

Short Communication

Changes in body mass index among Tongan adults in urban and rural areas between the 1970s and 2000s

Nobuko Murayama PhD¹, Taeko Yamamoto PhD², Midori Ishikawa PhD³, Taniela Palu MD⁴, Miyuki Adachi PhD⁵

¹Department of Health and Nutrition, Niigata University of Health and Welfare, Japan

²School of Nutrition and Dietetics, Faculty of Health and Social Work, Kanagawa University of Human Services, Japan

³Department of Nutrition, Nayoro City University, Japan

⁴Diabetics Center, Vaiola Hospital, Kingdom of Tonga

⁵Nagoya University of Arts and Science, Japan

The purpose of this study was to determine trends in body physique among Tongan adults, between the late 1970s and the 2000s. Two areas were studied: Kolofou town (as an urban area) and 'Uiha village (as a rural area). Measurements of body weight and height were taken 4 times for all residents in both areas in 1977/79, 1983, 1990, and 2001. The number of the subjects in 1977/1979, 1983, 1990, 2001 were 130, 138, 102, 71 in the urban area and 92, 89, 90, 66 in the rural area respectively. The mean body mass index (BMI, kg/m²) values of males in the rural area increased significantly, from 28.0 kg/m² in 1977 to 31.0 kg/m² in 2001 ($p = 0.001$); in females, mean BMI values were 30.6 kg/m² in 1977 and 33.3 kg/m² in 2001, this change was not statistically significant. However, the BMI values did not significantly change in males or females in the urban area. The proportion of rural males with a BMI ≥ 30 kg/m² had increased from 24.5% in 1977 to 55.5% in 2001 ($p = 0.012$). Although the mean BMI values for males and females were higher in the urban area than in the rural area until 1990, the differences between the two areas were not observed in 2001, due to an increase of BMI in the rural area. Changes of the mean BMI values in the rural and urban areas studied, between the late 1970s and 2000s, were 10% and 4%, respectively.

Key Words: Tonga, body mass index, urban, rural, trend

INTRODUCTION

Non-communicable diseases and obesity have recently emerged among Pacific Island populations. In the Kingdom of Tonga, located in the South Pacific region, the prevalence of non-communicable disease is increasing rapidly, posing a threat to the health of the entire population.¹⁻³ Although the factors associated with disease patterns are numerous and complex, obesity is the most important risk factor to be considered, since its prevalence rate has reportedly increased in a dramatic fashion and contributed to increasing case numbers of type 2 diabetes, hypertension, and cardiovascular disease.

The prevalence of overweight and obesity in Tongans has increased rapidly since the 1970s and is among the highest in the world. The 1986 National Nutrition Survey of the Kingdom of Tonga, the 1992 National Non-communicable Diseases and Nutrition Survey and a Tonga Type II Diabetes and Cardiovascular Disease Prevention Survey suggest an increase in the prevalence of obesity among Tongan adults between the 1970s and 2000s and higher body mass index (BMI, kg/m²) value in females than males.^{1,4,5}

The prevalence of obesity was higher in urban areas than in rural areas in the late 1970s,⁶ but no significant difference could be found between urban and rural areas

in the 1980s. Additionally, higher BMI values were found in rural areas than in urban areas in 2000.³ These findings suggest more rapid changes to BMI values in rural areas than in urban areas.

Changes in body physique are important to predicting nutritional transition, health-based transitions, and increases in lifestyle-related disease. However, there has been no longitudinal study related to trends in body physique among Tongans while taking into account differences in gender, age, and the urban-rural habitat. Therefore, in the present study, we focus on the changes in BMI among habitants of the urban area of Kolofou and the rural, isolated island of 'Uiha, both in the Kingdom of Tonga, from the late 1970s to 2001. Data for this study were obtained from studies carried once every ten years and trends and changes in BMI were found.

Corresponding Author: Prof Nobuko Murayama, Department of Health and Nutrition, Niigata University of Health and Welfare, 1398 Shimami, Kita-ku, Niigata, Niigata 950-3198, Japan. Tel/Fax: +81-25-257-4421

Email: nobuko-m@nuhw.ac.jp

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MATERIALS AND METHODS

Study area, period, and subjects

The study areas were Kolofo'ou town (an urban area) and 'Uiha village (a rural area). Kolofo'ou town is a central part of Kolofo'ou village in Nuku'alofa, the capital city of Tonga, in Tongatapu Island. This is where the King's palace, government office, bank and market places are located. 'Uiha village is located in the Ha'apai Island group, a remote island that can be reached by 1-h flight or 2-h cruise from the capital. These areas were selected by the ministry of health, Kingdom of Tonga in 1976, before starting this study. The condition of selection was the levels of modernization of lifestyle. Kolofo'ou town was selected as most modernized area. And 'Uiha village was selected as least modernized area with traditional lifestyle, and the family tomb of the King of Tonga was in the village as symbol of tradition. The Kolofo'ou means Kolofo'ou town and 'Uiha' means Uiha village in this study.

Field researches were conducted in 1977, 1983, 1990, and 2001 at both areas. All field research was conducted in the month of August, except in 1983 when it was conducted in March due to the schedule of researchers.

All adults aged 30-69 years old living in the study areas were recruited by ministry of health of the Kingdom of Tonga, through town block/village leaders and public health nurses with an invitation letter and explanation the purpose and methods of the study, and through community radio programs. People who agreed to participate in the study were examined. The response rates (number of subjects participated in this study among the populations the age of 30-69) in Kolofo'ou were 23.0% (130 among 566) in 1979, 21.0% (138 among 661) in 1983, 14.7% (102 among 695) in 1990, and 9.8% (71 among 725) in 2001. The response rate in 'Uiha were 39.3% (92 among 238) in 1977, 38.0% (89 among 234) in 1983, 41.9% (90 among 215) in 1990, and 36.9% (66 among 179) in 2001. Data collected from the population of Kolofo'ou in 1979 and in 1983, and the population of 'Uiha in 1977 were counted by our research team. The population data for other years were estimated from the population census of the Kingdom of Tonga.⁷⁻⁹ The population census of the Kingdom of Tonga were available every 10 years, so the census data in 1986, 1996, 2006 were used as the population data in 1983 for 'Uiha, and 1990 as well as 2001 for both areas. Because the populations at the village level were the smallest unit of the census data, the populations of Kolofo'ou which is part of Kolofo'ou village, were not available in the census. So, the populations of Kolofo'ou were estimated as 21% of the populations of the Kolofo'ou village in 1990 and 2001, because population of Kolofo'ou, 661 persons, obtained by our team in 1983 was 21% of the population of Kolofo'ou village, 3148 persons, in census in 1986.

This research was jointly conducted by Vaiola Hospital, the Ministry of Health of the Kingdom of Tonga, and the Japanese research team. The staff members of the Ministry of Health of the Kingdom of Tonga helped in planning the research; they also coordinated the field work and informed the subjects of the research.

Ethics

Subjects were informed of the investigation and their consent was obtained; subject anonymity was preserved. Since there is no formal ethics committee in Tonga, the study protocol was assessed and approved by the Ministry of Health, Tonga. The protocol for the research project of 2001 was approved by the Ethics Committee of Kagawa Nutrition University, and conformed to the provisions of the Declaration of Helsinki in 1995 (revised in Edinburgh in 2000).

Measurement of weight and height

Body weight and height were measured to the nearest 0.1 kg and 0.1 cm, respectively. BMI was also calculated.

Statistical analysis

Differences in mean \pm SD of the data among the study years were examined by the ANOVA, using a multiple comparison by Tukey's method. Differences in mean \pm SD of the data between areas were examined by Student *t*-test. Differences in the distribution of the subjects by BMI categories among the study years and the area studied were examined by Fisher's exact test. A *p*-value of less than 0.05 was considered to be significant. All analysis was conducted using the statistical package SPSS, version 16.0 (SPSS, Chicago, IL, USA).

RESULTS

Table 1 shows the BMI for Tongan adults recorded between the 1970s and the 2000s. In 'Uiha, the BMI (in kg/m²) increased significantly among males, from 28.0 in 1977 to 31.0 in 2001 (*p* = 0.001); in females, they were 30.6 in 1977 and 33.3 in 2001, this change was not statistically significant. The BMI values of the younger generation (30-49 years) increased more than that of the elderly generation. The BMIs did not significantly change in the males or females of Kolofo'ou: for males, it was 30.7 in 1979 and 31.4 in 2001, and for females, it was 34.6 and 36.1, respectively. As for differences between areas, the BMI values in Kolofo'ou were significantly higher than those of 'Uiha in 1977-79, 1983, and 1990 for both males and females. However, such differences were not found in 2001. During the study period, the BMI values of males and females in 'Uiha had increased by 3.0 (10.7%) and 2.7 (8.8%) units, respectively. While the BMI of males and females in Kolofo'ou had increased by 0.7 (3.6%) and 1.5 (4.3%) units, respectively.

The proportions of males in 'Uiha with BMI \geq 30 kg/m² were 24.5% in 1977 and 55.5% in 2001, and there was significant difference among years (*p* = 0.012). The proportions of females in 'Uiha with BMI \geq 30 kg/m² were 53.5% in 1977 and 74.4% in 2001, there was no significant difference among the years. There were no significant differences between the proportions of males or females in Kolofo'ou with BMI \geq 30 kg/m² among the years. In terms of differences between areas, in Kolofo'ou, the proportion of subjects with higher BMI values was larger in 1977/79 and 1983 for males and in 1977/79 and 2001 for females. (Table 2)

Table 1. Mean and SD of body mass index (BMI, kg/m²) of Tongan adults recorded between the 1970s and the 2000s

Sex	Age (y)		'Uiha				Kolofolou				<i>p</i> -value: Comparison between areas [‡]						
			1977	1983	1990	2001	<i>p</i> -value: Comparison among years [†]	1979	1983	1990	2001	<i>p</i> -value: Comparison among years [†]	1977/79	1983	1990	2001	Total [§]
Male	30-49	mean	27.9	27.5	29.6	32.1	<i>p</i> = 0.004	31.1	30.9	31.8	32.2	n.s.	<i>p</i> = 0.001	<i>p</i> = 0.003	n.s.	n.s.	<i>p</i> < 0.001
		SD	3.0	3.1	4.9	3.9	1977 < 2001	4.3	4.4	6.4	4.4						
		n	30	22	19	11	1983 < 2001	35	31	32	16						
	50-69	mean	28.1	27.1	28.0	30.3	n.s.	30.3	29.2	31.2	30.4	n.s.	n.s.	n.s.	<i>p</i> = 0.018	n.s.	<i>p</i> = 0.006
		SD	3.6	3.7	4.3	5.4		5.3	5.3	4.0	4.4						
		n	19	24	20	16		34	35	21	13						
	Total	mean	28.0	27.3	28.8	31.0	<i>p</i> = 0.001	30.7	30.0	31.6	31.4	n.s.	<i>p</i> = 0.001	<i>p</i> = 0.002	<i>p</i> = 0.011	n.s.	<i>p</i> < 0.001
		SD	3.2	3.4	4.6	4.9	1977 < 2001	4.8	4.9	5.5	4.4						
		n	49	46	39	27	1983 < 2001	69	66	53	29						
Female	30-49	mean	30.5	31.6	33.5	35.5	n.s.	34.2	35.0	36.6	36.1	n.s.	<i>p</i> = 0.007	<i>p</i> = 0.018	n.s.	n.s.	<i>p</i> = 0.003
		SD	5.2	5.5	6.0	7.7		4.8	5.4	7.5	7.9						
		n	21	23	30	16		38	43	20	25						
	50-69	mean	30.7	31.3	31.3	31.7	n.s.	35.2	33.5	34.2	36.2	n.s.	<i>p</i> = 0.012	n.s.	n.s.	<i>p</i> = 0.022	<i>p</i> < 0.001
		SD	5.5	5.4	5.1	4.5		6.0	6.6	6.1	7.4						
		n	22	20	21	23		23	29	29	17						
	Total	mean	30.6	31.5	32.6	33.3	n.s.	34.6	34.4	35.2	36.1	n.s.	<i>p</i> < 0.001	<i>p</i> = 0.008	<i>p</i> = 0.039	n.s.	<i>p</i> < 0.001
		SD	5.3	5.4	5.7	6.2		5.3	5.9	6.7	7.6						
		n	43	43	51	39		61	72	49	42						

† Differences in the BMI among the study years were examined by one-way ANOVA and subsequent multiple comparison by Tukey's method.

‡ Differences in the BMI between the areas in each year were examined by Student's *t* test.

§ Data for all the years were combined in each area and difference in the BMI between the areas was examined by Student's *t* test.

n.s. nonsignificant

Table 2. Distribution of the subjects by the category of body mass index (BMI, kg/m²) between the 1970s and the 2000s

Sex	Age (y)	Category of BMI (kg/m ²)	'Uiha				<i>p</i> -value: Comparison among years [†]	Kolofo'ou				<i>p</i> -value: Comparison among years [†]	<i>p</i> -value: Comparison between areas [‡]					
			1977	1983	1990	2001		1979	1983	1990	2001		1977/79	1983	1990	2001	Total	
Male	30-69	18.5-24.9	n	12	15	8	1	<i>p</i> = 0.012	9	10	5	2	n.s.	<i>p</i> = 0.001	<i>p</i> = 0.015	n.s.	n.s.	<i>p</i> < 0.001
			%	24.5	32.6	20.5	3.7		13.0	15.2	9.4	6.9						
		25.0-29.9	n	25	21	14	11	24	28	15	10							
			%	51.0	45.7	35.9	40.7	34.8	42.4	28.3	34.5							
		30.0-34.9	n	12	9	13	12	23	16	21	12							
			%	24.5	19.6	33.3	44.4	33.3	24.2	39.6	41.4							
		≥35.0	n	0	1	4	3	13	12	12	5							
			%	0.0	2.2	10.3	11.1	18.8	18.2	22.6	17.2							
		Total	n	49	46	39	27	69	66	53	29							
			%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0							
Female	30-69	18.5-24.9	n	7	3	2	4	n.s.	0	2	3	4	n.s.	<i>p</i> = 0.001	n.s.	n.s.	<i>p</i> = 0.044	<i>p</i> < 0.001
			%	16.3	7.0	3.9	10.3		0.0	2.8	6.1	9.5						
		25.0-29.9	n	13	17	13	6	9	14	7	5							
			%	30.2	39.5	25.5	15.4	14.8	19.4	14.3	11.9							
		30.0-34.9	n	13	12	20	17	25	27	13	8							
			%	30.2	27.9	39.2	43.6	41.0	37.5	26.5	19.0							
		≥35.0	n	10	11	16	12	27	29	26	25							
			%	23.3	25.6	31.4	30.8	44.3	40.3	53.1	59.5							
		Total	n	43	43	51	39	61	72	49	42							
			%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0							

[†] Differences in the distribution of the subjects by the category of BMI among the study years were examined by Fisher's exact test.

[‡] Differences in the distribution of the subjects by the category of BMI between the areas in each year were examined by Fisher's exact test.

[§] Data for all the years were combined in each area and Fisher's exact test was performed to examine the difference in the distribution of the subjects by the category of BMI between the areas.
n.s. nonsignificant

DISCUSSION

BMI changes between the 1970s and the 2000s

This study showed significant increases in BMI among Tongan males, especially in rural areas, between the 1970s and the 2000s. To our knowledge, this is the first report of a study for body physiques of Tongans in the same rural and urban areas for over 20 years.

The 1986 National Nutrition Survey of the Kingdom of Tonga revealed that BMI of those aged 40–49 years were 28.0 for males and 32.3 for females in rural areas (islands such as Ha'apai, Vava'u, 'Eua, Niua) and 29.0 for males and 32.7 for females in an urban area (Tongatapu). The prevalence of obesity (BMI ≥ 30 kg/m²) was 10% in males and 31.9% in females as a whole country.⁴ The 1992 National Noncommunicable Diseases and Nutrition Survey reported obesity in 29.8% of males and 39.1% of females as a whole country.¹

Mean BMI in 1983 of this study were slightly lower than National Nutrition Survey in 1986 for males and females in rural area ('Uiha vs islands), and were slightly higher than the national survey for males and females in urban area (Kolofo'ou vs Tongatapu). This could be attributed by the differences in the study areas. The mean BMI values in 'Uiha were less than other rural area such as Vava'u and others, and this would mean people in 'Uiha kept the traditional lifestyle than other islands in the 1980s. And the mean BMI values in Kolofo'ou were higher than mean BMI values of people in Tongatapu island in general and this would mean Kolofo'ou was more urbanized than other areas on Tongatapu island.

The prevalences of obesity in 1983 and 1990 of this study were higher than those of the National Nutrition Survey in 1986 and National Noncommunicable Diseases and Nutrition Survey in 1992, respectively. This could be attributed to differences in study areas also: the national surveys included large populations with lower BMI from less urbanized areas than our study.

In the present study, mean BMI values among males and females had increased by 10.7% and 8.8%, respectively, in 'Uiha, and increased by 3.6% and 4.3% in Kolofo'ou, between the late 1970s and 2001. Duarte et al. reported results of the Tonga Type II Diabetes and Cardiovascular Disease Prevention Survey conducted in Tongatapu, Ha'apai, and Vava'u; therein, the mean BMI values were 30.2 for males and 33.8 for females in 1998–2000, indicating increases of 11.9% and 19.4% between 1973 and 1998–2000, respectively.⁵ The BMI levels of our study in 2001 are comparable to the data of Duarte et al. in 1998–2000; however, in the present study, the percentage values of increases in BMI between the 1970s and 2000s were lower than those of Duarte et al., for both genders. These differences could have resulted from different data from the 1970s: our study was conducted in 1977–1979, and the BMI therein could have been higher than those of the 1973 base data of Duarte et al.

Differences in BMI changes between age groups

Our results suggest that BMI changed more rapidly among younger people than the elderly. Between the 1970s and the 2000s in 'Uiha, the BMI values of males aged 30–49 years had changed more than those of males aged 50–69 years. This data suggests that during the study period,

changes in diet and physical activity were more marked among the younger generation than older age groups. Previous studies suggested marked increases in obesity during adolescence.^{10,11} Increases in the prevalence of obesity are more likely to begin before the age of 30 years, and the rate of change among individuals of this age group is likely to be faster than that in older age groups.

Differences in BMI changes between males and females

Mean BMI increased significantly only among males in 'Uiha—not among females—during the proscribed study period. The mean BMI in 1977 for females in 'Uiha was already 30 kg/m² and over, and the mean BMI was higher for females than males in both 'Uiha and Kolofo'ou in every study year. These results suggest that females sustained a greater increase than males in BMI further back in history or that females have a biological inclination for higher BMI values originally, and that female BMI values are less prone to fluctuations that are otherwise in line with environmental changes.

Differences in BMI between areas

Regarding differences between areas, the mean BMI values in Kolofo'ou were significantly larger than those of 'Uiha, in 1977/79, 1983, and 1990, and for both males and females. However, these differences were not found in 2001.

Traditionally urban-rural differences have existed with respect to the prevalence of obesity in Tonga. Koike et al. reported that Tongan adults living in an urban area (Tongatapu) were more likely to be obese than those living in a rural area (Ha'apai).⁶ However, Colagiuri et al. reported mean BMI values (mean age) for males of 29.7 kg/m² (41.0 years) at Tongatapu in 1998, and 31.0 kg/m² (47.3 years) at Ha'apai and Vava'u in 2000. The mean BMI values (mean age) for their female counterparts were 33.2 kg/m² (38.1 years) and 34.5 kg/m² (42.1 years).³ These studies suggest that BMI differences between areas were not observed by 2000, which accords well with our results. Before the 1970s, BMI values had been increasing in urban and more affluent areas; in this study, there were comparable increases within rural, isolated areas, between the 1980s and 1990s.

Factors contributing to BMI changes

Several studies have been conducted on diet, physical activity, and obesity among Tongans and other inhabitants of the Pacific islands.^{12–14} We have also undertaken dietary surveys at the same time-points as this anthropometrical study. We reported the importance of a traditional dietary pattern—a healthy diet that combines starchy roots, fish, and coconut—as compared to decreases in the consumption of those traditional foods and increases in the consumption of imported foods such as bread, meat, and tea.^{15–19}

Mavoia and McCabe reviewed previous studies and found that changes in food choices and reductions in physical activity have been direct factors contributing to obesity among Tongans and indigenous Fijians; they also mentioned about economic and socio-cultural factors that underpin patterns of eating, physical activity, and body size.²⁰ These factors should be structurally identified in

future studies, in an effort to mitigate obesity among Tongans.

Limitations of the study

Most of the limitations of this study were related to the sampling size and sampling method. The sample size of this study was small and only large difference would be detected. This would be one of the reasons why there were no differences among the years in females in Table 1.

As the sampling method was not random sampling or whole population sampling but voluntary participation, sampling bias should be considered. The average BMI values and the prevalence of obesity would be higher, if the persons who were obese did not participate in the study. However, the sampling method was the same for all years included, so it would not affect the statistical difference among years.

Response rates in 'Uiha were about 40% in all years, however, those in Kolofo'ou were lower than 'Uiha and decrease by years, about 20% in 1979 and 1983, 15% in 1990 and 10% in 2001. The differences in response rates between areas suggest that the BMI itself and differences of BMI among years in 'Uiha were more accurate than those of Kolofo'ou. If the response rate in Kolofo'ou would be higher than this study, BMI in Kolofo'ou would be higher than what was found with this data, and the difference between areas would be detected more than what was found in this study. Decrease of the response rate in Kolofo'ou by year, would affect the ability to detect difference in BMIs and in the prevalence of obesity among years. These limitations should be considered when interpreting the results.

CONCLUSION

The changes in BMI among the rural and urban Tongans studied during the study period (between the 1970s and 2000s) were 10% and 4%, respectively. The increase in BMI occurred later in people in the rural area, especially males, than those in the urban area; however, differences between the areas disappeared in 2001.

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AUTHOR DISCLOSURES

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Nobuko Murayama PhD¹, Taeko Yamamoto PhD², Midori Ishikawa PhD³, Taniela Palu MD⁴, Miyuki Adachi PhD⁵

¹Department of Health and Nutrition, Niigata University of Health and Welfare, Japan

²School of Nutrition and Dietetics, Faculty of Health and Social Work, Kanagawa University of Human Services, Japan

³Department of Nutrition, Nayoro City University, Japan

⁴Diabetics Center, Vaiola Hospital, Kingdom of Tonga

⁵Nagoya University of Arts and Science, Japan

東加王國城鎮及鄉村的成年人在 1970 與 2000 年代間身體質量指數的改變

這個研究的目的是為評估東加群島的成年人體格，從 1970 年代後期至 2000 年代的改變趨勢。共有兩個地區被研究：Kolofo'ou 鎮(城鎮區域)和 'Uiha 村(鄉村區域)。在 1977/79、1983、1990 及 2001 年，所有居民共完成四次體重及身高的測量。1977/1979、1983、1990、2001 年研究參與者在城鎮及鄉村區域分別為 130、138、102、71 名及 92、89、90、66 名。居住在鄉村區域的男性，其平均身體質量指數 (BMI) 顯著地增加，從 1977 年的 28.0 kg/m² 到 2001 年的 31.0 kg/m² ($p=0.001$)；在女性方面，平均 BMI 值 1977 年為 30.6 kg/m²，2001 年為 33.3 kg/m²，這個改變沒有顯著性差異。然而，在城鎮區域，不論男女性，BMI 值都沒有顯著改變。鄉村區域的男性，BMI ≥ 30 kg/m² 的比例，從 1977 年的 24.5% 增加到 2001 年佔 55.5% ($p=0.012$)。直到 1990 年，不論男性或女性，城鎮居民的 BMI 值都較鄉村居民高；但由於鄉村居民的 BMI 增高，在 2001 年已看不到這兩個地區的差異。從 1970 年代後期至 2000 年代，在鄉村及城鎮地區，平均 BMI 值的改變分別是 10% 及 4%。

關鍵字：東加、身體質量指數、城鎮、鄉村、趨勢