

# Body mass index, physical activity and dietary behaviours among adolescents in the Kingdom of Tonga

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## Abstract

**Objectives:** To compare the prevalence of overweight and obesity among adolescents using international and ethnic-specific cut-off points and to examine patterns of physical activity and dietary behaviours.

**Design:** Cross-sectional analytical study.

**Setting:** Schools on Tongatapu, Vava'u and Hapa'ai islands in the Kingdom of Tonga.

**Subjects:** A total of 443 school students aged 11–16 years underwent anthropometric measures of height and weight and provided self-reported measures of physical activity and dietary behaviours.

**Results:** Mean body mass index (BMI) was higher among girls than boys ( $23.7 \text{ kg m}^{-2}$  vs.  $21.8 \text{ kg m}^{-2}$ ) and tended to increase with age. A total of 36.0% of boys and 53.8% of girls were overweight or obese using the international cut-off points, whereas 25.0% of boys and 37.6% of girls were classified in this way using Polynesian-specific cut-off points. Tinned mutton or beef was the food that most participants (56.9%) reported eating once or more per day. Over half of the young people did not eat taro, fruit or vegetables at least once per day. Regular physical activity outside of school hours was reported by 20.7% of respondents, and 58.2% watched 1 h or more of television per day. Physical activity participation was the only behaviour independently associated with a lower risk of overweight or obesity.

**Conclusions:** Using Polynesian-specific cut-off points for overweight and obesity the prevalence of these conditions was still among the highest found in adolescents. The prevalence of physical inactivity and poor dietary habits indicate that risk factors for chronic disease are well established during adolescence in Tonga.

**Keywords**  
Body mass index  
Adolescents  
Tonga  
Exercise  
Food habits

An alarming increase in the prevalence of overweight and obesity among children has been well documented in Western nations<sup>1–6</sup>, and is increasingly being reported in low- and middle- income countries<sup>7–12</sup>. The underlying determinants of this global trend are not fully understood, although an increase in sedentary leisure activities and greater consumption of energy-dense foods are likely to be major contributors<sup>13</sup>. This is a serious public health concern because obese children are at greater risk of becoming obese adults<sup>14</sup> and of experiencing the chronic disease consequences associated with this. Furthermore, obesity in children and adolescents is a direct risk factor for problems such as insulin resistance, hypertension and dislipidaemia<sup>15</sup>.

The island nations in the western Pacific region have been found to have high rates of chronic disease and, at least among adults, of overweight and obesity. In the

Kingdom of Tonga, for instance, it has been reported that >60% of adults are obese according to World Health Organization (WHO) criteria for adults (i.e. body mass index (BMI)  $\geq 30 \text{ kg m}^{-2}$ ) and that ~37% have hypertension and 15.1% have diabetes<sup>16</sup>. Other countries with high levels of adult obesity, hypertension and diabetes include French Polynesia, American Samoa, the Republic of Nauru, Cook Islands and the Federated States of Micronesia<sup>17,18</sup>. Relatively little has been reported about the prevalence of child and adolescent obesity in these countries, and this is an important area of investigation in order to determine the age at which these problems emerge and the need for preventive interventions in young people.

A challenge in describing the prevalence of overweight and obesity among young people in Pacific Island nations is identifying the appropriate cut-points for defining the problems in these ethnic groups. Cole *et al.*<sup>19</sup> developed

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cut-off points for overweight and obesity for the International Obesity Task Force which take into account the impact of growth and maturational stage upon the BMI of young people at different ages<sup>19</sup>. While these are intended to be a standardised way of describing the distribution of BMI within populations, it is questionable whether they are appropriate for young people from the Pacific Islands, especially those of Polynesian descent. A number of studies have found that Polynesian adults<sup>20–22</sup> and, to a lesser extent children and adolescents<sup>23–25</sup>, have a lower percentage body fat and higher fat-free mass than Caucasians with an equivalent BMI. Because of this, revised cut-off points for overweight and obesity (i.e. 26 and 32 kg m<sup>-2</sup>, respectively) have been recommended for Polynesian adults<sup>26</sup>. It may also be necessary to adopt revised cut-off points for young people, but these have not yet been developed.

The purpose of the present study was to describe the prevalence of overweight and obesity and the related behaviours of physical activity, watching television and dietary habits among adolescents in the Kingdom of Tonga. This article presents the findings obtained, first using international cut-off points for overweight and obesity, and secondly using new Polynesian-specific cut-off points, to examine the impact these cut-off points have on the prevalence of these conditions in this country. The distribution of overweight and obesity and the relationships between these problems and physical activity, watching television and dietary behaviours are examined.

## Methods

### *Sampling methods and study population*

The Health Behaviour and Lifestyle of Pacific Youth (HBLPY) study was a cross-sectional survey of a representative national sample of Tongan school students aged 11–16 years old. The methodology of this survey was modelled on the Health Behaviour in School-aged Children (HBSC) surveys conducted by WHO Europe since 1982<sup>27,28</sup>. Although originally designed for use in developed countries, the HBSC framework and measures were selected for Tonga because they have been tried with diverse countries, are flexible for adaptation to new environments and are designed for cross-national comparability<sup>29,30</sup>.

Students were selected by cluster random sampling of primary and secondary government and non-government schools from the three island groups of Tongatapu, Vava'u and Hapa'ai. International schools with relatively high enrolments of expatriate students and schools located on remote islands or difficult to reach parts of the country were removed from the sampling frame. Approximately 20 and 43% of all eligible primary and secondary schools were selected, respectively. Permissions were sought from the Ministry of Education, individual schools and the parents of students before enrolling young people into the

study. Within each selected school, students in the school years corresponding to ages 11–17 years were surveyed. The present analysis is based on a sub-sample of students randomly selected (every sixth student in the classroom) for height and weight measurement. This was intended to yield a sample of at least 400, which would provide an estimate of the prevalence of overweight and obesity that should, at a significance level of 0.05, not be  $\pm 5$ –7% different from the true prevalence in the population.

### *The questionnaire*

The HBLPY questionnaire contained items about: substance use; consumption of various foods and drinks; physical activity; watching television and videos; general happiness, depression, confidence and loneliness; perceptions of the school environment; ease of communication with family, peers and others; community participation; injury and violence; personal hygiene; and sociodemographic characteristics. These measures are further described in a separate report<sup>31</sup>.

The dietary questions were designed to estimate how often respondents typically ate fruits, vegetables, soft drinks and sweets each week, with response options of 'more than once a day', 'once a day', 'at least once a week but not daily', 'seldom' or 'never'. These questions have been reported to have acceptable retest reliability and concurrent validity measured against 24-hour dietary recall<sup>32</sup>. Using the same question format, food frequency questions were added for the Tongan survey to measure consumption of taro, tinned fish and tinned mutton or beef.

The physical activity questions measured the frequency and hours per week that young people usually engaged in physical activity outside of school hours at a level of intensity that caused them to get out of breath. These questions have been found previously to have reasonable reliability and criterion validity measured by agreement with an aerobic fitness test<sup>33</sup>. The measure of sedentary behaviour used was a modified version of the European HBSC question concerning usual hours spent watching television or videos each day<sup>32</sup>.

Contents of the questionnaire were extensively pre-tested with school students and key stakeholders to ensure relevance and comprehension<sup>34</sup>.

### *Height and weight measurements*

Height was measured using portable height scales by the stretch stature method, with shoes and head gear removed. The measurement was recorded to the nearest 0.1 cm. Weight was measured with digital bathroom scales, with shoes, heavy clothing and personal objects removed from pockets. The measurement was recorded to the nearest 0.1 kg.

### *Data collection procedure*

Survey staff were trained in the survey methodology, height and weight measurement procedures and field

supervision. Students completed the questionnaire either in their classrooms or in designated areas under the supervision of field staff. To ensure the privacy of students and to allow for anonymous participation, teachers or any authoritative figures were not present during the survey. Following completion of the questionnaire, field staff measured the height and weight of the sub-sample of students in privacy. All surveys were administered in the Tongan language and conducted between October and November 2000.

**Statistical analysis**

Analyses were conducted using the statistical package SAS V9.1 for Windows (SAS Institute Inc.). Respondents were classified by gender and age group into categories of non-overweight, overweight and obese based on: (1) the international age and sex-specific BMI cut-off points for overweight and obesity developed by Cole *et al.*<sup>19</sup>; and (2) newly derived cut-off points for Polynesian youth which were extrapolated from fitted fourth order polynomial curves to Cole *et al.*'s published data with 26 and 32 kg m<sup>-2</sup> set as the reference points for overweight and obesity<sup>26</sup> at age 18 years (Table 1).

For the analyses, the dietary questions were coded to classify respondents as high consumers of each food type (daily or more often) or lower consumers (≤2–3 times week<sup>-1</sup>). Physical activity participation was classified as regular (≥2–3 h week<sup>-1</sup> and 4–6 bouts week<sup>-1</sup>), sedentary (≤30 min week<sup>-1</sup> and ≤1 bout week<sup>-1</sup>) or low (falling between the other categories). Time spent watching television or videos each day was categorised as ≤1 h, 1–3 h or ≥4 h.

**Table 1** Definitions of overweight and obesity for boys and girls between 10 and 18 years of age based on the international and Polynesian criteria

Age (years)	Overweight (kg m <sup>-2</sup> )				Obesity (kg m <sup>-2</sup> )			
	Inter-national*		Polynesian		Inter-national*		Polynesian	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
10	19.84	19.86	20.78	21.05	24.00	24.11	25.98	26.40
10.5	20.20	20.29	21.13	21.48	24.57	24.77	26.52	27.03
11	20.55	20.74	21.50	21.92	25.10	25.42	27.05	27.65
11.5	20.89	21.20	21.86	22.36	25.58	26.05	27.56	28.24
12	21.22	21.68	22.23	22.80	26.02	26.67	28.05	28.82
12.5	21.56	22.14	22.59	23.23	26.43	27.24	28.51	29.36
13	21.91	22.58	22.95	23.65	26.84	27.76	28.95	29.87
13.5	22.27	22.98	23.30	24.05	27.25	28.20	29.35	30.34
14	22.62	23.34	23.65	24.43	27.63	28.57	29.73	30.76
14.5	22.96	23.66	23.98	24.79	27.98	28.87	30.09	31.13
15	23.29	23.94	24.31	25.11	28.30	29.11	30.41	31.45
15.5	23.60	24.17	24.62	25.39	28.60	29.29	30.71	31.70
16	23.90	24.37	24.92	25.62	28.88	29.43	30.99	31.90
16.5	24.19	24.54	25.21	25.81	29.14	29.56	31.26	32.03
17	24.46	24.70	25.49	25.93	29.41	29.69	31.51	32.09
17.5	24.73	24.85	25.75	26.00	29.70	29.84	31.76	32.08
18	25.00	25.00	26.00	26.00	30.00	30.00	32.00	32.00

\* Taken from Cole *et al.*<sup>19</sup>

Proportions with 95% confidence intervals, adjusted for clustering within schools, were calculated to show the prevalence of overweight and obesity, dietary behaviours, participation in physical activity and watching television. Multiple logistic regression analyses were conducted to identify the independent relationships between overweight and obesity and dietary behaviours, physical activity and watching television, adjusting for all behavioural variables, age, sex, parents' occupational status (office worker vs. other) and island group (Tongatapu vs. Vava'u or Hapa'ai).

**Results**

There were 2754 students aged 11–16 years from the participating schools who completed the HBLPY survey, a response rate of 62%, and 443 of these had height and weight measurements taken. There was a slightly higher representation of girls than boys among those undergoing anthropometric measurement (55.3% girls), with 27.3% aged 11–12 years, 43.6% aged 13–14 years and 29.1% aged 15–16 years. Most respondents (76.1%) were from the largest island of Tongatapu while the remainder were from Vava'u or Hapa'ai. The father or mother's occupation was reported as being an office worker by 35.9% of participants.

**BMI**

As shown in Table 2, mean BMI tended to be higher among girls than boys and increased in both genders between the ages of 11–12 years and 15–16 years.

Using the international cut-off points, the prevalence of overweight and obesity was 36.0% among boys and 53.8% among girls, which was markedly higher than the prevalence found using the cut-off points derived for Polynesian youth (25.0% for boys and 37.6% for girls) (Table 2). Using both criteria, there was a trend towards increased overweight and obesity from ages 11–12 years to 15–16 years. The findings using the Polynesian criteria showed a sharp increase in the prevalence of these conditions among girls between the ages of 11–12 years and 13–14 years.

The prevalence of overweight and obesity did not differ between students from different island groups, but tended to be higher among students having a parent in a white collar occupation compared with those who did not. Because of the sample size in this study and the need to adjust for cluster sampling, the confidence intervals around the proportions were large and therefore the apparent trends in overweight and obesity related to age, sex and parental occupation were not found to be statistically significant.

**Dietary behaviours and physical activity**

Table 3 shows that tinned mutton or beef was the food that participants most often reported eating once or more

**Table 2** Prevalence of overweight and obesity among Tongan adolescents 2001

	<i>n</i>	Mean BMI (kg m <sup>-2</sup> )	International classification		Polynesian classification	
			Overweight % (95% CI)	Obese % (95% CI)	Overweight % (95% CI)	Obese % (95% CI)
Age group						
All	445	22.8	36.2 (29–43)	9.7 (5.0–14)	27.9 (20–36)	4.0 (0.8–7.3)
Boys	200	21.8	28.5 (22–35)	7.5 (3.9–11)	21.0 (15–27)	4.0 (1.5–6.5)
Girls	245	23.7	42.4 (33–52)	11.4 (4.8–18)	33.5 (22–45)	4.1 (0.0–8.5)
11–12 years						
Boys	53	20.1	28.3 (18–39)	9.4 (2.7–16)	17.0 (7.6–26)	3.8 (0.0–8.5)
Girls	68	21.0	35.3 (18–52)	4.4 (0.5–8.3)	22.1 (4.3–40)	1.5 (0.0–4.4)
13–14 years						
Boys	93	21.6	28.0 (19–37)	6.5 (2.2–11)	19.4 (11–28)	3.2 (0.0–6.6)
Girls	102	24.3	42.2 (26–59)	16.7 (7.0–26)	38.2 (24–53)	4.9 (0.8–9.0)
15–16 years						
Boys	54	23.8	29.6 (16–43)	7.4 (1.7–13)	27.8 (16–40)	5.6 (0.9–10)
Girls	75	25.2	49.3 (40–58)	10.7 (3.9–17)	37.3 (31–44)	5.3 (0.0–13)
Island group						
Tongatapu	338	22.8	38.5 (31–46)	7.7 (3.8–12)	29.0 (19–39)	2.7 (1.1–4.2)
Vava'u/Hapa'ai	107	23.0	29.0 (22–36)	15.9 (3.3–28)	24.3 (14–34)	8.4 (0.0–19)
Parent's job						
Office worker	160	23.3	41.3 (31–51)	13.1 (5.7–21)	31.9 (22–41)	6.3 (1.8–11)
Other	283	22.5	33.2 (27–40)	7.8 (3.6–12)	25.4 (17–34)	2.8 (0.0–5.7)

BMI – body mass index; CI – confidence interval.

per day. Over half of the young people did not eat taro, fruit or vegetables at least once per day. Soft drinks were consumed by about one-third of young people every day while a slightly higher proportion reported that they ate sweets this regularly. A significantly higher proportion of girls than boys ate sweets on a daily basis. The percentage of those aged 15–16 years who ate fruit, vegetables and tinned mutton and beef once or more per day tended to be higher than among 11–12 year olds, but the confidence intervals around these proportions were overlapping.

Participants from Tongatapu reported a higher prevalence of daily consumption of tinned mutton or beef and soft drinks compared with those living in Vava'u or Hapa'ai, and a lower prevalence of eating taro or fruit at least once per day, but again the differences were not statistically significant (Table 3).

Regular physical activity outside of school hours was reported by 20.7% of respondents. Just over a quarter of the young people were classified as inactive in out-of-school hours, while about half reported a low level of

**Table 3** The prevalence (95% confidence interval) of dietary behaviours, participation in physical activity and time spent watching television by gender, age and island group

	All ( <i>n</i> = 443)	Gender		Age group (years)			Island group	
		Boys ( <i>n</i> = 198)	Girls ( <i>n</i> = 245)	11–12 ( <i>n</i> = 121)	13–14 ( <i>n</i> = 193)	15–16 ( <i>n</i> = 129)	Tongatapu ( <i>n</i> = 337)	Vava'u/Hapa'ai ( <i>n</i> = 106)
Fruits								
≥ once day <sup>-1</sup>	46.1 (40–52)	45.6 (38–53)	46.4 (38–54)	42.2 (32–53)	44.5 (34–55)	51.6 (43–60)	43.4 (37–50)	55.7 (43–68)
Soft drinks								
≥ once day <sup>-1</sup>	32.8 (27–38)	32.4 (26–39)	33.0 (25–41)	33.0 (23–43)	32.4 (25–40)	33.1 (22–44)	35.1 (29–41)	23.8 (16–32)
Sweets/chocolates								
≥ once day <sup>-1</sup>	39.0 (34–44)	30.4 (23–37)	45.8 (39–52)	39.6 (29–51)	38.4 (30–47)	39.2 (31–47)	40.6 (35–47)	33.3 (25–41)
Vegetables								
≥ once day <sup>-1</sup>	38.0 (34–43)	42.1 (35–49)	34.7 (29–40)	35.2 (25–46)	35.9 (29–43)	43.4 (36–51)	36.7 (31–42)	42.9 (37–49)
Taro								
≥ once day <sup>-1</sup>	47.4 (42–53)	50.3 (42–59)	45.0 (39–51)	47.3 (36–58)	47.7 (39–56)	47.1 (40–54)	45.6 (40–51)	54.1 (42–66)
Tinned fish								
≥ once day <sup>-1</sup>	35.4 (29–42)	40.4 (29–52)	31.4 (27–36)	34.0 (26–42)	37.2 (26–48)	34.2 (25–44)	35.0 (27–43)	36.9 (29–45)
Tinned mutton/beef								
≥ once day <sup>-1</sup>	56.9 (52–61)	54.3 (47–61)	58.9 (55–63)	45.9 (39–53)	60.5 (55–66)	61.9 (53–71)	59.2 (55–64)	48.2 (41–55)
Physical activity								
Sedentary	28.0 (23–33)	18.8 (14–24)	35.5 (31–40)	24.4 (17–32)	24.9 (17–32)	36.2 (26–47)	26.9 (21–33)	31.7 (23–40)
Low	51.3 (46–57)	51.8 (44–59)	50.8 (45–57)	52.9 (45–61)	53.9 (48–60)	45.7 (32–59)	52.8 (47–59)	46.2 (37–55)
Regular	20.7 (17–25)	29.4 (24–35)	13.6 (10–17)	22.7 (16–30)	21.2 (16–27)	18.1 (11–25)	20.3 (15–25)	22.1 (17–27)
Television watching								
< 1 h day <sup>-1</sup>	41.8 (34–49)	41.4 (33–50)	42.0 (32–53)	55.4 (46–65)	40.9 (31–50)	30.2 (24–37)	38.0 (30–46)	53.8 (46–62)
1–3 h day <sup>-1</sup>	30.9 (26–36)	30.3 (22–39)	31.4 (26–37)	23.1 (16–31)	33.7 (26–41)	34.1 (27–41)	31.5 (26–37)	29.2 (20–38)
≥ 4 h day <sup>-1</sup>	27.3 (22–33)	28.3 (20–36)	26.5 (19–34)	21.5 (13–30)	25.4 (18–33)	35.7 (26–46)	30.6 (25–36)	17.0 (10–24)

**Table 4** The prevalence and adjusted odds of overweight or obesity using Polynesian cut-off points, by dietary behaviours, physical activity and television viewing time

Behaviours	<i>n</i>	Normal weight (%)	Overweight/obese (%)	Adjusted odds of overweight/obesity*,† (95% CI)
Fruits				
≤ once day <sup>-1</sup>	219	66.2	33.8	1.00
> once day <sup>-1</sup>	187	69.5	30.5	0.80 (0.49–1.29)
Soft drinks				
< once day <sup>-1</sup>	271	69.4	30.6	1.00
≥ once day <sup>-1</sup>	132	63.6	36.4	1.30 (0.57–2.97)
Sweets/chocolates				
< once day <sup>-1</sup>	249	68.3	31.7	1.00
≥ once day <sup>-1</sup>	159	67.3	32.7	0.84 (0.55–1.29)
Fresh vegetables				
≤ once day <sup>-1</sup>	246	68.7	31.3	1.00
> once day <sup>-1</sup>	151	64.2	35.8	1.63 (0.98–2.72)
Taro				
≤ once day <sup>-1</sup>	212	67.0	33.0	1.00
> once day <sup>-1</sup>	191	68.1	31.9	1.02 (0.60–1.73)
Tinned fish				
< once day <sup>-1</sup>	257	65.0	35.0	1.00
≥ once day <sup>-1</sup>	141	71.6	28.4	0.76 (0.46–1.26)
Tinned mutton/corned beef				
< once day <sup>-1</sup>	170	68.2	31.8	1.00
≥ once day <sup>-1</sup>	224	66.5	33.5	1.05 (0.70–1.57)
Exercise frequency/duration				
Sedentary	123	61.0	39.0	1.00
Low	225	71.6	28.4	0.55 (0.31–0.99)‡
Regular	91	70.3	29.7	0.61 (0.32–1.20)
Time watching television/videos				
1 h day <sup>-1</sup>	185	76.2	23.8	1.00
1–3 h day <sup>-1</sup>	137	63.5	36.5	1.82 (0.85–3.93)
4 h day <sup>-1</sup>	121	62.0	38.0	1.45 (0.74–2.85)

\* Adjusted for all behavioural variables as well as age, gender, island group (Tongatapu vs. Vava'u or Hapa'ai) and parent's job (office worker or other).

† All 95% confidence intervals (CIs) adjusted for clustering effect by school.

‡  $P < 0.05$ .

physical activity. The prevalence of inactivity was higher among girls than boys. The percentages of young people who were sedentary tended to increase between the ages of 11–12 years and 15–16 years.

Most young people reported watching at least 1 h or more of television or videos per day, and just over a quarter watched 4 h or more. The proportion of respondents who watched television or videos for < 1 h per day was lower at ages 15–16 years than at 11–12 years. Watching television or videos for 4 h or more per day was more common in Tongatapu than in Vava'u or Hapa'ai.

#### **Relationship between dietary behaviours, physical activity and overweight**

Multiple logistic regression modelling, adjusting simultaneously for demographic factors and each of the dietary and physical activity variables, showed that those reporting low out-of-school activity were 45% less likely than the sedentary to be overweight or obese. The trend towards a lower likelihood of overweight or obesity was also evident among those who reported regular physical activity, but the adjusted odds compared with those who were sedentary did not reach significance because of the smaller number of people in this physical activity category. Watching > 1 h per day of television or videos also tended

to be associated with a higher likelihood of overweight or obesity, but again the adjusted odds ratios for this association were not statistically significant. None of the dietary behaviours was found to be independently associated with overweight or obesity, although those eating vegetables regularly appeared to have an increased likelihood of these problems (Table 4).

#### **Discussion**

The island nations in the western Pacific region have been among the most severely affected by the worldwide increase in chronic diseases, therefore it is imperative that the underlying causes of this trend be identified and addressed. Overweight and obesity among young people is one manifestation of the lifestyle transitions that are contributing to chronic disease risk in numerous countries, yet the present study is the first to report on the prevalence of these problems in the Kingdom of Tonga.

BMI was used to measure overweight and obesity in this study, which is the most practical and widely used method in population studies<sup>35</sup>. Compared with self-report data collected from 13- and 15- year olds from 15 countries in 1997–1998, encompassing Europe, North America and the Middle East<sup>36</sup>, the mean BMI of Tongan adolescents was

relatively high. The differences were small between 13- to 14-year-old males and their 13-year-old counterparts in these 15 countries (21.6 vs. 18.3–20.6 kg m<sup>-2</sup>), but greater between 15- to 16-year-old males and 15-year-olds from these countries (23.8 vs. 19.5–22 kg m<sup>-2</sup>). Among girls, the differences were more marked between Tongans and youth from other countries; 24.3 vs. 18.3–20.2 kg m<sup>-2</sup> at 13–14 years and 25.2 vs. 19.8–21.7 kg m<sup>-2</sup> at 15–16 years.

Studies conducted in New Zealand have also found that young people of Polynesian descent have higher average BMI than those of European descent<sup>24,25</sup>. Factors that have been identified as contributing to this include larger frame size, muscle mass and a higher relative sitting height<sup>37</sup>. Interestingly, compared with Pacific Island youth measured in New Zealand between 1992 and 1996, the age- and sex-specific mean BMI of Tongan youth appeared to be slightly lower<sup>38</sup>. The samples in the respective studies were not large enough to determine if these differences were significant, but it may be that greater affluence among those living in New Zealand is the cause of this.

Using the international cut-off points, the prevalence of overweight and obesity found in Tonga was more than double that reported in 32 of the 34 countries examined in an international comparison of overweight and obesity among 10–16-year-olds, and 20% higher than in the two countries with the highest prevalence<sup>39</sup>. These cut-off points are, however, extrapolated from the WHO standards of 25 and 30 kg m<sup>-2</sup> for overweight and obesity, respectively, among adults. Adjusting the adult cut-off points to those recommended for Polynesians, and generating sex-specific centile curves for BMI of the same shape as that in the analyses of Cole *et al.*, yielded overweight and obesity cut-off points for Tongan youth that were ~1–2 units higher at each age level. Applying these, the prevalence of overweight and obesity in Tongan youth was dramatically reduced, but was still >6% higher than in the countries found to have the highest prevalence of this problem in the above-mentioned study, namely Malta (25.4%) and the USA (25.1%)<sup>39</sup>.

While it is of interest to consider how Polynesian-specific cut-off points affect the estimates of overweight and obesity among Tongan youth, these analyses need to be treated with caution. First, it is not yet known to what extent the relationship between percentage body fat and BMI that has been found in Tongan adults, that provides the rationale for the Polynesian cut-off points for overweight and obesity, applies in Tongans at younger ages. Research by Rush *et al.*<sup>24</sup> suggests that the pattern of lower percentage body fat at a given BMI, relative to Caucasians, applies for Tongan girls aged 9–14 years but not among boys. It may be that among males this relationship does not emerge until late adolescence or early adulthood, in which case the prevalence of overweight and obesity among Tongan boys given here may underestimate the extent of this problem. Secondly, in matching the shape of the

sex-specific centile curves for the distribution of BMI to that derived by Cole *et al.*<sup>19</sup> it was assumed that the age- and sex-related trends in overweight and obesity in Tongan youth are similar to those in the reference countries used by these researchers. However, there were just six reference countries used by Cole *et al.* and only one of these included a proportion of children and young people, i.e. black North Americans, who have body shape and body mass characteristics with any similarity to those of Polynesians<sup>40</sup>. Thirdly, as several researchers have stated<sup>20,21</sup>, BMI cut-off points should represent not just body fatness but levels of risk of subsequent morbidity and mortality. The different pattern of body fat distribution among Pacific Islanders, particularly the extent to which they store this fat in the visceral area, will affect the levels of health risk associated with different BMI levels.

The dietary measures revealed that more than half of Tongan adolescents consumed tinned mutton every day, with the prevalence exceeding 60% among 15–16-year-olds. This is consistent with reports that this processed food is in plentiful supply in Pacific Island nations<sup>41</sup> and confirms that this is a serious nutritional problem given its high fat content and tendency to be substituted for locally grown foods. In addition to this, most young people did not report daily consumption of fruits and vegetables, although the prevalence of consumption of these foods was still in the top quartile of the range found among 10–16-year-olds across 34 countries<sup>39</sup>. On the other hand, the prevalence of daily consumption of sweets in Tonga was also in the highest quartile of the range in this group of countries, while the prevalence of daily soft drinks consumption was above the median in that international comparison. This indicates that Tongan youth have a higher level of consumption across several food types than youth in other countries, which is suggestive of higher energy intake overall.

Physical activity levels during out-of-school time were found to be low, particularly among girls, with <15% of this group reporting at least 2 h of exercise over four or more sessions per week. Comparison with other countries is hampered by differences in questions and methods of classifying physical activity, but it should be noted that the upper category of physical activity in the present study was still lower than the recommended total of 1 h of activity on most days of the week<sup>42</sup>. In spite of its status as a developing country, watching television and videos appears to be well established as a leisure activity among youth in Tonga. There was a trend of increased television viewing between the ages of 11–12 years and 15–16 years that corresponded to an increase in sedentariness across these age groups. This indicates that early and mid-adolescence are important stages for the implementation of physical activity promotion strategies in Tonga.

Across the whole sample of young people, the one factor found to be independently associated with a higher risk of overweight and obesity in multivariate analysis was

sedentariness. There was also a trend towards a higher likelihood of overweight and obesity with a greater number of hours of watching television, but this did not reach significance due to the sample size in the present study. None of the dietary variables was found to be significantly related to overweight and obesity, although daily consumption of vegetables tended to be associated with a greater risk of this problem. A possible explanation for this is that high levels of vegetable consumption could be an indicator of more regular consumption of prepared meals. The lack of association found with the other dietary variables may be because the dietary questions only measured frequency and did not take into account portion size. Dietary behaviours could also be more strongly associated with obesity, rather than overweight, but the present study did not provide sufficient numbers of obese adolescents to examine this.

A limitation of this study was that the behavioural measures were collected by self-report and may be subject to measurement bias. However, the HBLPY questions were those that have been used in the WHO HBSC survey in >40 countries and have been found to have acceptable reliability and validity<sup>32,33</sup>. In order to avoid potential bias in the Tongan context due to language and cultural factors, these questions were carefully pre-tested and then translated and back-translated before being used in the field. A limitation of the physical activity measure is that it only examined activity outside of school hours and is therefore likely to have underestimated total activity.

This study has found that risk factors for chronic disease in Tonga are well established in adolescence. Adjustment of the cut-off points for overweight and obesity, to take into account the lower ratio of body fat to BMI that has been found in Polynesians, still yielded a prevalence of overweight and obesity that was among the highest that has been reported among adolescents. Physical activity levels are low and poor dietary habits appear to be widespread. There is a need for interventions to address these health risks that are locally directed and engage a range of government, non-government, educational and religious institutions. Thorough evaluation of these actions will help to contribute to the evidence needed to strengthen chronic disease prevention efforts in the western Pacific region.

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