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Does the prescriptive lifestyle of Seventh-day Adventists provide 'immunity' from the secular effects of changes in BMI?

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Abstract

Objective: To examine the effect of Seventh-day Adventist (SDA) membership on 'immunity' to the secular effects of changes in BMI.

Design: Three independent, cross-sectional, screening surveys conducted by Sydney Adventist Hospital in 1976, 1986 and 1988 and a survey conducted among residents of Melbourne in 2006.

Subjects: Two hundred and fifty-two SDA and 464 non-SDA in 1976; 166 SDA and 291 non-SDA in 1986; 120 SDA and 300-non SDA in 1988; and 251 SDA and 294 non-SDA in 2006.

Measurements: Height and weight measured by hospital staff in 1976, 1986 and 1988; self-reported by respondents in 2006.

Results: The mean BMI of non-SDA men increased between 1986 and 2006 ($P < 0{\cdot}001$) but did not change for SDA men or non-SDA women. Despite small increases in SDA women's mean BMI ($P = 0{\cdot}030$) between 1988 and 2006, this was no different to that of SDA men and non-SDA women in 2006. The diet and eating patterns of SDA men and women were more 'prudent' than those of non-SDA men and women, including more fruit, vegetables, grains, nuts and legumes, and less alcohol, meat, sweetened drinks and coffee. Many of these factors were found to be predictors of lower BMI.

Conclusion: The 'prudent' dietary and lifestyle prescriptions of SDA men appear to have 'immunised' them to the secular effects of changes that occurred among non-SDA men's BMI. The dietary and lifestyle trends of SDA women did not reflect the increase in their BMI observed in 2006.

Keywords
Lifestyle
Diet
Body mass index
Seventh-day Adventist
Physical activity

The burden from 'lifestyle diseases' is rising rapidly and represents one of the major health challenges worldwide. However, the development of many, if not all, of the 'lifestyle diseases' is attributed to overweight and obesity[1]. Furthermore, obesity is the most obvious manifestation of the global epidemic of sedentary lifestyles and excessive energy intake[2]. The prevalence of obesity is reaching epidemic proportions in both developed and developing countries. In Australia, the prevalence of overweight in the adult population is 60 % (67 % for males and 52 % for females) and 21 % for obesity (22 % females and 19 % males), having risen from 8 %, 20 years earlier[2]. This increase poses major concerns in terms of health and the economy[3].

Although several food and physical activity factors have been implicated in the development of overweight and obesity, little is known about the role of people's eating patterns or food consumption behaviours in relation to diets. The traditional dietary patterns of many cultures often meet current dietary guidelines and can serve as a means of examining the effects of specific dietary patterns in the prevention and management of patients with chronic disease and as models for dietary improvement. The Seventh-day Adventist (SDA) diet, formed as a basis of religious beliefs, is an example of a notable dietary tradition that has been studied for its relationship between food consumption and chronic disease.

SDA live in countries where lifestyle diseases are prevalent yet they appear to enjoy low disease rates (e.g. CVD, cancer and total mortality) and unusually good health[4]. They are a conservative religious group first organised as a denomination in 1863 in the eastern USA, but Seventh-day Adventism has now become a worldwide religion with more than 13 million members[5]. In that same year, SDA 'also began to emphasise the role of lifestyle in promoting health, happiness and enhanced spirituality'; not as a measure of virtue but as a valuable spiritual discipline[5]. SDA lifestyle prescriptions prohibit the use of alcohol and tobacco and the consumption of

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biblically unclean foods such as pork and shellfish. The church does, however, recommend a vegetarian diet with regular exercise and the avoidance of tea, coffee and other caffeine-containing beverages, rich and highly refined foods, and hot condiments and spices[5].

Although the health of SDA has been studied since 1960, there have been limited studies that directly compare health outcomes for SDA and non-SDA[6–9]. The aims of the present study were therefore to examine the effect of SDA membership on 'immunity' to the secular effects of changes in BMI and to investigate the changes in diet and lifestyle of SDA and non-SDA between 1976 and 2006.

Methods

Participants

Between 1976 and 1990, residents of the general community around the Sydney Adventist Hospital (SAH) were invited to take part in heart health screening surveys that assessed heart health, food consumption and other lifestyle practices. Samples were randomly selected from these surveys for every biennial year from 1976 to 1990. These biennial samples were selected to examine changes in BMI. However, due to insufficient numbers of SDA, only data for 1976, 1986 and 1988 were examined. Each year's sample comprised a different set of individuals. Although the hospital continued to collect data after 1990, no information on religious affiliation was included and so data post-1990 were not available for the present study. As a result, the authors conducted another study in 2006. Melbourne was selected as the site of the survey. The Socio-Economic Indices For Areas (SEIFA) relative socio-economic disadvantage score for the area SAH services was 1095·03 in 2001. As all Australian capital cities have SEIFA scores >1087, using a Melbourne sample in place of a sample from New South Wales was convenient and valid[10]. Questionnaires, consent forms and reply-paid envelopes were sent out to 1000 individuals randomly selected from the Melbourne White Pages Telephone Directory. The response rate was 37 %. In addition, 500 surveys were distributed in person to SDA via church gatherings, schools and administration facilities. The SDA response rate was 50 %.

As well as the examination of changes in BMI, two SAH years (10 years apart: 1976, 1986; 1996 not available due to lack of demographic data) and 2006 were selected to examine changes in diet and lifestyle and to determine which behaviours predict BMI for the two groups. Respondents were older and better educated than the general population in all years examined (except 1986, which was younger than the general population).

Respondents were asked to complete a questionnaire that included an FFQ and queried about the frequency of various moderate and vigorous physical activities, dietary habits, smoking and alcohol usage and lifestyle behaviours.

FFQ

Forty-two different foods and drinks, ranging from a variety of meats, cheeses, milks, sweets, desserts, sweet drinks, alcoholic drinks, tea, coffee, spreads, salad dressings, vegetables, fruit, cereals and breads, were included in the 1976 questionnaire. Dietary practices included 'relative breakfast size', 'dieting to lose weight' and frequency of 'cut fat from meat', 'eat between meals' and 'add salt at table'. These foods and dietary practices were replicated in the 1986 questionnaire, with the addition of fish and cream. The 2006 questionnaire included more than seventy foods and drinks and comprised variables from previous years as well as takeaway foods, refined grains *v.* whole grains, legumes, nuts, low-energy drinks, water, yoghurt, decaffeinated drinks and various breakfast foods. All categorical variables were converted to continuous variables to determine the midpoint of the range for each category. Variables consumed on a daily basis were converted to weekly consumption by multiplying the midpoint value by seven.

Physical activity

This portion of the questionnaire was similar for 1976 and 1986 in terms of frequency of the activities of walking, running, cycling, swimming, tennis, vigorous gardening and other vigorous activity. However in 1986, the questionnaire sought responses only if each activity was engaged in for more than 20 min. These categorical variables were converted to continuous variables by determining the midpoint of the range for each category (similar to the FFQ conversion). Due to these differences, the 1999 Australian National Physical Activity Survey was incorporated into the 2006 questionnaire[11]. Variables related to frequency and duration (minutes) of walking, moderate and vigorous physical activity. 'Sufficient' physical activity was calculated by: (i) 'sufficient' time ≥150 min/week = total minutes spent in walking and other moderate physical activity, plus twice the minutes in vigorous activity; and (ii) 'sufficient' physical activity ≥150 min/week and sessions ≥5/week = as above, however the ≥150 min/week must be accumulated in at least five separate sessions (i.e. by summing the frequency items). In addition, each individual physical activity variable (walking, vigorous physical activity and moderate physical activity) was examined.

Other lifestyle factors

Other lifestyle factors examined included hours of sleep per night, smoking status (current, past and never smoked), frequency of alcohol consumption and number of drinks consumed per sitting.

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BMI

Height and weight used to determine BMI were measured objectively by SAH staff. In 2006, respondents were asked to measure and record two height and weight measurements. BMI (kg/m^2) was calculated as weight (in kilograms) divided by the square of height (in metres).

Data analysis

A one-way, between-groups analysis of covariance (ANCOVA) was conducted to compare the changes in BMI between 1976 and 2006, with age as the covariate. Bivariate analyses were conducted to examine the relationships between respondents' BMI and a series of variables that have been associated with BMI in the literature, including age, sex, education, occupation status, marital status, food consumption variables and eating habits. Pearson's correlation was used to assess relationships between BMI and continuous variables. Spearman's rank-order correlation, using two-tailed tests of significance, was used to examine relationships between nominal or ordinal variables and BMI. Those variables that were significantly related to BMI were subsequently entered into a multiple regression analysis of BMI (one analysis for each survey year). Data were analysed using the Statistical Package for the Social Sciences statistical software package version 12·0 (SPSS Inc., Chicago, IL, USA).

Results

Age

Table 1 shows large variations in mean age between SDA and non-SDA men and women, particularly in 1986 and 1988. This table also shows larger standard errors of the mean within the SDA group compared with non-SDA in 1986, 1988 and 2006.

Table 1 Age comparison (independent *t* test) of the samples of Seventh-day Adventists (SDA) and non-SDA studied in the present analysis

		Men			Women		
			Age (years)			Age (years)	
		n	Mean	SE	*n*	Mean	SE
1976	SDA	133	44·33	1·220	119	45·75	1·427
	Non-SDA	247	44·63	0·742	217	45·98	0·853
	t		0·206			0·134	
	P		0·837			0·894	
1986	SDA	75	42·13	1·744	91	35·46	1·823
	Non-SDA	163	46·51	0·860	128	50·51	1·029
	t		2·250			7·187	
	P		0·026			<0·001	
1988	SDA	43	28·98	2·439	77	32·45	1·883
	Non-SDA	155	52·01	0·986	145	49·27	0·985
	t		8·756			7·911	
	P		<0·001			<0·001	
2006	SDA	118	51·63	1·595	133	51·29	1·357
	Non-SDA	120	55·89	1·437	174	48·68	1·131
	t		1·987			−1·485	
	P		0·048			0·139	

Trends in mean BMI

After adjusting for age, there was no significant difference in mean BMI between 1976, 1987, 1988 and 2006 for SDA men ($F(3,358) = 0{\cdot}625$, $P = 0{\cdot}599$, partial $\eta^2 = 0{\cdot}005$) (Fig. 1). There was, however, a statistically significant difference in mean BMI between the four years for non-SDA men ($F(3,684) = 6{\cdot}782$, $P < 0{\cdot}001$, partial $\eta^2 = 0{\cdot}029$). *Post hoc* comparisons using the Tukey HSD test indicated that the mean BMI for 1976 (25·57 (SE 0·18) kg/m^2) was significantly lower ($P = 0{\cdot}002$) than in 2006 (26·97 (SE 0·48) kg/m^2) and the mean BMI for 1986 (24·96 (SE 0·24) kg/m^2) was significantly lower than in 1988 ($P = 0{\cdot}004$, mean 26·24 (SE 0·41) kg/m^2) and 2006 ($P < 0{\cdot}001$) (Fig. 1). In addition, the mean BMI of SDA men was significantly lower than that of non-SDA men in 1976 ($F(1,376) = 9{\cdot}881$, $P = 0{\cdot}002$, partial $\eta^2 = 0.026$) after adjusting for age ($F = 26{\cdot}860$, $P < 0{\cdot}001$), in 1986 ($F(1,230) = 3{\cdot}922$, $P = 0{\cdot}049$, partial $\eta^2 = 0{\cdot}017$) after adjusting for age ($F = 6{\cdot}041$, $P = 0{\cdot}015$), in 1988 ($F(1,196) = 10{\cdot}341$, $P = 0{\cdot}002$, partial $\eta^2 = 0{\cdot}050$) with no age adjustment, and in 2006 ($F(1,235) = 6{\cdot}974$, $P = 0{\cdot}009$, partial $\eta^2 = 0{\cdot}029$) with no age adjustment (Fig. 1).

On the other hand, no significant differences in mean BMI between the four years was found for non-SDA women ($F(3,662) = 1{\cdot}814$, $P = 0.143$, partial $\eta^2 = 0.008$) (Fig. 2). Although the ANCOVA for SDA women's BMI showed no significant differences ($F(3,417) = 1{\cdot}944$, $P = 0{\cdot}122$, partial $\eta^2 = 0{\cdot}014$), the mean BMI in 2006 (24·95 (SE 0·37) kg/m^2) was significantly higher ($P = 0{\cdot}030$) than in 1976 (23·80 (SE 0·38) kg/m^2) (Fig. 2). Despite this increase the BMI of SDA women in 2006 was not significantly different to that of non-SDA women ($F(1,301) = 2{\cdot}947$, $P = 0{\cdot}087$, partial $\eta^2 = 0.010$) after adjusting for age ($F = 12{\cdot}093$, $P = 0{\cdot}001$), a finding also observed in previous years.

Antecedents of BMI between 1976 and 2006

The predictors of BMI differed for SDA and non-SDA men, except for age, dieting to lose weight, eating

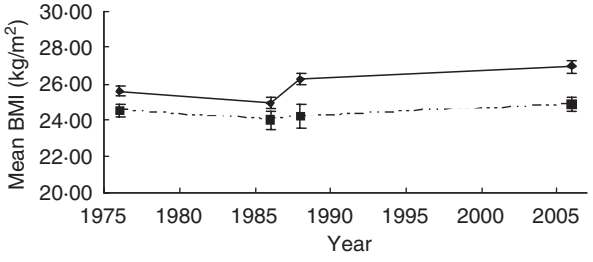


Fig. 1 Differences in Seventh-day Adventist (SDA; —■ · · —) and non-SDA (—◆—) men's BMI in 1976, 1986, 1988 and 2006. Values are means with their standard errors represented by vertical bars. After adjusting for age: SDA men ($F = 13{\cdot}496$, $P < 0{\cdot}001$) and non-SDA men (NS)

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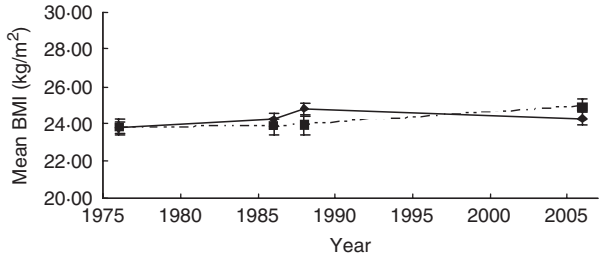


Fig. 2 Differences in Seventh-day Adventist (SDA; —■ · · —) and non-SDA (—◆—) women's BMI in 1976, 1986, 1988 and 2006. Values are means with their standard errors represented by vertical bars. After adjusting for age: non-SDA women ($F = 14{\cdot}575$, $P < 0{\cdot}001$) and SDA women ($F = 11{\cdot}581$, $P < 0{\cdot}001$)

between meals and frequency of consumption of chicken (Table 2). Although found to be predictors of BMI in both groups, eating between meals and frequency of vigorous physical activity were differentially related to BMI for SDA and non-SDA men (Table 2). For SDA men, frequent eating between meals predicted increases in BMI while more frequent physical activity predicted decreases in BMI (Table 2). Conversely, non-SDA men who ate once or twice between meals each day had lower BMI than those who never or more frequently ate between meals (Table 2). Furthermore, frequency of vigorous physical activity was positively associated with BMI among non-SDA men (Table 2). Nevertheless, the factors that predicted increases in BMI included age, dieting to lose weight, eating between meals, consumption of meat, low-fat milk, low-energy soft drinks and extra foods (pie and cake, coffee and hot chocolate) (Table 2). On the other hand, factors that predicted decreases in BMI included food variety, regular meals, breakfast, fruit, tea, spreads, legumes and physical activity (Table 2). For men, the larger the reported breakfast consumed the lower their BMI.

The predictors of BMI differed for SDA and non-SDA women, except dieting to lose weight (Table 3). Even so, the factors that predicted increases in BMI for women included age, dieting to lose weight, eating between meals, table salt use and consumption of meat, whole milk and extra foods (soft drinks and low-energy soft drinks, cola, sugar, pizza, margarine) (Table 3). In contrast, factors that predicted decreases in BMI for women in 1986 included consumption of soya milk and spreads, and physical activity (Table 3).

Trends in diet and lifestyle factors between 1976 and 2006

Although vegetables, fruit, grains (including bread, cereals and rice), extra foods and moderate to large breakfasts were consumed by a smaller proportion of SDA and non-SDA men in 2006 than in previous years, these foods (except extra foods) together with soya milk, legumes and spreads were consumed by a greater proportion of SDA men than non-SDA men (Figs 3 and 4). In addition, the proportion of non-SDA men who consumed low-fat milk increased in 2006 while the proportion of SDA men did not change between 1986 and 2006. Furthermore, the proportion of SDA men who consumed alcohol, tea and meat and ate between meals (coffee did not change) increased, while the proportion of non-SDA men who consumed alcohol, tea and coffee (meat and eating between meals did not change) decreased (Figs 3 and 4). Despite these changes, a smaller proportion of SDA men consumed meat, alcohol, extra foods, low-fat milk, coffee and tea than non-SDA men (Figs 3 and 4). Soya milk, legumes, rice, fruit, spreads and vegetarianism predicted lower BMI in the present study, whereas low-fat milk, meat, alcohol, sweetened drinks and coffee predicted higher BMI. These differences may have contributed to the lower BMI and proportion of overweight and obese SDA men (40 % in 2006) compared with non-SDA men (65 % in 2006), supporting the hypothesis that SDA men are more resistant to changes in diet and lifestyle than non-SDA men.

The changes observed for men were also found for women in both groups except for tea (no change for SDA women) and substantial breakfast (already low in both groups) (figures available upon request from the corresponding author). Unlike men though, the differences between the women were not as prolific. In 2006, a greater proportion of SDA women consumed soya milk, vegetables, fruit and were vegetarian, while a smaller proportion consumed legumes, low-fat milk, meat, alcohol, sweetened drinks (except soft drink), coffee and tea than non-SDA women. All other foods were consumed by similar proportions of SDA and non-SDA women.

However, a greater share of SDA women than men were vegetarian, consumed butter, fruit and vegetables, while a smaller proportion consumed desserts, takeaway foods, meat and cola. Conversely, SDA men consumed grains more frequently than SDA women. These results show a disparity between diet and BMI, and proportion of overweight and obese SDA men (41 %) and women (42 %). Figure 2 shows that the mean BMI of SDA women increased marginally between 1988 and 2006. No significant increase was observed for SDA men.

On the other hand, a greater proportion of non-SDA men than women consumed extra foods (in particular takeaway foods, sweetened drinks, flavoured milk, alcohol and margarine), while a smaller proportion consumed vegetables, soya milk, legumes, grains and butter. These differences may have contributed to the higher BMI and the greater proportion of overweight and obese respondents among non-SDA men than women (65 % compared with 34 %).

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Table 2 Statistically significant demographic, food and lifestyle predictors or associates of BMI in 1976, 1986 and 2006 among Seventh-day Adventist (SDA) men and non-SDA men

	SDA men					Non-SDA men				
Variable	Year	*F*	*P*	*B*	R^2 (%)	Year	*F*	*P*	*B*	R^2 (%)
Smoking status						1976	7·485	0·007		3·5
Never smoked or gave up >1 year ago (1)* *v.* currently smoke or gave up <1 year ago (2)							NA	0·007	1·100	NA
Smoking status						2006	4·405	0·015		7·9
Never (3)* *v.* quit >1 year ago (4)							NA	0·004	2·334	7·6
Breakfast	1976	4·870	0·009		7·9					
Somewhat less or smaller (1)* *v.* somewhat or much more (2)		NA	0·030	−2·823						
About the same (3)* *v.* somewhat or much more (2)		NA	0·045	−1·255						
Frequency of breakfast consumption	2006	5·204	0·025	−0·618	4·9					
Dieting to lose weight	1976	15·115	<0·001	4·283	11·7	1976	16·325	0·000	1·744	7·3
	1986	15·455	<0·001	4·241	20·8	1986	14·591	0·000	0·057	9·5
Chicken	1976	4·977	0·028	2·183	4·2	1976†	12·737	0·000	2·849	5·8
Fruit	1976	7·069	0·009	−0·078	5·8					
	1986	11·030	0·002	−0·132	15·7					
Age	1976	23·707	<0·001	0·095	17·2	1976	14·703	0·000	0·092	6·6
	1986	6·858	0·011	0·070	10·4					
Low-fat milk						1976†	7·238	0·008	0·683	3·4
Hot chocolate						2006	12·028	0·001	0·789	10·5
Tea						2006	10·840	0·001	−0·138	9·5
Coffee						1986	10·044	0·002	1·364	6·7
Spreads						1976	12·400	0·001	−0·108	5·6
Legumes						2006	13·506	0·000	−0·807	11·6
Local soft drinks						2006	7·227	0·008	1·036	6·6
Table salt						1986	8·505	0·000		15·5
Every meal/very frequently (1)* *v.* never (2)							NA	<0·001	−3·094	13·4
Quite often (3)* *v.* never (2)							NA	0·001	−2·573	7·1
Every meal/very frequently (1)* *v.* seldom (4)							NA	0·003	−2·131	NA
Quite often (3)* *v.* seldom (4)							NA	0·047	−1·805	NA
Food variety						1976	9·323	0·003	−0·256	4·3
Regular meals	1986	26·056	0·000	−2·390	15·8					
Eating between meals	1986	6·612	0·013	1·903	10·1	1976	5·653	0·004		5·2
Never (1)* *v.* once or more (2)			0·013	1·903	10·1					
Rarely (1)* *v.* 1–2 times/d (2)						1976	NA	0·003	−1·069	NA
1–2 times/d (2)* *v.* >3 times/d (3)							NA	0·016	1·151	NA
Occupation	2006	6·959	0·001	NA	12·0					
Manager/middle manager (1)* *v.* professional/associated professional (2)		NA	<0·001	−3·336	NA					
Pie and cake	2006	16·995	0·000	1·159	14·3					
Frequency of vigorous exercise	2006	5·056	0·027	−0·341	4·7	2006	16·636	0·000	0·337	13·9
Frequency of moderate exercise	2006					2006	15·513	0·000	0·309	13·1
Sufficient physical activity (time)	2006					2006	12·051	0·001	−2·694	10·5
Total R^2	1976				43·7					32·6
	1986				43·2					35·1
	2006				30·4					53·2

P, significance; R^2, partial η^2; NA, not available.
( ) refers to number in cell. Non-SDA smoking status 1976 and 2006: (1) = 173; (2) = 47; (3) = 60; (4) = 38. SDA breakfast 1976: (1) = 20; (2) = 34; (3) = 67. Non-SDA table salt 1986: (1) = 37; (2) = 49; (3) = 22; (4) = 38. SDA eating between meals 1986: (1) = 42; (2) = 22. Non-SDA eating between meals 1976: (1) = 78; (2) = 106; (3) = 36. SDA Occupation 2006: (1) = 42; (2) = 48.
*Distinguishes categories with significant differences.
†Interaction with age (chicken positively associated with BMI among <45-year-olds and low-fat milk positively associated with BMI among 25–34-year-olds).

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Table 3 Statistically significant demographic, food and lifestyle predictors or associates of BMI in 1976, 1986 and 2006 among Seventh-day Adventist (SDA) women and non-SDA women

	SDA women					Non SDA women				
Variable	Year	*F*	*P*	*B*	R^2 (%)	Year	*F*	*P*	*B*	R^2 (%)
Chicken	1976	10·862	0·001	1·774	9·0					
Cola						1986	5·538	0·020	1·791	4·9
Soft drinks	1976	7·656	0·007	0·736	6·5					
Low-energy soft drinks						2006	5·455	0·023	0·806	8·0
Whole milk	1976	7·996	0·006	−0·109	6·8	1986	4·829	0·030	0·120	4·3
Soya milk						1976†	4·598	0·033	−10·312	2·4
Wieners	1986	7·881	0·006	11·711	8·5					
Spreads	1986	10·307	0·002	−0·335	10·8					
Age	1986	7·514	0·007	0·076	8·1	1976	21·899	0·000	0·081	10·3
						2006	21·502	<0·001	0·122	25·4
Added sugar	2006	17·219	0·000	1·415	12·2					
Margarine						1986	6·440	0·013	0·061	5·7
Bread rolls	2006	5·467	0·021	0·469	4·2					
Dieting	2006	20·907	0·000	5·848	14·4	1976	35·594	0·000	2·698	15·8
						1986	27·438	<0·000	3·837	20·4
Pizza	2006	11·591	0·001	5·860	8·5					
Eating between meals						1976	3·121	0·046	NA	3·2
Rarely (1)* *v.* 1–2 times/d (2)							NA	0·021	1·220	NA
Rarely (1)* *v.* >3 times/d (3)							NA	0·034	1·295	NA
Table salt						1986	7·249	0·001		11·9
Seldom (1)* *v.* never (2)								<0·001	−2·959	11·9
Quite often/more regularly (3)* *v.* seldom (1)								0·059	1·593	NA
Time in vigorous exercise						2006	4·852	0·031	−0·007	7·2
Total R^2	1976				24·7					26·0
	1986				21·2					34·4
	2006				36·2					34·0

P, significance; R^2, partial η^2; NA, not available.
( ) refers to number in cell. Non-SDA eating between meals 1976: (1) = 48; (2) = 110; (3) = 57. Non-SDA table salt 1986: (1) = 37; (2) = 44; (3) = 33.
*Distinguishes categories with significant differences.
†Positive interaction between soya milk and age.

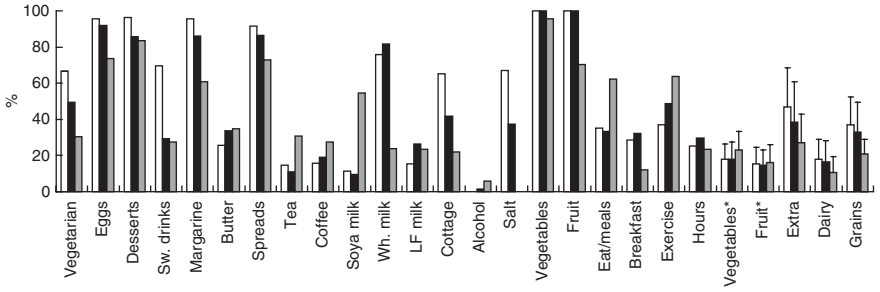


Fig. 3 Changes in food consumption and other lifestyle patterns between 1976 and 2006 (□, 1976; ■, 1986; ▩, 2006) for Seventh-day Adventist men. Figure shows proportions unless indicated otherwise in the following. 'Vegetarian' refers to no meat consumption; 'Desserts' refers sweet foods (pie, cake, pastries, pudding, jelly, ice cream, cream, lollies, chocolate); 'Sw. drinks' refers to cola, soft drinks, cordial, fruit juice; 'Wh. milk' refers to whole milk; 'LF milk' refers to low-fat milk; 'Salt' refers to table salt; all other foods are as the names suggest. 'Eat/meals' refers to eating between meals; 'Breakfast' refers to the consumption of a relatively large breakfast (comprising a bowl of cereal, a serving of fruit or juice, a cup of milk and a slice of toast with spread); 'Exercise' refers to physical activity on 5 d/week; 'Hours' refers to more than 55 h spent at work/week. Using the same numeric scale, the last five categories with error bars refer to the weekly consumption frequency of the core food groups (error bars represent standard deviation). 'Vegetables*' refers to frequency of consumption of unspecified vegetables and low-fat prepared potatoes (e.g. boiled, steamed, mashed); 'Fruit*' refers to frequency of consumption of unspecified fruit; 'Extra' refers to frequency of consumption of extra foods (pie and cake, pastries, biscuits, pudding, ice cream, cream, takeaway foods, butter, margarine, tea, coffee, hot chocolate, flavoured milk, cola drinks, spreads); 'Dairy' refers to frequency of consumption of milk, cheese and yoghurt; and 'Grains' refers to frequency of consumption of bread, cereals, muffins, crackers, rice and pasta

Discussion

When SDA were compared with non-SDA over the period examined, differences were found among men but not women. The SDA prescriptions appear to have better protected SDA men from the changes that contributed to the increase in overweight and obesity among non-SDA men during the onset of the epidemic in the mid to late 1980s.

A vegetarian diet is recommended by the SDA church. Consequently, the BMI of SDA men may have been lower

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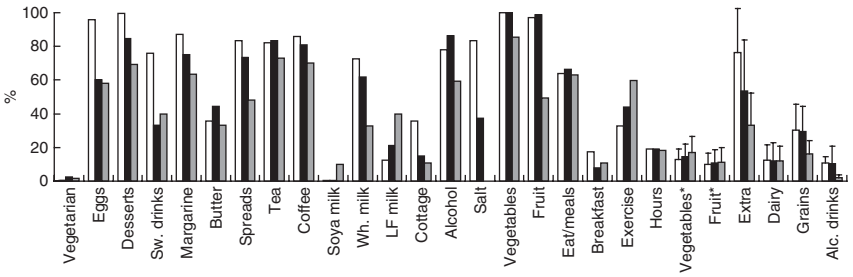


Fig. 4 Changes in food consumption and other lifestyle patterns between 1976 and 2006 (□, 1976; ■, 1986; ▩, 2006) for non Seventh-day Adventist men. Figure shows proportions unless indicated otherwise in the following. 'Vegetarian' refers to no meat consumption; 'Desserts' refers sweet foods (pie, cake, pastries, pudding, jelly, ice cream, cream, lollies, chocolate); 'Sw. drinks' refers to cola, soft drinks, cordial, fruit juice; 'Wh. milk' refers to whole milk; 'LF milk' refers to low-fat milk; 'Salt' refers to table salt; all other foods are as the names suggest. 'Eat/meals' refers to eating between meals; 'Breakfast' refers to the consumption of a relatively large breakfast (comprising a bowl of cereal, a serving of fruit or juice, a cup of milk and a slice of toast with spread); 'Exercise' refers to physical activity on 5 d/week; 'Hours' refers to more than 55 h spent at work/week. Using the same numeric scale, the last six categories with error bars refer to the weekly consumption frequency of the core food groups plus alcoholic drinks (error bars represent standard deviation). 'Vegetables*' refers to frequency of consumption of unspecified vegetables and low-fat prepared potatoes (e.g. boiled, steamed, mashed); 'Fruit*' refers to frequency of consumption of unspecified fruit; 'Extra' refers to frequency of consumption of extra foods (pie and cake, pastries, biscuits, pudding, ice cream, cream, takeaway foods, butter, margarine, tea, coffee, hot chocolate, flavoured milk, cola drinks, spreads); 'Dairy' refers to frequency of consumption of milk, cheese and yoghurt; 'Grains' refers to frequency of consumption of bread, cereals, muffins, crackers, rice and pasta; and 'Alc. drinks' refers to frequency of consumption of beer, wine and liquor.

than that of non-SDA men because there was a greater prevalence of vegetarians among them; vegetarians tend to have lower BMI than non-vegetarians[12–14]. However, it does not appear that vegetarianism accounted entirely for the differences between SDA and non-SDA men as the proportion of SDA vegetarians decreased over the three decades and yet SDA maintained lower BMI than non-SDA men.

The common predictors of high BMI for both SDA and non-SDA men came from the 'extra' and 'meat' food groups. In addition, low physical activity was associated with higher BMI while eating between meals and dieting to lose weight were linked to lower BMI for both groups. Despite these similarities, the food consumption patterns of the two groups varied markedly. Although SDA men consumed more dessert foods than non-SDA men in 2006, they also tended to consume more of the foods that predicted lower BMI and fewer of the foods that were associated with higher BMI. The lifestyle philosophy of SDA appears to have 'immunised' SDA men from the secular changes that contributed to increases in BMI observed among non-SDA men since 1986. This philosophy advocates physical activity; a regular diet that is rich in grains, fruits, nuts, vegetables and water; avoidance of tea, coffee, rich and highly-refined foods; and abstinence from tobacco, alcohol and other drugs[15]. Despite adverse changes in breakfast size, eating between meals and consumption of meat and alcohol (small increases), the findings of the present research support those of Fraser[5] that the majority of SDA men 'adhere to behaviours that may sometimes fall short of the church's recommendations but that still represent a substantial departure from those of others'.

SDA women also tended to consume more of the foods associated with lower BMI and fewer of the foods associated with higher BMI than non-SDA women. In addition, a greater proportion of SDA women were vegetarian and consumed more vegetables and grain foods compared with SDA men. The finding that the diet of SDA women better approximated the Australian Guide to Healthy Eating[16] than that of non-SDA women or SDA men poses a conundrum. Why did SDA women's BMI increase while non-SDA women's BMI remained stable over the 30-year period? The questionnaire design of the present study does not enable an adequate answer to this question, but increases in the portion size of foods prepared outside the home (since the 1980s) may account for the difference[17–19]. SDA women may have consumed 'healthy food' more frequently and 'extra foods' less frequently than other women, but they also may have consumed larger portions. Portions sizes are important as 'larger portions mean more calories' and excess energy increases weight[18].

Another explanation may lie in other limitations of our study. The measurement of dietary intake and physical activity employed in these surveys was a major limitation. Dietary assessment based on dietary recall has biases. Respondents, especially women, may choose socially desirable responses (rather than more objectively accurate ones) in an effort to present themselves in a positive light and avoid criticism[20]. This may be particularly relevant among SDA women as the SDA church advocates certain lifestyle prescriptions[21]. In addition, the SAH questionnaires were changed on four occasions over the 30-year period and further in the 2006 Melbourne survey, making it difficult to maintain continuity in variables that showed associations with BMI. Longitudinal studies and sentinel sites need to develop comprehensive measurement procedures such as FFQ

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that include dietary recall data (24 h dietary recall which provides both qualitative and quantitative information on diet) and use these consistently throughout the life of the programme.

Another limitation is the measurement bias of self-report height and weight used to calculate BMI in 2006. Although self-reported height and weight do correlate highly with BMI calculated from objectively measured heights and weights[22–25], the error in self-reported BMI increases with increasing measured BMI, especially in women, with a trend towards underestimating BMI[25]. It is likely that overweight and obese individuals in our 2006 survey underestimated weight and/or overestimated height, therefore underestimating mean BMI for that year. Validating self-report BMI by obtaining objective measures would provide a correction factor to correct for these biases. A further limitation was the variation in age between SDA and non-SDA, particularly in 1986 and 1988, which may explain the differences in BMI between SDA and non-SDA. However, BMI–lifestyle associations were adjusted age. Furthermore, age differences were found between SDA and non-SDA women where no differences in BMI were found.

A number of spurious BMI associations were found. The consumption of low-energy soft drinks was positively associated with BMI. These drinks may be chosen by individuals with higher BMI as they are lower in energy. In addition, the frequency of vigorous and moderate physical activity was positively associated with BMI for non-SDA men but vigorous physical activity was negatively associated with BMI for SDA men in 2006. BMI differences in the two groups could account for the differential effect of physical activity between SDA and non-SDA men. Physical activity may be performed by non-SDA men to reduce their high BMI. Furthermore, spreads (jams, marmalades, syrup and honey), which were negatively associated with BMI, are energy-dense foods. However, the consumption of spreads may somehow be a marker for a prudent diet as it correlates with the consumption of fruit, vegetables, more frequent and larger breakfast, cereals, bread and legumes. All of these foods were expected to be associated with lower BMI and as outlined earlier each, except for cereals, bread and vegetables, were multivariate predictors of BMI. The reason for these exclusions could be correlations with other foods and this needs to be addressed in future research. Moreover, it is not certain whether the positive associations of low-fat milk and bread rolls have any biological significance or whether they were due to chance, so future longitudinal studies could test these putative relationships.

In summary, it would appear from the main findings that consumption of meat, energy-dense foods and behaviours that may contribute to adverse changes in energy balance (eating between meals, dieting to lose weight and minimal physical activity) result in overweight and obesity. These factors are typical of food consumption, eating behaviour and lifestyle patterns that characteristically make up the 'Western lifestyle'. The dietary guidelines[26] recommend people consume a variety of foods including fruits, vegetables, whole grains, nuts and seeds, small amounts (if any) of sugars, salt, alcohol and saturated fat, and perform regular physical activity. These guidelines reflect the philosophy of the SDA church. The present study has shown that Australians who have embraced the 'Western lifestyle' while moving away from the principles of a 'prudent lifestyle' tend to have higher BMI.

The present results also indicate that in other groups and communities where health is a defining feature of the group, value systems and behaviours relating to diet and lifestyle could be changed[5]:

> When the group culture supports a belief in clear benefits, defines standards of behaviour, and then provides skills and opportunities to improve self-efficacy, success becomes more likely. The perception that one's performance is being observed and compared with community values may be motivating. The teaching of the necessary skills becomes easier when one belongs to a supportive and focused society.

The present findings suggest that policies which promote dietary restraint, physical activity and other dietary and lifestyle practices are likely to provide the public with important health benefits. Such policies would help to refocus the dietary and lifestyle habits of industrialised countries from the 'Western lifestyle' to more 'traditional' ways of eating and living, thus reducing the prevalence of obesity.

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