(write number of serves)*
 my child doesn't eat fruit
 don't know

6. Do you have any concerns about your child's eating habits?

Yes No

Comments: _____

PHYSICAL ACTIVITY

The following questions are about your child's physical activity. Physical activity is any activity that increases your heart rate and makes you get out of breath some of the time.

7. On about how many days during the school week does your child usually do physical activity outside of school hours? This includes before and after school sports, playing with friends, walking/ riding to and from school.

- ___ number of school days per week
 none
 don't know

8. On these days, about how many hours does your child usually do physical activity? *(in hours and minutes)*

- ___ hours ___ minutes *(average time on each school day)*
 don't know

9. On about how many days during the weekend does your child usually do physical activity?

- ___ number of weekend days
 none
 don't know

10. On a typical weekend day, about how many hours does your child usually do physical activity?

- ___ hours ___ minutes *(average time on each weekend day)*
 don't know

Thank you. Please return the completed form to your child's school in a sealed envelope.
 The results of the Kindergarten Health Check will be posted to your nominated address

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Supplementary Table 1: Odds ratios from logistic regression analyses, sensitivity analysis using categorical physical activity

SDQ Subscale ^(b)	Logistic regression independent variables ^(a)												
	Sex	Indigenous status	Socio-economic status ^(c)				Physical activity (minutes)			Under-weight ^(d)	Over-weight ^(d)	Obese ^(d)	Age
			Q1	Q2	Q3	Q4	30 to <60	60 to <90	≥90				
	Odds Ratio (95% CI)												
Total difficulties	1.80 (1.49-2.17)	2.69 (1.76-4.11)	1.85 (1.37-2.48)	1.50 (1.11-2.02)	1.29 (0.96-1.75)	1.28 (0.94-1.75)	0.95 (0.71-1.28)	0.67 (0.49-0.91)	0.93 (0.71-1.22)	1.06 (0.73-1.54)	1.04 (0.79-1.37)	1.85 (1.27-2.70)	1.03 (1.00-1.05)
Emotional difficulties	0.97 (0.83-1.13)	1.96 (1.29-2.98)	1.25 (0.99-1.59)	1.09 (0.85-1.38)	0.95 (0.75-1.21)	0.90 (0.71-1.16)	0.90 (0.70-1.15)	0.81 (0.63-1.04)	0.84 (0.66-1.06)	0.98 (0.70-1.36)	0.94 (0.74-1.20)	1.77 (1.28-2.46)	1.04 (1.01-1.06)
Conduct problems	1.56 (1.35-1.82)	1.65 (1.08-2.52)	1.48 (1.17-1.86)	1.32 (1.05-1.67)	1.08 (0.85-1.37)	0.98 (0.77-1.25)	1.05 (0.82-1.35)	0.91 (0.71-1.18)	1.08 (0.86-1.37)	0.58 (0.39-0.86)	1.29 (1.05-1.59)	1.15 (0.79-1.68)	1.02 (1.00-1.04)
Hyperactivity & inattention	2.03 (1.76-2.34)	1.84 (1.25-2.70)	1.34 (1.08-1.66)	1.27 (1.03-1.57)	0.90 (0.73-1.13)	1.04 (0.84-1.29)	0.87 (0.70-1.08)	0.69 (0.55-1.87)	0.88 (0.71-1.08)	0.91 (0.67-1.22)	1.09 (0.89-1.33)	1.39 (1.01-1.93)	1.01 (0.99-1.02)
Peer problems	2.72 (1.60-4.61)	1.41 (0.34-5.82)	1.65 (0.74-3.69)	1.21 (0.52-2.81)	1.68 (0.77-3.65)	1.76 (0.81-3.83)	0.91 (0.46-1.81)	0.64 (0.30-1.33)	0.60 (0.30-1.20)	2.42 (1.18-4.98)	1.89 (1.02-3.51)	1.96 (0.70-5.49)	1.03 (0.97-1.10)
Prosocial	2.48 (1.94-3.18)	0.65 (0.24-1.76)	1.25 (0.86-1.82)	1.13 (0.78-1.64)	1.34 (0.94-1.91)	1.27 (0.88-1.82)	0.70 (0.50-0.97)	0.54 (0.38-0.77)	0.52 (0.38-0.73)	1.07 (0.68-1.68)	1.12 (0.80-1.57)	1.03 (0.56-1.91)	1.00 (0.97-1.03)

(a) Reference categories: girls, non-Indigenous, Q5 - least disadvantaged, healthy weight (BMI), physical activity < 30 minutes daily; age is continuous.
 (b) Each category excludes those children for which the reported measure is not available.
 (c) Socioeconomic status based on ACT quintiles of relative disadvantage from IRSd at SA1 level. Q1 – most disadvantaged; Q5 – least disadvantaged.
 (d) Based on BMI.

STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract Page 1 Line 2; Page 2 Line 5 (b) Provide in the abstract an informative and balanced summary of what was done and what was found Page 2 Lines 5-27
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported Page 2 Line 40 to Page 3 Lines 39
Objectives	3	State specific objectives, including any prespecified hypotheses Page 3 Lines 35-39
Methods		
Study design	4	Present key elements of study design early in the paper Page 3 Line 41 to Page 4 Line 3
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection Page 3 Line 41 to Page 4 Line 28
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants Page 3 Line 41 to Page 4 Line 4
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable Page 4 Lines 2-41
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group Page 3 Line 41 to Page 4 Line 35
Bias	9	Describe any efforts to address potential sources of bias n/a
Study size	10	Explain how the study size was arrived at Page 3 Line 41 to Page 4 Line 4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why Page 3 Line 41 to Page 4 Line 35
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding Page 4 Line 37 to Page 5 Line 3 (b) Describe any methods used to examine subgroups and interactions Page 4 Line 37 to Page 5 Line 3 (c) Explain how missing data were addressed Page 5 Line 3 (d) If applicable, describe analytical methods taking account of sampling strategy Page 4 Line 37 to Page 5 Line 3 (e) Describe any sensitivity analyses Page 4 Line 43 to Page 5 Line 2
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed Figure 1 (b) Give reasons for non-participation at each stage Figure 1 (c) Consider use of a flow diagram Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders Table 1, Table 2, Figure 2 (b) Indicate number of participants with missing data for each variable of interest Table 1, Table 2
Outcome data	15*	Report numbers of outcome events or summary measures Table 1, Table 2, Figure 2
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and

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their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included [Table 1](#), [Table 2](#), [Table 3](#)

(b) Report category boundaries when continuous variables were categorized [Table 1](#), [Table 2](#), [Table 3](#)

(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period [n/a](#)

Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses Supplementary Table S2.1
Discussion		
Key results	18	Summarise key results with reference to study objectives Page 10 Line 2 to Page 11 Line 41
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias Page 11 Line 43 to Page 12 Line 39
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence Page 10 Line 2 to Page 11 Line 41
Generalisability	21	Discuss the generalisability (external validity) of the study results Page 10 Line 2 to Page 11 Line 41
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based Page 15 Lines 29-32

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.