The Analysis of Sex Differences in Body Mass Index among Thai Labor Forces

Supawan Manosoontorn[1)], Duanpen Theerawanviwat[2)]

[1)] Ph.D. Candidate in Population and Development Program, National Institute of Development Administration
(supawan@health.moph.go.th)
[2)] National Institute of Development Administration, School of Applied Statistics, Department of Population and Development
(duanpen@as.nida.ac.th)

Abstract

Objectives – To analyze demographic, socioeconomic, psychological, and behavioral differences in body mass index between male and female labor forces and to determine factors affecting males as well as females body masses.
Methods – The National Health Examination Survey III (NHES III), with the permission from the Health Systems Research Institute, provided data for this study. A total of 19,200 respondents aged 15–60 years were included. A multiple regression analysis was used to investigate the association between demographic characteristics, socioeconomic status, psychological and behavioral factors and BMI for both male and female samples.
Results – The mean and standard deviation of BMI for overall sample were 24.06$\pm$4.42 kg/m^2, with males slightly leaner than females on the average (23.31$\pm$4.08 kg/m^2 in male and 24.69$\pm$4.60 kg/m^2 in female). For all strata across the entire studied characteristics, the mean and standard deviation of female BMIs were higher than its counterpart, except income (over 25,000 baht) and education (university educated). Factors influencing male and female BMIs were quite different.
Conclusion – The mean BMI of the Thai labor forces tends to increase steadily and will approach the lower bound of overweight in the near future. The growing prevalence of overweight and obesity in Thai population heralds a large increase in the incidence of obese-related morbidity in the coming decades. Differing patterns of male and female BMIs suggest different etiology and different strategies to deal with this problem.

1. Introduction

The rising epidemic of overweight and obesity over past decades reflects the profound changes in society as well as in individual behavioral patterns. Economic growth, modernization, urbanization and globalization of food markets are just some of the forces thought to underlie the epidemic (Reddy and Yusuf, 1998: 596-601). Increasing income, more urban population, and high in complex carbohydrates diets give way to more variety diets with a higher proportion of fats, saturated fats and sugars. At the same time, large shifts towards less physically demanding work are observed worldwide. Moves towards less physical activity are also found in the increasing use of automated transport, technology in the home, and more passive leisure pursuits. While genes are important in determining a person's susceptibility to weight gain, energy balance is determined by calorie intake and physical activity. Thus societal changes and worldwide nutrition transition are driving the obesity epidemic.

The prevalence of overweight and obesity is commonly assessed by using the body mass index: BMI, defined as the weight in kilograms divided by the square of the height in meters (kg/m^2). A BMI $\geq$ 25 kg/m^2 is defined as overweight, and a BMI of $\geq$ 30 kg/m^2 as obese. These markers provide common benchmarks for the risk assessment of various critical health problems. The mean BMI levels of 22-23 kg/m^2 have been found for adults in Africa and Asia, while levels of 25-27 kg/m^2 are prevalent across North America, Europe, Latin America, North Africa and Pacific Island (World Health Organization, 2002: 83-84). Generally, BMI will increase markedly during the transition to middle-aged and to old-aged

stages of life. Compared with child and adolescence, adulthood especially elderly is at the greatest risk of health complications.

In countries undergoing nutrition transition, overnutrition often co-existed with undernutrition. People with a BMI below 18.5 kg/m^2 tend to be underweighted. The distribution of BMI is shifting upwards in many populations. Recent studies show that people who are undernourished in early life and then become obese in adulthood, tend to develop conditions such as high blood pressure, heart disease and diabetes at an earlier age and in a more severe form than those who were never undernourished. Overweight and obesity leads to adverse metabolic effects on blood pressure, cholesterol, triglycerides and insulin resistance. These adverse metabolic affects more life-threatening problems, which fall into four main areas: CVD problems; conditions associated with insulin resistance such as Type 2 diabetes; certain types of cancers, especially the hormonally related and large-bowel cancers; and gallbladder disease (World Health Organization, 2002: 60-61).

In Thailand, Piyamit Sritara et al. (2003) compared BMI from the three national health examination surveys as shown in Table 1. It was found that not only the mean value of BMI but also the prevalence of overweight and obesity are increasing steadily. However, current research incompletely documents whether this upward trend occurs across all population groups. The question -Is there any specific group at risk?- is not yet being answered. This study therefore aims to identify population groups with relatively high BMI when compared to the others. Consequently, proper preventive strategies to curb this upward trend in overweight and obesity prevalence and its adverse health implications would be indicated.

Table 1 Mean BMI and Overweight and Obesity Prevalence of Thai population*

BMI	NHES I (1991-1992)	NHES II (1996-1997)	Inter ASIA (2000-2001)
Mean (kg)	22.8	23.8	24.4
Prevalence (%)			
Overweight (BMI=25-29.9 kg/m^2)	20	25	30
Obesity(BMI$\geq$30 kg/m^2)	5	8	9

*2000 adjusted population, age 35-39 years
Source: Piyamit Sritara, et al. (2003)

2. Objectives

The objectives of this study are twofold.

(1) To compare demographic, socioeconomic, psychological, and related behavioral differences in body mass index among Thai labor forces.
(2) To determine factors affecting males as well as females body masses.

3. Research Design and Method

3.1 Data

The analysis of BMI of Thai population in the present study used data from the NHES III that conducted in 2003-2004. The aim of the NHES III was to provide precise information on health status of Thai population. BMI in this cross-sectional survey was collected by trained heath personnel. Sampling plan of the NHES III was three staged stratified random sampling. The three factors for stratification were geographical structure, health regional area and socioeconomic status that caused a great distinct effect on culture, economic status, attitude, and also health behavior of Thai population. The target population in the NHES III was divided into four population groups using age and sex criterions. The age group was classified into two age groups, which were labor force group (age 15 to 59 years) and an elderly group (age 60 years and over), while sex was classified into males and females. The unit of analysis was individuals of Thai citizenship. The appropriate sample size for estimating population proportion in the NHES III was designed to cover all cardiovascular risk factors. Moreover, the estimating population proportion was based on estimator of simple random sampling with specified absolute errors under a confidence level of 0.95 with the population proportion rate equaled to 0.50. This sample size formula worked well as long as the proportion was more than 0.20 and less than 0.80. The required sample size was 384, or around 400, for one sex, thus a sample size for both sexes in one province was 800. Further

details about the NHES III could be found in Executive Summary of the Third National Health by Yongyuth Chaiyapong (2005). This present study covered only the labor force group, age 15 – 60 years, both males and females from all regions, including Bangkok Metropolis. After data editing, a total of 19,200 respondents was used for the analysis.

3.2 Variables and Measurements

Questionnaire for a labor force group used in the NHES III was composed of eleven parts. However, this study involved only nine parts that are individual profile, general health status, food intake, physical movement, tobacco use, alcohol consumption, disease and health problem, history of medical diagnosis, and results of physical health examination. These were classified into five groups of variables, they were demographic characteristics, socioeconomic status, psychological factors, behavioral factors, and BMI. Details are as follows.

Demographic variables was chosen directly from the NHES III and composed of five characteristics, which were region of residence, sex, age, religion, and marital status. Region of residence was divided into four geographical areas and Bangkok Metropolis. Age was defined in term of a calendar year in a ratio scale. Religion was classified into Buddhist, Christian, and Islamic and finally, marital status was categorized into single, married, and separated (divorced and widowed) statuses.

Socioeconomic statuses in this study defined as individual income/month, occupation and education. The individual income/month came from the NHES III questionnaire, while an occupation was created based on the physical movement. This occupation variable composed of office worker, home worker OTOP worker, unemployment and students. Educational attainment was defined as the highest formal schooling that a person had finished or graduated, it was classified into illiterate, elementary school, high school, technical college, and university levels.

Psychological factors selected for the present study were stress and anxiety. Stress and anxiety in the NHES III were self-reporting on a thirty days recall. A stress variable was derived from the question asking about a sad feeling while that related to anxiety was derived from the question asking about a feeling of an interfere problem that made people feeling uncomfortable or felt anxiety to themselves. These variables were measured in four ordinal scales that were no-stress/anxiety, little- stress/anxiety, moderate-stress/anxiety, and severe-stress/anxiety.

Behavioral factors were the health behavior or lifestyle pattern that a person performs regularly on their daily life. Unhealthy lifestyles mainly bring about the accumulation of cardiovascular risk factors that cause abnormal biological factors, such as high blood pressure, high blood sugar and high blood cholesterol. In this study, behavioral factors included fruit and vegetable intake, physical movement, tobacco use, and alcohol consumption.

Fruit and vegetable intake can prevent major disease such as CVD. The NHES III collected data about fruit and vegetable intake not only in terms of the number of days/week that a person had eaten fruit and vegetables, but also the number of standard cups/day that had consumed. These two variables were added up and computed in terms of standard cups/day. It then was classified into three categories: 0, less than 5 cups, and equal or more than 5 cups per day.

Physical movement reduces the risk of CVD and improves glucose metabolism, reduces body fat, and lowers blood pressure. Physical movement in this study is defined as a total sum of three major domains of day-to-day activities; a movement to/from work place, a movement during work, and a movement from exercise. These areas were computed and measured in the unit of hour/day. This variable was divided into five categories: movement <10 minutes (physical inactivity), movement from $\geq$10 minutes - 1 hour (lightly movement), movement $\geq$1-3 hours (minimum movement), movement $\geq$3-5 hours (moderate movement) and movement $\geq$5 hours (vigorous movement).

Tobacco use, the NHES III collected tobacco consumption in terms of current smoker, ex smoker, and never smoke. A current smoker was defined as an individual who reports smoking at present while an ex-smoker was defined as that who currently discontinued the smoking habit. Smoking status was constructed from four questions. The first question was ‘have you ever smoked during your lifetime?’, the second, was ‘have you ever smoked more than 100 cigars during your lifetime?’, the third was ‘at present, do you smoke?’ and the final was ‘did you smoke regularly in the past?.’

Alcohol consumption was asked in terms of beverage types, drinking habits, and the quality of alcohol that consumed. Alcohol consumption was then computed in terms of average gram% of alcohol consume/day. Following the standard drink/week that was relevant to the causal of CVD, this variable was categorized into light drinker, moderate drinker, heavy drinker and never drink.

Finally, BMI was measured in terms of weight in kilogram divided by height in square meter (kg/m^2). The NHES III collected height in centimeters, using a portable stadiometer with a sliding head plate, a

base plate and three connecting rods marked with a metric measuring scale. Participants were requested to remove their shoes and to stretch (to maximum height) with their head positioned in the Frankfort plan. A single measurement was recorded in centimeters. In addition, weight was also one time measured using a calibrated manual scale. Participants were also asked to remove their shoes, heavy outer garments and jewelry, loose change and keys. Similarly, a single measurement was recorded in term of kilograms.

3.3 Statistical Method

Multiple linear regression with enter method was employed to analyze the determinants of BMI for the total, male, and female samples. The four demographic characteristics, three socioeconomic status, two psychological, and four behavioral variables were selected as independent variables or determinants. Individual BMI, which was measured in a ratio scale, was a dependent variable. For the categorical independent variable, dummy coding was created and being used instead in the regression analysis. In addition, the assumptions of linearity, multicollinearity, heteroscedasticity, and autocorrelation were checked and found no violation to such assumptions.

4. Results and Discussions

Results of the study are presented in two related parts. The first part deals with levels and differences in BMI among various segments of Thai population. The other part discusses findings derived from multiple regression analysis of variables influencing body mass index for overall sample and for males and females, as well.

4.1 BMI Levels and Differentials

Table 2 depicted mean BMI by demographic characteristics, socioeconomic status, psychological factors, and behavioral factors for total as well as separate sex samples. The mean BMIs were 24.06 (standard deviation, SD 4.42), 23.31 (SD 4.08), and 24.69 (SD 4.6) for overall, male, and female samples respectively. Even though the mean BMI for the Thai labor force was still lower than those of some other developing and most developed countries, it tended to increase steadily and will approach the lower bound of overweight (BMI 25 kg/m^2) in the near future. Female labor force on the average was expected to reach overweight level faster than the male counterpart. The table also revealed that the variation of female BMI was higher than male's. This may be attributed to more diversity of life styles among females than males.

Before going any further, it should be emphasized that for almost all categories of demographic characteristics, socioeconomic status, psychological factors, and behavioral factors, the mean as well as standard deviation of BMIs among females were higher than males. The groups that male mean BMI higher than female's were income over 25,000 baht and university education. This seemed to suggest that men with high socioeconomic status tended to have body masses higher than females with the same qualifications, otherwise females tended to be leaner. For the standard deviation of BMIs, it was found that Christian, students, and zero standard cup/day of fruit and vegetable intake categories had higher standard deviation of male than female BMIs. However, it was interesting to find out that moderate to severe stress and heavy alcohol consumption tended to reduce BMI regardless of sex, due to similar variation of BMIs among males and females who reported moderate to severe stress and a comparable variation of BMIs among males and females who were heavy drinkers.

Turning now to demographic characteristics, it was found that for both sexes, the categories: Bangkok Metropolis (mean 24.83, SD 4.83), Islamic (mean 24.65, SD 4.71), being separated (mean 24.75, SD 4.56), and aged 50 to 59 (mean 24.81, SD 4.20) had the highest mean BMI. The results for females followed the same pattern as the overall sample whereas the male pattern was quite different. For males, the results that were different associated with region and marital status. They were for region: North (mean 23.99, SD 3.85) and Bangkok Metropolis (mean 23.95, SD 4.30) and for marital status: married (mean 23.62, SD 3.85) that had the highest mean BMI, instead of only Bangkok Metropolis and separated, respectively.

Regarding socioeconomic status, Results from Table 2 demonstrated that the categories: income over 25,000 baht (mean 24.86, SD 4.05), OTOP workers (mean 24.74, SD 4.50), and elementary education (mean 24.42, SD 4.33) had the highest mean BMI for overall sample. Males with monthly income higher than 25,000 baht tended to have the highest mean BMI whereas for females, the highest mean BMI belonged to those who earned 5,000-25,000 baht per month. More importantly, income differentials in BMI were more obvious among males than females. The mean BMI differed also by occupation both in

males and females. However, differences between occupational groups were wider in females compared to males. It should be noted further that female mean BMIs of home worker, OTOP worker, and unemployment are on the average 1.65 kg/m^2 heavier than those of males. For the remaining groups: office worker and students, both sexes had about the same mean BMIs. For education, its effects on male and female BMIs were found in the opposite directions. That is, the mean BMI tended to increase with education in males, but in females it seemed to decrease. The relationship between socioeconomic status and body masses suggests causal hypotheses or mechanisms that will require further in-depth analyses to understand more fully.

For psychological factors which consisted of stress and anxiety, we found no substantial differences in the mean BMIs among Thai labor forces. This may be caused by inaccurate measurement of both variables since they were based on self reporting. However, we did find a rather narrow variation in BMIs (SD ranged from 3.99 to 4.09) among males with little or no psychological problems, when compared with those of whom having moderate to severe problems (SD 4.43 for stress and SD 4.31 for anxiety).

Finally, concerning behavioral factors, the finding indicated that for overall sample, the categories: 5 and over standard cups/day of fruit and vegetable intake (mean 24.34, SD 4.48), inactivity (mean 24.17, SD 4.56) to lightly moderate physical movement (mean 24.18, SD 4.57), never drink alcohol (mean 34.50, SD 4.65), and non-smokers (mean 24.48, SD 4.57) had the highest mean BMIs. It should be pointed out that increased fiber intakes in both males and females tended to be associated with increased body masses. This may be due to the fact that those with overweight problem had tried to control their dietary by increasing fruit and vegetable intake and suppressing other nutrients. Moreover, it was expected noticeably physical movement, alcohol consumption, and smoking habits differentials in BMI for the overall sample. We however found moderate differentials for the latter two. For physical movement, no BMI differential was found in the female sample. Table 2 also revealed that mean BMIs decreased with the amount of alcohol consumption and smoking habit. In spite of this, it was found that the male mean BMI disparities were less pronounced than females' for alcohol consumption whereas they were more prominent than females' regarding smoking habit.

Table 2 Mean and Standard Deviation of BMI for Total, Male, and Female Populations

	Body mass index (kg/m^2)								
	Total			Male			Female		
	n	Mean	S D	n	Mean	S D	N	Mean	S D
Total	19,200	24.06	4.42	8,891	23.31	4.08	10,309	24.69	4.60
Region									
Bangkok	1,370	24.83	4.83	477	23.95	4.30	893	25.30	5.03
Central	6,165	24.40	4.66	2,959	23.72	4.31	3,206	25.03	4.87
Northeast	4,628	23.76	4.12	2,228	23.14	3.88	2,400	24.35	4.24
North	4,227	23.68	4.00	1,961	23.99	3.85	2,266	24.28	4.04
South	2,810	23.95	4.65	1,266	22.93	4.04	1,544	24.79	4.93
Religion									
Buddhist	18,528	24.04	4.41	8,598	23.30	4.07	9,930	24.68	4.60
Christian	183	24.04	4.08	73	23.71	4.27	110	24.25	3.95
Islamic	489	24.65	4.71	220	23.78	4.46	269	25.36	4.79
Marriage status									
Single	3,613	22.47	4.76	2,069	22.33	4.59	1,544	22.65	4.97
Separated	1,582	24.75	4.56	344	23.43	4.15	1,238	25.12	4.60
Married	1,4005	24.39	4.22	6,478	23.62	3.85	7,527	25.04	4.40
Age (years)									
15-29	3,810	22.20	4.50	2,004	21.94	4.19	1,806	22.50	4.81
30-39	4,791	23.96	4.24	2,181	23.36	3.92	2,610	24.46	4.43
40-49	5,566	24.72	4.33	2,477	23.91	4.07	3,089	25.37	4.43
50-59	5,033	24.81	4.20	2,229	23.84	3.87	2,804	25.58	4.30
Income(baht)									
< 999	3,709	23.55	4.68	1,148	22.09	4.30	2,561	24.21	4.69
1,000 – 4,999	8,324	23.98	4.37	3,658	22.94	4.01	4,666	24.79	4.46
5,000 – 9,999	4,394	24.23	4.32	2,425	23.64	3.89	1,969	24.95	4.70
10,000 – 24,999	2,280	24.66	4.34	1,347	24.43	4.03	933	25.01	4.72
> 25,000	493	24.86	4.05	313	24.96	3.80	180	24.69	4.46

Table 2 Mean and Standard Deviation of BMI for Total, Male, and Female Populations(continued)

	Body mass index (kg/m^2)								
	Total			Male			Female		
	n	Mean	S D	n	Mean	S D	N	Mean	S D
Total	19,200	24.06	4.42	8,891	23.31	4.08	10,309	24.69	4.60
Occupation*									
Office worker	4,600	23.56	4.13	2,640	23.34	3.95	1,960	23.86	4.35
Home worker	5,572	24.49	4.43	1,777	23.18	4.00	3,795	25.10	4.48
OTOP worker	5,304	24.74	4.50	2,622	24.01	4.11	2,682	25.47	4.75
Unemployment	2,607	23.65	4.17	1,262	22.84	3.77	1,345	24.42	4.37
Students	1,117	21.61	4.52	590	21.55	4.67	527	21.68	4.35
Education									
Illiterate	682	24.16	4.71	220	22.38	4.39	462	25.00	4.63
Elementary	11,556	24.42	4.33	4,945	23.31	3.93	6,611	25.25	4.43
High school	4,470	23.32	4.46	2,463	23.08	4.24	2,007	23.63	4.70
Technical college	866	23.74	4.64	475	23.69	4.43	391	23.79	4.89
University	1,626	23.58	4.41	788	24.09	4.14	838	23.10	4.60
Stress									
No	13,717	24.07	4.42	6,724	23.38	4.08	6,993	24.73	4.63
Little	4,002	24.02	4.40	1,640	23.10	3.99	2,362	24.65	4.56
Moderate to severe	1,481	24.04	4.47	527	23.08	4.43	954	24.57	4.41
Anxiety									
No	12,177	24.00	4.41	6,090	23.31	4.05	6,087	24.70	4.63
Little	4,983	24.16	4.41	2,061	23.32	4.09	2,922	24.75	4.52
Moderate to severe	2,040	24.13	4.52	740	23.34	4.31	1,300	24.58	4.59
Fruit and vegetable intake (Std. cups/day)									
0	44	23.03	3.84	24	22.62	4.06	20	23.50	3.60
< 5	14,372	23.96	4.40	6,899	23.24	4.02	7,473	24.63	4.62
> 5	4,784	24.34	4.48	1,968	23.57	4.29	2,816	24.88	4.54
Physical movement									
Inactivity	2,500	24.17	4.56	1,120	23.63	4.40	1.380	24.61	4.64
Lightly movement	2,940	24.18	4.57	1,250	23.58	4.26	1.690	24.63	4.75
Minimum movement	3,780	24.12	4.43	1,560	23.47	4.09	2.220	24.58	4.60
Heavy movement	2,887	24.11	4.46	1,303	23.25	4.15	1.584	24.82	4.57
Vigorous movement	7,093	23.90	4.28	3,658	23.08	3.88	3.435	24.77	4.52
Alcohol consumption (Std. drink/week)									
Light drinker	5,258	24.05	4.34	2366	23.52	4.17	2892	24.49	4.42
Moderate drinker	2,610	23.40	4.03	2111	23.15	3.96	499	24.45	4.13
Heavy drinker	2,144	22.98	3.76	1898	22.88	3.75	246	23.73	3.76
Never drink	9,188	24.50	4.65	2516	23.59	4.30	6672	24.84	4.72
Smoke									
Current smoker	4,441	22.80	3.91	4,120	22.69	3.87	321	24.19	4.24
Ex-smoker*	2,607	24.19	4.13	2,162	24.07	4.01	445	24.81	4.58
Non smoker	12,152	24.48	4.57	2,609	23.67	4.32	9,543	24.71	4.61

* Office worker = government officer and private officer, Home worker = working in a family to help a family gain more money without income, OTOP(One Tumbon One Product = working in a family to help a family gain more money with income

4.2 Determinants of Body Mass Index

As described in the previous section, there appeared to be a strong association between some of demographic characteristics, socioeconomic status, psychological factors, behavioral factors and body masses. We found the existence of differentials in BMIs among different segments of Thai labor forces. Hence, in the following analysis, BMI was regressed on these individual characteristics. This analysis will extend our understanding of the relationships between individual social position and BMI. We also would like to investigate whether there was any varying nature of these associations between males and females. Therefore, Table 3 presented unstandardized regression coefficients for the total as well as for different sexes.

Table 3 Multiple Regression of BMI on Selected Independent Variables for Total, Male, and Female Populations

Variables	Total	Male	Female
Demographic characteristics			
Central	-0.18	0.12	**-0.36***
Northeast	**-0.59*****	-0.07	**-0.94*****
North	**-0.80*****	-0.37	**-1.07*****
South	**-0.50*****	**-0.49***	**-0.48***
Male	**-0.67*****	---	---
Age	**0.05*****	**0.05*****	**0.06*****
Buddhist	**-0.41***	**-0.54***	-0.40
Single	**-0.58*****	-0.27	**-0.90*****
Married	0.06	-0.14	0.26
Socioeconomic status			
Education	**-0.03****	**0.07*****	**-0.09*****
Office worker	**0.83*****	**0.90*****	0.40
Home worker	**1.21*****	**0.93*****	**1.09*****
OTOP worker	**1.47*****	**1.22*****	**1.42*****
Unemployment	**0.93*****	**0.90*****	**0.82****
Income < 999 baht	**-0.63****	**-1.30*****	0.06
Income < 4,999 baht	**-0.46***	**-0.90*****	0.31
Income < 9,999 baht	-0.28	**-0.50***	0.38
Income < 24,999 baht	-0.01	-0.19	0.56
Psychological factors			
Little stress	**-0.28****	**-0.39****	-0.23
Moderate stress	**-0.32***	-0.45	-0.26
Little anxiety	0.11	0.15	0.02
Moderate anxiety	0.05	0.36	-0.19
Behavioral factors			
Fruit and vegetable in take	**0.03****	**0.04***	0.03
Physical movement	**-0.03*****	**-0.05*****	-0.02
Current smoker	**-1.15*****	**-0.99*****	**-0.89*****
Ex smoker	-0.02	0.11	-0.03
Alcohol consumption	**-0.01****	**-0.01****	**-0.01****
Constant	23.02***	21.93***	22.90***
R^2	9.79%	8.87%	9.11%
Durbin Watson	1.96	1.99	1.98
F	77.02***	33.16***	39.65***

Reference groups: Region (Bangkok), Sex (female), Religion (Christ and Islam), Marriage status (Separate), Occupation (student), Income (> = 25000 baht), Stress (no stress), Anxiety (no anxiety), Smoke (Non smoker)

Overall the total, male, and female regression models explained approximately 9% - 10% of the variation in BMI. As already known, the health especially body mass is a cumulative outcome of individual's behavior, practices over long periods of time, and hence current information may be poor predictors of one's BMI. Moreover, the low R^2 values are quite common in studies examining the determinants of BMI (Reddy and Yusuf, 1998: 596-601, Bark et al. 1997: 167-176, Croft et al. 1992: 821–826, Ballantyne, Devine and Fife, 1978: 880-881).

In the first set of explanatory variables which consisted of regional residence, gender, age, religion, and marital status, they all appeared to be significant determinants of BMI for the total population. However, the impacts of these characteristics on male's and female's BMI were differed. For males, those who resided in the South had significantly lower BMI than those living in Bangkok Metropolis while the BMI of males in the remaining regions were not significantly different from males in the reference group (Bangkok Metropolis). In contrast, BMIs of females not only in the South but also in the Central, Northeast, and North were significantly lower than those in Bangkok Metropolis. Moreover, females in the Northeast and North on the average had considerably lower BMI than those in the Central and South. Lower BMI among females in the former two regions may be due to different reasons. The same was true for higher BMI in the latter two. However, the leading causes should be applied only to females, not to males. This finding suggested that sex and region seemed to have interaction effects on BMI of the Thai labor forces. It is not yet clear how the interaction between sex and region connected with BMI. This was subjected to further investigation.

We found an association between advanced age and increased BMI for both males and females, with the magnitudes of this association were about the same. It indicated that the impact of age on BMI was uniform across sex subgroups. It should be noted that the analysis of this study based on sample aged 15 – 60 years old. Therefore, within this age range while holding other variables in the model constant, an additional year older would increase the BMI of males and females on the average by 0.05 and 0.06 kg/m^2 respectively. Gaining some weight with age is inevitable since we tended to consume far more than needs to sustain life (National Heart, Lung and Blood Institute, 1998: 3-5). However, it was documented that BMI tended to increase until age 50 in male and age 70 in females before leveling off (http://www.thailabonline.com).

Regarding effects of the other two indicators of individual characteristics: religion and marital status on BMI, different patterns were observed between sexes. In males, Buddhists had significantly lower BMI than Christians and Islamic; but marital status was statistically insignificance in determining males' BMI. On the contrary, in females, the BMI was not associated with religion but it depended on marital status. Single women tended to be leaner than married and separated women. A possible explanation might relate to the effects of body weight on interpersonal attractiveness. Assuming that being in a marriage-like relationship was a desirable state for most women, and that thinness increased attractiveness to potential partners, one might expect that single women might try to be thin as part of a strategy for attracting a partner, and similarly, those who become married might gain weight because of weakened motivation for keeping body weight down (Jeffery and Rick: 2002). Furthermore, Rosenberg et al. (2003) assessed the influence of bearing a first, second, or later child on weight gain among ever married African-American women and found that the BMI of participated women increased by an average of 1.6 kg/m^2, equivalent to a weight gain of ~4.4 kg. Women who had a first child gained more than those who had a second or later child. Therefore, BMI was directly associated with marriage and number of children.

All three indicators of socioeconomic status: education, occupation, and income were statistically significant in the total and male models. However, females' BMI were significantly influenced only by education and occupation. As already described in the previous section, the educational effect on male and female BMIs were in the opposite directions although the magnitudes of the effect were about the same. An additional year of education was likely to increase male BMI by 0.07 kg/m^2 and to decrease female BMI by 0.09 kg/m^2. Similarly, income appeared to have a strong positive effect on male BMI. Although income was not statistically significant in the female model, it showed a negative relationship with BMI. Moreover, it was found that for males the effects of office workers, home workers, OTOP workers and unemployment on BMI were similar in magnitudes. On the contrary, the four mentioned occupations inserted quite different effects on female BMI. Thus, we may conclude that socioeconomic status and BMI were positively related for males while for females they were inversely related. It was obvious that socioeconomic status interacts with gender to affect body masses of Thai labor forces. This finding indicated that body masses reflected not simply weight and height, but in fact were rooted in complex social forces including gender roles and norms as well as access to resources that support healthy body weights. Thailand has been in the midst of transition from agrarian to urban and industrialized society so did the changing norm of overweight and obesity from merely beauty concern (body silhouette – only the concern of women) to health and well-being related. Females are quick to change because both values are probably their primary concerns. Higher socioeconomic status females were leaner than those with lower status due to greater access to resources, facilities, and opportunities that make obesity less likely. However, at present a large proportion of Thai males, particularly the older generation, perceived that taking good cares of body weight through diet or physical activity were not the role of masculine. Therefore, higher socioeconomic status males use their resources to enjoy modernized life styles practices instead. This speculation however needs to be confirmed by further investigations.

Psychological factors considered in this study were stress and anxiety. A number of researches suggested that there is a biological link between stress and anxiety and the drive to eat. Foods that are high in sugar, fat, and calories seem to calm the body's response to chronic stress and anxiety. In addition, hormones produced when one is under stress or anxiety encourages the formation of fat cells. Interestingly, for both males and females, it was found that psychological health and physical health were not significantly associated except the relationship between stress and the male BMI. Such effect was however not so strong. It should be pointed out that the directions of the relationship between anxiety and BMI for both males and females were consistent with those from biological research mentioned above. On the contrary, those related to stress were just the opposite. It was documented that the effects of psychological factors on BMI were poorly understood. This is in part attributed to measurement problem since most studies (including the present one) based entirely on self reporting which tends not to be valid.

Finally, among behavioral factors examined in this study which were fruit and vegetable intake, physical movement, smoking habit, and alcohol consumption, all these variables were significantly associated with the male BMIs. For females, of the four behavioral variables, only smoking habit and alcohol consumption were statistically significant. These results were consistent with BMI differential patterns shown in Table2. According to various amount of fruit and vegetable intake and levels of physical movement, females appeared to be more homogenous in body masses than males. This led to the insignificant effects of the two variables for female sample.

Increasing BMI is directly caused by high calorie intake and binge eating disorder. Besides, the relationship between frequency of eating and weight gain is somewhat controversial. There are many reports of overweight people eating less often than people with normal weight. Scientists had observed that people who eat small meals four or five times daily, have lower cholesterol levels and stable blood sugar levels than people who eat less frequently large meals daily. One possible explanation was that small frequent meals produced stable insulin levels, whereas large meals caused large spikes of insulin after meals (Spitzer RL et al., 1992: 191-203). However, this study analyzed only the total amount of fruit and vegetable intake per day and showed positive association with BMI. It may be on the one hand that the quantity of fruit and vegetable intake were highly related with the quantity of other types of food intake. On the other hand, those with overweight problem had tried to control their dietary by increasing fruit and vegetable intake and suppressing other nutrients. This argument which is out of the scope of this study has as yet to be fully understood.

Physical movement was hypothesized to directly affect BMI. It however was significant only in the male model. Physical movement in the present study was measured as times spend in day-to-day activities, a movement to/from work place, a movement during work, and a movement from exercise. Several studies indicated that intensity or quality of physical activity rather than its quantity that affect BMI (Reilly and others, 2006; and Abbott and Davies). This seemed to suggest that to perform similar physical activity in a particular time length, men expended higher energy than females. Evidently, it was most likely among females that energy expenditures for lightly, minimum, heavy, and vigorous movements were not different substantially.

Statistically significant tobacco smoking differences in BMI were found for both sexes in this study. Current smokers on the average were leaner than ex-smokers and non-smokers. A similar pattern was observed for alcohol consumption. In both sexes, BMI was inversely associated with alcohol consumption. Heavy alcohol drinkers had mean BMI lower than moderate and light drinkers as well as non-drinkers. These findings were consistent with most studies done elsewhere (Ali Mohammad and Lindstrom, 2005; Jackson et. al., 2003; and Tavani et. al., 1994). According to extensive medical research, consumption of sugar decreased as the consumption of alcohol drinking increased (Prentice, 1995: S44-S50). In addition, alcohol appeared to increase metabolic rate significantly, thus causing more calories to be burned rather than stored in the body as fat. It was even indicated that moderate alcohol drinking was a protective factor for coronary heart disease. In contrast, the effect of smoking on BMI was poorly understood.

5. Summary and Conclusions

This study showed clear sex differences in the levels of as well as factors affecting BMI. The mean and standard deviation of BMI for the overall sample were 24.06 ± 4.42 kg/m^2, with males slightly leaner than females on the average (23.31 ± 4.08 kg/m^2 in male and 24.69 ± 4.60 kg/m^2 in female). For all strata across the entire studied characteristics, the mean and standard deviation of female BMI were higher than its counterpart, except income (over 25,000 baht) and education (university educated). Regarding factors determining male and female BMIs, this study found substantial differing patterns in demographic, socioeconomic, and behavioral characteristics. More importantly, results related to socioeconomic status indicated that males with higher social classes were heavier when compared with those in the lower ones. In contrast, BMI and socioeconomic status were inversely associated among female labor forces. Moreover, we found not only inter-sex differences in BMI but also intra-sex differences by several important characteristics.

These findings seemed to suggest that males tended to be more conservative and wide disparities in body masses than females. This led us to believe that even though females on the average have higher BMI than males, it will be more difficult to solve the overweight and obesity problems in males than its counterpart. However, differing patterns of male and female BMIs suggest different etiology and different strategies to deal with overweight and obesity of the Thai labor forces. Nevertheless, there were still some unresolved problems pointed out in this study that needed further investigation.

The obesity epidemic is not restricted only to industrialized societies. It in fact has been increasing at a faster speed in developing countries than in the developed world (World Health Organization, 2002: 83-84). The health consequences range from increased risk of premature death, to serious chronic conditions that reduced the overall quality of life. The rising epidemic reflects the profound changes in society and in behavioral patterns of communities over recent decades. While genes are important in determining a person's susceptibility to weight gain, energy balance which is determined by calorie intake and physical activity is considered to be more important. Thus societal changes and worldwide nutrition transition are driving the obesity epidemic. However, economic growth, modernization, urbanization and globalization of food markets are just some of the forces thought to underlie the epidemic. Overweight/obesity is not only a major contributor to the burden of chronic disease and disability, but in itself is also a complex condition.

Acknowledgments

The authors would like to express their sincere appreciation to the dissertation committee comprised of Dr.Yawarat Prapakkharn (Health Systems Research Institute), Dr. Gun Chernrungroj (Ministry of Public Health) and Dr. Pachitjanut Siripanich (National Institute of Development Administration) who provided invaluable guidance with the project. This project would have never come to pass without the assistance from Health Systems Research Institute for providing the National Health Examination Survey data. The authors are truly appreciate their involvement in this study.

References

[1] Abbott, R.A. and Davies, P.S.W. Habitual Physical Activity and Physical Activity Intensity: Their Relation to Body Composition in 5.0-10.5 Year-Old Children. **European Journal of Clinical Nutrition.** Vol. 58(2), pp 285-291, 2004.

[2] Ballantyne, D., Devine, BL. and Fife, R. Interrelation of Age, Obesity, Cigarette Smoking, and Blood Pressure in Hypertensive Patients. **British Medical Journal.** Vol. 1, pp 880-881, 1978.

[3] Bardekar, A., et al. Insulin Resistance in 8 year old Indian Children. **Diabetes.** Vol. 48, pp 2422-2429, 1999.

[4] Bark, R., et al. Risk Perception of Men and Women Scientists. **Social Science Quarterly.** Vol. 78, pp 167-176, 1997.

[5] Colditz GA. Economic costs of obesity and inactivity. **Medical Science Sports Exercise**. Vol. 31(11 Suppl), pp S663-S667, 1999.

[6] Croft, J.B., et al. Socioeconomic and Behavioural Correlates of Body Mass Index in Black Adults: The Pitt County Study. **American Journal of Public Health.** Vol. 82, pp 821–826, 1992.

[7] Darwin, R.L. and James, W.R. **Epidemiology and Prevention of Cardiovascular Diseases**. Maryland: Aspen Publishers. 1998.

[8] Field AE, Coakley EH, Must A, Spadano JL, Laird N, Dietz WH, et al. Impact of overweight on the risk of developing common chronic diseases during a 10-year period**. Archives of Internal Medicine**. Vol. 161(13), pp 1581-1586, 2001.

[9] Hu, F.B., et al. Prospective Study of Major Dietary Patterns and Risk of Coronary Heart Disease in Men. **American Journal of Clinical Nutrition.** Vol. 72, pp 912–921, 2000..

[10] Jequier, E. Alcohol Intake and Body Weight: a Paradox. **American Journal of Clinical Nutrition.** Vol. 69, pp 173-174, 1999.

[11] Jousilahti, P., et al. Body Weight, Cardiovascular Risk Factors, and Coronary Mortality. 15-Year-Follow-Up of Middle-Aged Men and Women in Eastern Finland. **Circulation: Journal of the American Heart Association.** Vol. 93, pp 1372–1379, 1996.

[12] Katzel, LI., et al. Effects of Weight Loss vs Aerobic Exercise Training on Risk Factors for Coronary Disease in Healthy, Obese, Middle-aged and Older Men. A Randomized Controlled Trial. **Journal of the American Medical Association**. Vol. 274, pp 1915-1921, 1995.

[13] Kimm, S.Y., et al. Race, Socioeconomic Status, and Obesity in 9- to 10-Year-Old Girls: The NHBLI Growth and Health Study. **Annuals of Epidemiology.** Vol. 6, pp 266–275, 1996.

[14] Kivimäki, et al. Work Stress, Weight Gain and Weight Loss: Evidence for Bidirectional Effects of Job Strain on Body Mass Index in The Whitehall II study. **International Journal of Obesity.** Vol. 10, pp 1038, 2006.

[15] Monterio, C.A., et al. Shifting Obesity Trends in Brazil. **European Journal of Clinical Nutrition.** Vol. 54, pp 342-346, 2000.
[16] National Heart, Lung, and Blood Institute. Clinical Guidelines on the Identification, Evaluation and Treatment of Overweight and Obesity in Adults. National Institute of Health, pp 10-12, 1998.
[17] Piyamitr Sritara. Executive Summary: **Study of Risks Factors of Cardiovascular Disease in Thailan**d. (Copy document). Bangkok: Faculty of Medicine at Ramathibodi Hospital. 2001.
[18] Popkin BM. The nutrition transition and obesity in the developing world. **Journal of Nutrition.** Vol. 131(3), pp 871S-873S. 2001.
[19] Prentice, A.M. Alcohol and Obesity. **International Journal of Obesity.** Vol. 19 (Suppl 5), pp S44 - S50. 1995.
[20] Reddy, K.S. and Yusuf, S. The Emerging Epidemic of Cardiovascular Disease in Developing Countries. **Circulation: Journal of the American Heart Association.** Vol.97, pp 596-601, 1998.
[21] Singh PN, Lindsted KD, Fraser GE. Body weight and mortality among adults who never smoked. **American Journal Epidemiology**. Vol. 150(11), pp 1152-1164, 1999.
[22] Smith, J. Healthy Bodies and Thick Wallets: The Dual Relationship between Health and Socioeconomic Status. **Journal of Economic Perspectives.** pp 145-166, 1999.
[23] Sobal, J. and Stunkard, J. Socioeconomic Status and Obesity. A Review of the Literature. **Psychology Bullatine.** Vol. 105, pp 260–275, 1989.
[24] Spitzer, RL., et al. Binge Eating Disorder: a Multisite Field Trial of the Diagnostic Criteria. **International Journal of Eatting Disorder.** Vol. 11, pp 191-203. 1992.
[25] Tambs K, Moum T, Eaves L, et al. Genetics and environmental contributions to the variance of the BMI in a Norwegian sample of first-degree and second-degree relatives. **American Journal of Human Biology**. Vol. 3, pp 257-268, 1991.
[26] Thompson D, Edelsberg J, Colditz GA, Bird AP, Oster G. Lifetime Health and Economic Consequences of Obesity. **Archives of International Medicine**. Vol. 159(18), pp 2177-83, 1999.
[27] Vogler GP, Sorensen TI, Stunkard AJ, Srinivasan MR, Rao DC. Influences of genes and shared family environment on adult BMI assessed in an adoption study by a comprehensive path model **International Journal of Obesity Related to Metabolic Disorder**. Vol. 19, pp 40-45, 1995.
[28] Yongyuth Chaiyapong. Executive Summary of the Third National Health Examination Survey. (Copy Document) Bangkok: Thailand Health Survey Office. 2005.
[29] World Health Organization. The World Health Report 2002: Reducing Risk and Promoting Healthy Life. Geneva, World Health Organization. 2002.