A Review of Adult Obesity Research in Malaysia

Lim Kean Ghee, FRCS

International Medical University Clinical School, Seremban

ABSTRACT

A literature search of articles as detailed in the paper B*ibliography of clinical research in Malaysia: methods and brief results,* using the MESH terms Obesity; Obesity, Abdominal; and Overweight; covering the years 2000 till 2015 was undertaken and 265 articles were identified. Serial population studies showed that the prevalence of obesity increased rapidly in Malaysia in the last decade of the twentieth century. This follows the rising availability of food per capita which had been begun two to three decades previously. Almost every birth cohort, even up to those in their seventh decade increased in prevalence of overweight and obesity between 1996 and 2006. However, the rise in prevalence in obesity appears to have plateaued after the first decade of the twentieth century. Women are more obese than men and Malays and Indians are more obese than Chinese. The Orang Asli (Aborigines) are the least obese ethnic group in Malaysia but that may change with socio-economic development. Neither living in rural areas nor having low income protects against obesity. On the contrary, a tertiary education and an income over RM4,000/month is associated with less obesity. Malaysians are generally not physically active enough, in the modes of transportation they use and how they use their leisure time.

Other criteria and measures of obesity have been investigated, such as the relevance of abdominal obesity, and the Asian criteria or Body Mass Index (BMI) cut-offs value of 23.0 kg/m² for overweight and 27.0 kg/m2 for obesity, with the view that the risk of diabetes and other chronic diseases start to increase at lower values in Asians compared to Europeans. Nevertheless the standard World Health Organization (WHO) guidelines for obesity are still most widely used and hence is the best common reference.

Guidelines for the management of obesity have been published and projects to combat obesity are being run. However, more effort needs to be invested. Studies on intervention programmes showed that weight loss is not easy to achieve nor maintain. Laboratory research worldwide has uncovered several genetic and biochemical markers associated with obesity. Similar studies in Malaysia have found some biomarkers with an association to obesity in the local population but none of great significance.

KEY WORDS:
overweight, obesity, Malaysia, abdominal obesity, physical activity, food intake, hypertension, diabetes, metabolic syndrome, psychiatric conditions, breast cancer, colorectal cancer

INTRODUCTION

265 articles were identified and examined in a literature search on adult obesity in Malaysia. The search using the medical subject headings (MeSH) Obesity; Obesity, Abdominal; and Overweight; followed the method that has been previously described.[1] In brief, clinical research publications containing data on Malaysia for the period Jan 2000 - Dec 2015 were included (last search date 2 Feb 2016). Conference proceedings (but not conference abstracts), relevant theses/dissertation, books/book chapters, reports and clinical practice guidelines were included. 365 articles were initially identified, but 100 articles pertaining to childhood and adolescent obesity were excluded.

Nutrition is vital for health. Undernourishment was a significant burden on human health in the past. However, human morbidity and mortality increases not only with undernourishment but also with excessive nutrition. Obesity, the disease of excessive adipose tissue is increasingly prevalent worldwide.

The WHO criteria for Body Mass Index(BMI) classifies a BMI of 25-29.9 kg/m^2 as overweight and >30 kg/m^2 as obese.[2] BMI does overestimate obesity in muscular individuals and underestimate it in such as the elderly who have lost body mass. However, it still is the most widely used index for obesity. Obesity is recognised as a major determinant of non-communicable diseases such as cardiovascular disease, cancers, type 2 diabetes mellitus, respiratory problems, gallbladder diseases, post-operative morbidity and musculoskeletal disorders such as osteoarthrosis.

There has been a clearly documented dramatic increase in the prevalence of obesity in Malaysia over the last three decades since large scale population data became available. The rise of obesity is not a problem unique to Malaysia. In the global context, alongside development and prosperity, in many countries especially in Asia, obesity has become a leading health issue.

This process has been termed nutrition transition, from low availability of calories mainly in the form of plant products to diets high in fats, sugars and energy dense processed foods. This in turn has been the result of rapid economic development which has taken place in Malaysia in the last quarter of the twentieth century. Malaysia has recently been ranked second highest in East and Southeast Asia in terms of being overweight.[3]

Corresponding Author: keanghee_lim@imu.edu.my

SECTION 1: REVIEW OF LITERATURE

PREVALENCE OF OBESITY

In the Adult* Population

There have been five large (>10,000 respondents) national population studies on the prevalence of obesity (Table I).

The National Health Morbidity Survey(NHMS II) in 1996 found that 16.6% prevalence of the adult population are overweight and 4.4% obese.[4] (This study is often quoted as finding a prevalence 20.7% of individuals aged 20 years and older who were overweight and 5.8% obese).[5] Six year later, the Malaysian Adults Nutrition Survey (MANS) carried out between October 2002 and July 2003,[6] found that the prevalence of obesity had more than doubled and that the number of adults overweight increased more than 60%. If that rather rapid increase in the prevalence of obesity seemed hard to believe, the findings were confirmed in another study in 2004.[7] Following shortly, the Third National Health and Morbidity Survey (NHMS III) in 2006 conducted among 33,055 adults found 29.1% were overweight and 14.0% obese.[8] When the next NMHS was done five years later in 2011, it showed only a slight increase in the rates of those overweight and obese, hopefully indicating the rising rate has reached a plateau.[9] (Figure 1 and 2)

Age

The NSCVDRF study only reported data for obesity and not overweight. Leaving that study aside the other four large population nutritional surveys come at almost 5-year intervals. The MANS study is two years late in 2003 instead of 2001. The data for these four large studies can be put alongside each other for examination of the prevalence of overweight and obesity in the various age groups.

The prevalence of both overweight and obesity are lowest among young adults but more than doubles to a peak in middle age (Figure 3 and 4). In the NHMS II in 1996, the peak age for obesity was the 40-49 year age band (Figure 4). In the NMHS III,[8] reported age in 5-year bands, the peak was the 50-54 year age band and in the NMHS 2011[9] the peak had moved further to the 55-59 year band (Figure 4). It therefore appears that the cohort born between 1952-1957 carried the high peak of obesity with them as they aged.

Does the rising prevalence of obesity mean only the young age groups move up in age carrying their higher prevalence with them or did all age groups also increase in weight? Figures 5 and 6 which shows the prevalence of overweight and obese by birth cohorts shows us that every birth cohort increased in prevalence of overweight and obesity between 1996 and 2006. Even the cohort born between 1927-1936 who were >60 years old in 1996 showed an increased in prevalence of overweight and obesity 10 years later in the NMHS III survey when they were the >70 year age group (prevalence of overweight 15.6% rose to 21.1-29.3%, obesity 3.1% rose to 7.2-8.6%). It appears that the period between 1996 and 2006 saw the most rapid rise in weight gain in the Malaysian population.

However, between 2006 and 2011, cohorts born before 1952, i.e. those who were above 55 years old in 2006, appeared no longer to have increased in prevalence of overweight (Figure 5), but instead plateaued or even decreased slightly in prevalence. As regards obesity four cohorts, starting with those born between 1957-1961, i.e. above 50 years old in 2006, showed a decline in prevalence even though two cohorts showed an increase in obesity prevalence.

The Elderly

As noted, from the age of about 60 years upwards, the prevalence of overweight and obesity declines. The prevalence of obesity declines more rapidly than overweight, reaching less than half the peak age value in the 70-75 year age group (Figure 4). The prevalence of overweight on the other hand stays up to 60-70% the peak age prevalence rates (Figure 3). **This may indicate the obese suffer a higher mortality rate. The decline in prevalence among those 80+years is even more striking.** Their prevalence of obesity is only half that of the 75-79 year age group (Figure 4).

Suzana *et al.* have also noted that while a large proportion of the elderly may be overweight and obese, signs of malnutrition may be present among them[10,11] (malnutrition will not be explored further in this review).

Sex

Consistently across the studies, more women are obese than men,[4,6,7,8] but more men are overweight than women.[4,6,7] Only among young adults are more men obese than women.[6,13] By the late 20s women have overtaken men in obesity; the cause of this is usually attributed to weight gain after pregnancy. This greater prevalence of overweight among men was especially true among Chinese but among Indians more women are overweight compared to men.[6] It appears that when women put on weight they 'go all the way'. Furthermore, the gap between the prevalence of obesity between women and men has widened.[4,8]

Three studies reported the prevalence of obesity by age and also by sex.[4,6,7] In the NHMS II and NSCVDRF studies[4,7] men appeared to have a peak age younger than women, but that is not clear in the MANS study.[6]

Suzana *et al.* have noted that elderly women are twice as obese as men, and by weight circumference (measure for abdominal obesity) women are three times as obese as men.[10,11]

There have been several studies focusing specifically on women (Table III). Chee *et al.* found that the prevalence of overweight among women electronic factory worker for younger age groups were similar to the survey NHMS II done four years before, but older women electronic factory worker had higher overweight prevalence and mean BMI than the national sample.[14] It has also been noted that being overweight and obese was associated with earlier menarche among women in a study of university students.[15]

Ethnic Differences

Across the national population surveys, **Indians are more overweight than Chinese and Malays**.[6,8,9] (Table VI) **except** perhaps in the NMHS 2011, where **Malays appear to have edged ahead.** The rise in Malays appears to be at a faster

* Unless otherwise stated, the adult population refers to those aged 18 years and above, and overweight and obesity are defined according to the WHO criteria of a BMI of 25-29.9kg/m^2 for overweight and >30kg/m^2 for obese.[2]

Table I: Sample size and prevalence of overweight and obesity of Large Malaysian Obesity Studies

	Sample Size	Prevalence of	
		Overweight*	Obesity*
National Health and Morbidity Survey II (NHMS II) 1996[4]	28,737	16.6% (20.7%#)	4.4% (5.8%#)
Malaysian Adults Nutrition Survey (MANS) 2003[6]	10,216	26.7%	12.2%
The National study on Cardio-Vascular Disease Risk Factors (NSCVDRF) 2004[7]	16,127		11.7%## (12.6%#)
Third National Health and Morbidity Survey (NHMS III) 2006[8]	33,055	29.1%	14.0%
National Health and Morbidity Survey 2011 (NHMS 2011)[9]	28,498	29.4%	15.1%

Prevalence among 20 years and above, ## Prevalence among 15 years and above

Table II: Prevalence of Overweight and Obesity by sex

	Overweight (%)		Obese (%)	
	Men	Women	Men	Women
NHMS 1996	20.1	21.4	4.0	7.6
MANS 2003	28.6	24.8	9.7	14.7
NSCVDRF 2004			9.6	13.8
NHMS 2006	29.7	28.6	10.0	17.4
NHMS 2011	30.9	27.8	12.7	17.6

Table III: Prevalence of overweight and obesity among women in several localised studies

Author, year of study	Sample size	Age group (years)	Characteristics	Ethnicity (%)	Overweight	Obesity
Chee,[14] 2000	1612	17-55	Women Electronic factory workers	Malays=78.5 Chinese=2.2 Indians=17.7	24.1	13.3
Sidik,[16] 2004	972	20-59	Women in Selangor	Malays=54.9 Chinese=20.0 Indians=23.4		19.4 6.2 19.0
Poh,[17] 2006	253	30-45	Women Teachers and civil servants in Kuala Lumpur	Malays=64.4 Chinese=26.1 Indians=9.5	53.4 28.8 66.7	
Norsa'adah,[18] 2000	175	20-70	Women with Breast Cancer, Kelantan	Malay=77.7 Chinese=20.6 Others=1.7	34.3	13.7
Yong[19]	368	20-75	Women with Breast Cancer, from 8 different Hospitals	Malay=57.1 Chinese=33.2 Indians=9.8	31.5	10.9
Lee[20]	115	20-59	Women Office Workers, Kuala Lumpur and Selangor	Malays	33.0	22.6
Siti Affira[21]	215	18-55	Women in Corporate Companies, Petaling Jaya	Malays=81.9 Chinese=10.2 Indians=7.9	24.7	7.9
Lua,[22] 2011	41	24-68	Women with Breast Cancer, Terengganu and Kelantan	Malay=92.7 Chinese=7.3	29.1	12.2
Hasnah[23]	125	50-65	Women in Low cost Housing Cheras	Malays	45.6	31.2

Table VI: Prevalence of Overweight and Obesity by ethnic group

	Overweight (%)			Obese (%)		
	Malays	Chinese	Indians	Malays	Chinese	Indians
NHMS II	16.5	15.1	18.6	5.1	3.5	5.0
MANS 2003	27.2	25.0	31.0	15.3	7.2	12.7
NSCVDRF 2004				13.6	8.5	13.5
NHMS III	29.8	28.5	33.2	16.6	8.7	17.7
NHMS 2011	31.1	27.6	30.8	18.7	9.7	20.6

Table V: Prevalence of Overweight and Obesity by sex and ethnic groups

	Overweight (%)						Obese (%)					
	Men			Women			Men			Women		
	Malays	Chinese	Indians	Malays	Chinese	Indians	Malays	Chinese	Indians	Malays	Chinese	Indians
NHMS 1996	20.0	24.5	24.2	23.9	18.7	25.6	4.5	4.7	3.8	9.5	5.3	9.8
MANS 2003	29.3	25.2	29.3	24.9	20.9	32.6	11.3	7.8	10.4	19.6	6.6	14.8
NSCVDRF 2004							10.5	8.4	9.8	16.6	8.5	17.2

Table VI: Prevalence of Overweight and Obesity by sex among *bumiputera* in Sabah and Sarawak

	Overweight				Obese			
	Men		Women		Men		Women	
	Bumiputra Sabah	Bumiputra Sarawak	Bumiputra Sabah	Bumiputra Sarawak	Bumiputra Sabah	Bumiputra Sarawak	Bumiputra Sabah	Bumiputra Sarawak
MANS 2003	24.3	24.6	23.2	31.9	8.4	5.3	7.4	8.4
NSCVDRF 2004					6.1	9.3	8.5	12.3

Table VII: The prevalence of overweight and obesity by state in Malaysia

	Overweight (%)			Obesity (%)		
	NHMS II	NMHS III	NHMS 2011	NHMS II	NMHS III	NHMS 2011
Johore	17.4	28.9	28.5	4.4	14.1	15.9
Kedah	14.9	31.1	31.6	3.3	15.5	15.2
Kelantan	12.9	28.3	31.5	3.4	12.5	16.2
Melaka	18.9	31.1	25.7	5.1	17.4	17.7
N Sembilan	19.4	29.5	27.6	6.3	18.6	16.0
Pahang	18.3	28.8	30.2	5.6	15.3	15.3
Penang	15.9	29.3	31.1	3.7	13.7	12.8
Perak	18.0	27.6	31.9	4.7	12.9	16.2
Perlis	18.2	32.1	29.5	5.1	17.2	21.7
Sabah	14.5	24.9	28.8	3.4	9.7	10.6
Sarawak	14.2	28.7	30.3	3.4	11.5	14.0
Selangor	17.0	31.0	27.3	4.8	16.0	17.1
Terengganu	17.9	28.6	32.8	5.8	15.2	14.0
Wilayah Per	17.5	29.8	29.2	4.8	12.5	13.5

rate. Indians of both sexes are more overweight than Chinese and Malays (Table V), the difference between Indian women and the other ethnic groups being wider than among the men.[4,6,8]

Data comparing men and women separately by ethnic groups are only available in three studies.[4,6,7] Malay and Indian women are equally obese but Chinese women have only about half their prevalence rates. Chinese women are about equally as obese as Chinese men, but both Malay and Indian women are much more obese than their male counterparts. Among men, Chinese had the highest prevalence of obesity in 1996, but they have been overtaken by both Indian and Malay men in later studies.[6,7,8]

Two studies listed the *bumiputera* of Sarawak and Sabah as separate categories,[6,7] which allows better observations to be made than when they are put together as just other indigenous people or others.[4,8,9] The results shown in Table VI are inconsistent, probably due to sampling error as there are many *bumiputera* groups spread over a wide area in both states. Their prevalence of overweight and obesity in 2003-2004 are lower than those of Indians and Malays and comparable to the rates among Chinese. It is hard to say with certainty whether the men or women are more overweight and obese. Except for one study which found *bumiputera* men in Sabah more overweight and obese than women (MANS), the rest of the data shows *bumiputera* women in Sarawak more overweight and obese than men, as did the NSCVDRF study find in contradiction with the MANS data (Table VI).

The ethnic group with the lowest prevalence of obesity in Malaysia are the Orang Asli. None of the Orang Asli were obese in the MANS study, and only 15% were overweight, but they only had a sample size of 28 Orang Asli. We must look at more focused studies for information. Chronic Energy Deficiency (CED) or under-nutrition (BMI <18.5 kg/m^2) has been and is still the larger nutritional problem among Orang Asli, but that is not the subject of this review.

A nutritional status survey of Orang Asli adults (Jahai, 58.7%, Temiar, 41.3%) in Lembah Belum, Grik, of 138 subjects found 26.7% underweight and 10.1% were either overweight/obese.24 Based on percentage body fat and waist circumference (WHO criteria) only one (0.7%) was obese. A study of 57 adult Orang Asli (Che Wong) in Pahang found three men (10.3%) and 8 women (29%) overweight and one man (3.3%) obese.[25] However, where the Orang Asli live very close to economic development such as in Sungai Ruil in Cameron Highlands, among 138 respondents, by BMI 25.4% were overweight and 34.8% obese.[26] In wide survey (n=636) of Orang Asli, classifying them by tribes (Proto-Malays, Senois and Negritos), as well as by socio-economic groups (Urbanized City Fringe Dwellers(UCFD), Resettled Communities (UC) and Deep Forest Hunter Gatherers (DFHG)), Phipps *et al.* found the prevalence of obesity ranged from 7.5-10.0% among the Proto-Malay, 4.5-10.0% among Senoi and only 2.6-5.5% among Negritos. By socio-economic groups, 31.6% of UCFD, 12.0% of RC and 2.0% of DFHG were obese.[27]

Geographical Variations

Sabah, Sarawak, Kedah and Kelantan showed the lowest rates of overweight (12.9%-14.9%) and obesity (3.3%-3.4%) in the NHMS II in comparison to other states (overweight =15.9%-19.4%, obesity =3.7%-6.3%) (Table VII). Negeri Sembilan had the highest rates of overweight and obese adults.4 In the NHMS III only Sabah stood slightly apart with low rates of overweight (24.9%) and obesity (9.7%).[8] The other states had rates of overweight between 27.6% (Perak)

Table VIII: Prevalence of Overweight and Obesity in several small localised studies

Author, year of study	Sample size	Age group (years)	Characteristics	Ethnicity (%)	Overweight	Obesity
Mohd Yunus,[28] 1999	570	>15	Hoseholds in Dengkil, Selangor	Malays=23.3 Chinese=57.1 Indians=30.5 Orang Asli=30.8		12.0 14.3 10.5 11.5
Nawawi[29]	609	30-65	Rural Community Raub, Pahang	Malays	33.5	11.2
Rampal,[30] 2004	2219	>15	Households in Selangor	Malays=52.9 Chinese=30.9 Indians=15.4		15.2 7.3 11.6
Nazri,[31] 2005	348	>18	Households in PulauKundur, Kelantan	Malays=99.4	49.1	
Chang[32]	260	20-65	Rural Community, Serian, Sarawak	Malays=32.3 Bidayuh=33.1 Iban=34.6	 39.6	14.3 11.6 10.0
Mohamud,[33] 2007	4428	>18	Households in 5 Different states	Malays=62.5 Chinese=14.6 Indians=8.5 Ind Sabah=12.2	34.0 32.1 39.5 30.9	23.2 8.2 24.6 12.3
Akter,[34] 2007	219	>18	Bukit Sekelau (rural) Pahang	Malays	54.8(BMI>27.5)	
Narayan[35]	441	>20	Coastal Viiages, Kedah	Malays	25.9	17.0
Shahar[11]	820	>60	4 Rural Villages	Malays	24.7	11.4
Jan Mohamed,[36] 2009	297	18-59	Bachok, Kelantan	Malays	41.7	13.4
Rampal,[37] 2010	454	30-68	University staff in Selangor	Malays=86.3 Chinese=8.8 Indians=4.9	30.1 37.5 36.4	12.0 17.5 0
Chew,[38] 2011	258	>21	Suburban New Village Selangor	Chinese	40	
Hazizi[39]	233	18-59	Government Employees Penang	Malays	29.6	20.6
Ayiesah[42]	82	21-59	Military Hospital Staff Malacca	Malays	24.3	58.5
Nor Afiah,[40] 2014	211	19-24	Medical Students	Malays=63.5	16.6	3.8
Kabir,[41] 2012-14	945	20-43	Postgraduate University Students,	Malays=79.3 Chinese=13.5 Indians=5.0 Others=2.2	23.1	8.9

Table IX: Physical Activity among Malaysians

	Adequate Exercise		Physically Inactive	
	Men	Women	Men	Women
NHMS II	16.2%	7.7%	60%	75%
MANS	18.9%	9.4%	60.0%	77.7%
MyNCDS-1			55.4%	60.1%
NMHS III			35.3%	50.5%

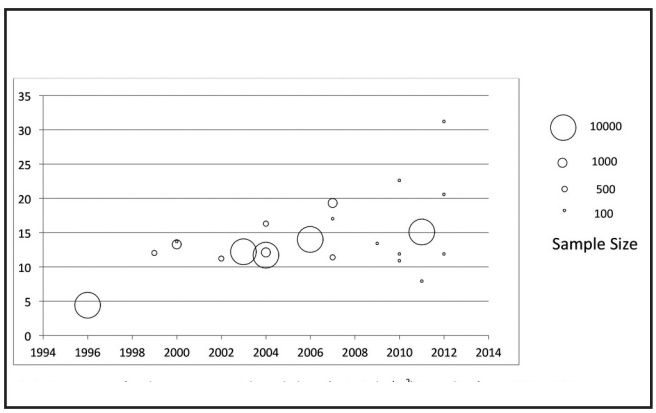

Fig. 1: Percentage of Malaysians overweight and obese (BMI>25kg/m^2) in studies from 1996 to 2015.

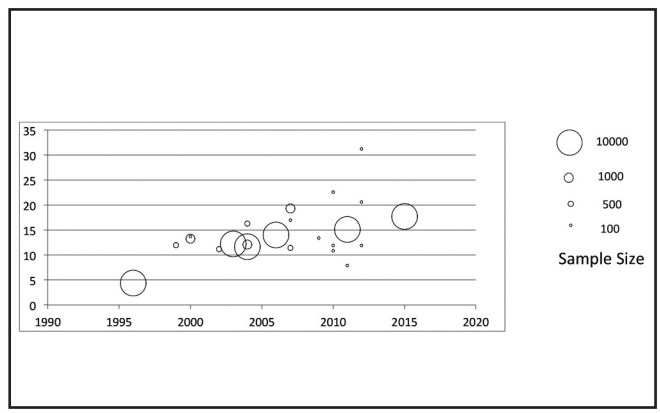

Fig. 2: Percentage of Malaysians obese (BMI>30kg/m^2) in studies from 1996 to 2015.

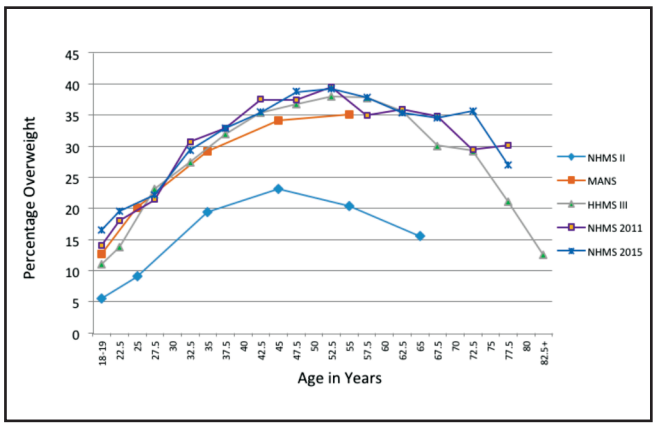

Fig. 3: Prevalence of Overweight (BMI 25-29kg/m^2) among Malaysians of Different Age Groups.

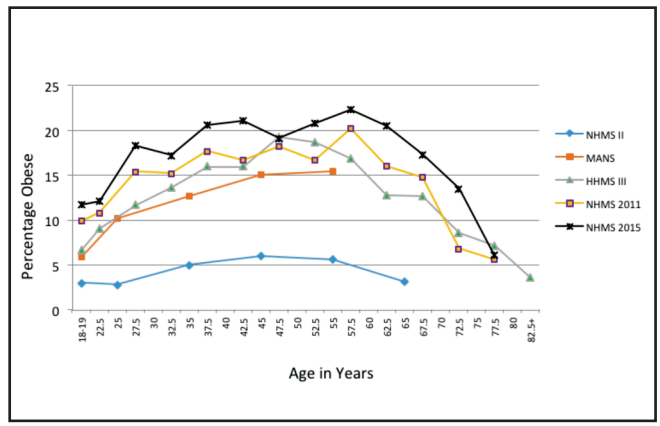

Fig. 4: Prevalence of Obesity (BMI >30kg/m2) among Malaysians of Different Age Groups.

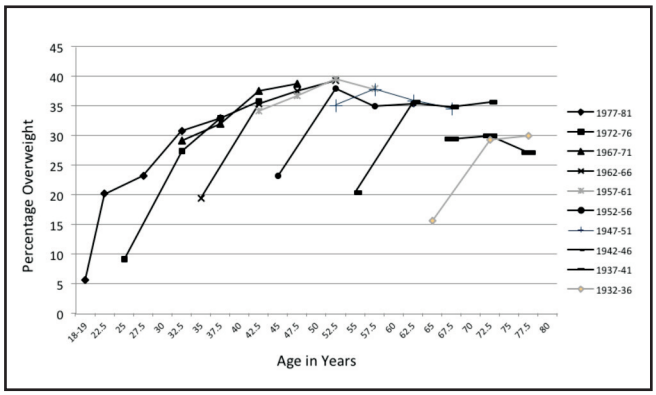

Fig. 5: Prevalence of Overweight at Various Age Groups for Different Birth Cohorts using data from NMHS II, MANS, NHMS III, NHMS 2011 and NMHS 2015.

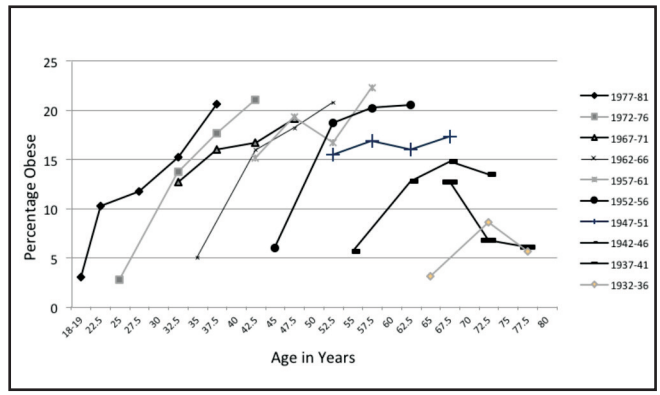

Fig. 6: Prevalence of Obesity (BMI >30kg/m^2) at Various Age Groups for Different Birth Cohorts using data from NHMS II, MANS, NHMS III and NHMS 2011.

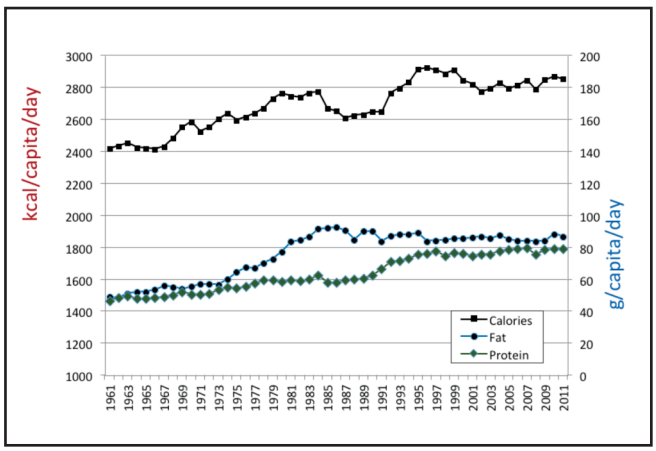

Fig. 7: Change in available calories, fat and protein per capita in Malaysia 1961-2011.

Source: FAO food balance sheet

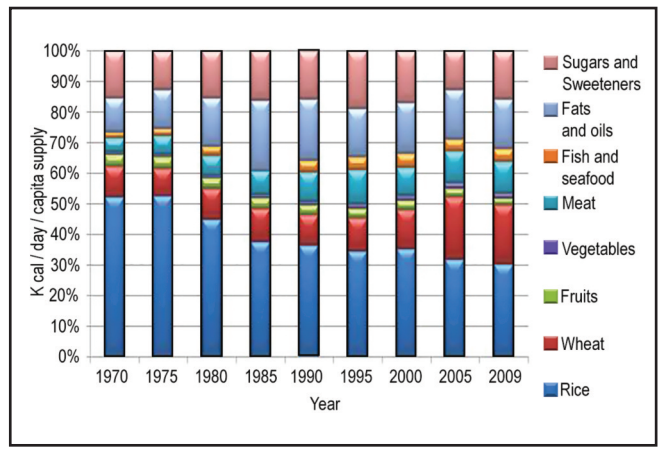

Fig. 8: Changes in source of calories in Malaysia between 1970 and 2009.

Source:Jan Mei Soon, E. Siong Tee. Changing Trends in Dietary Pattern and Implications to Food and Nutrition Security in Association ofSoutheast Asian Nations (ASEAN).International Journal of Nutrition and Food Sciences.Vol. 3, No. 4, 2014, pp. 259-269.doi: 10.11648/j.ijnfs.20140304.15

and 32.1% (Perlis) and rates of 11.5% (Sarawak) and 18.6% (Negeri Sembilan) for obesity. Sabah (10.6%) continued to show the lowest rate for obesity in the NMHS 2011, but Melaka had the lower prevalence of overweight (25.7%).[9] The trend indicates that over these critical years nutritional availability, the main driver for obesity levelled out geographically throughout Malaysia.

The MANS study also looked at geographical variation and grouped the states in Peninsular Malaysia into four groups, Northern, Central, South and East, besides Sabah and Sarawak.[6] This study considered the difference by sex which the NHMS II did not. There was no significant difference in the overweight category. Neither was there a significant difference in obesity among men. But women in Sabah (8.4%) and Sarawak (9.33%) were much less obese than in Peninsular Malaysia (12.5-13.8%). Women in the Southern Peninsular states had the highest prevalence of obesity (13.8%).

Most studies in the twenty-first century **has found no difference in the prevalence of overweight and obesity between rural and urban areas**.[6,7,8]

Although large national studies provide a picture of the average and overall prevalence of obesity, the Malaysian population is not homogenous. Age, sex, locality and social characteristics produce variations in the prevalence of obesity. Several small localised studies have mapped out finding is certain pockets of the population. Table VIII shows the prevalence of obesity found in several of these studies.

Social and Economic Factors

Education

The consistent pattern in the large nutritional status population studies is that the better educated are less obese.[4,6,8,9] Those with tertiary education have the lowest prevalence rates. On the other hand, those having no education is also associated to overweight and obesity rates slightly lower than those with primary and secondary education.

Occupation

The studies have not exhaustively nor consistently listed all occupations. However, one category that are **often most obese are the Administrative**,[4] or Senior Officer/Manager[8] or as listed in the NMHS 2011; Government/Semi government employee.[9] Although these terms are not equivalent, these categories have been the most obese or overweight in their respective studies. On the other hand, professionals are not usually most obese. The other occupation group that is also either most overweight or obese are **housewives**.[8,9] Mohd Nazri *et al.*[43] and Lim *et al.*[44] report that shift work was associated with higher BMI among male and female factory workers. Moy et al. reported similar findings among mainly female medical care shift workers.[45]

Income

The prevalence of obesity in Malaysia shows that food availability is to a large extent is no longer dependant on having enough income. There is a trend that the prevalence of overweight and obesity rises slowly from the poorest groups to the personal or household income level of RM4,000 a month.[4,8,9] After that, the prevalence drops slightly at first, in the RM4,000-RM5,000 bracket and noticeably in the >RM5,000 bracket. In the NMHS II data the lowest income group (<RM400) did appear to have noticeably lower prevalence of overweight (24.9%) and obesity (11.5%) compared to a few brackets above (e.g. RM1,000-RM1,999 = 30%overweight, 15.4% obesity)[4] but in the NMHS 2011, that poorest bracket (<RM400) have higher rates than the brackets above it.[9] Tan *et al.* however have contrary conclusions analysing data from the Malaysia Non-Communicable Disease Surveillance-1 (MyNCDS-1).[46] In a study of low income rural households in Selangor, Zalilah and Khor found that more women from food insecure households (56.0%, 65/116) were overweight and obese compared to their food secure counterparts (40.5%, 34/84). Food secure women spent more time in economic activities while food insecure women spent more time in domestic and leisure activities. The hypothesis that food insecurity may lead to binge eating, needs further investigation.[47] Ihab *et al.* have also reported on the phenomenon of maternal obesity in the presence of childhood malnutrition in low income households. They found 52.0% (116/223) Malay women welfare recipients in Bachok, Kelantan were overweight/obese, while 61.0% (136/223) of the children were underweight. There were 66 pairs (29.6%) of overweight/obese mothers with underweight children. More than half (57%) were single female-headed households, 69% of mothers were employed. Divorced or widowed poor women were five times more likely to be associated with the dual malnutrition condition than poor married women. Large households and a shift to higher consumption of refined grains, meat and edible oils inadequate in micronutrients (nutrition transition) may also be factors underlying this situation.[48]

Dunn *et al.* have analysed the relationship between socioeconomic characteristics and BMI between Malays and Chinese by quintile regression and concluded that reduction of economic inequality is unlikely to eliminate obesity disparities between Malays and Chinese.[49] Increased effort to alter lifestyle behaviour, they believe, are required.

Abdominal Obesity (AO) and other measures of obesity

There has been debate as a result of some evidence that although BMI is easily measured, it is not a good predictor of cardiovascular and obesity related health risks. Waist circumference (WC), a proxy measure of body fat is said to be a better predictor.[50] BMI is even a poorer predictor of body fat in Asian ethnic groups when calculations derived from a Caucasian population is used. There is concern that among Asians the risk of diabetes and other chronic diseases starts to increase even when BMI or waist circumference are well within the accepted range for Europeans[51] and it has been suggested that in Asians, the BMI cut-offs should be 23.0 kg/m^2 for overweight and 27.0 kg/m^2 for obese, lower than the WHO criteria.[52,53,54]

Investigating Cut-off Values

Asians are thought to be more prone to central or visceral obesity (AO). Studies have therefore been done to find more suitable parameters for obesity and its relationship to cardiovascular disease, dyslipidaemia, hypertension and diabetes among Asians[55,56] and it has been replicated in Malaysia.[57,58] Using Receiver Operating Characteristic (ROC)

analysis to compare the predictive validity and optimal cut-off values, and the Area under the curve (AUC) to determine its diagnostic power, Zaki Morad *et al.* found the optimal cut-off value for WC varied from 83-92 cm in men and from 83-88 cm in women in Malaysia, in a sample size of 1,893 individuals from 93 primary care clinics.[57] They also found the optimal BMI cut-off values predicting dyslipidaemia, hypertension, diabetes mellitus or at least one CVD risk factor varied from 23.5-25.5 kg/m^2 in men and 24.9-27.4 kg/m^2 in women. They concluded that WC may be a better indicator for predicting obesity related CVD risk. BMI is also a weak predictor for diabetes and WC appeared to be better. They also found that at a cut-off for WC >90 cm for men and >80 cm for women, AO was present in approximately 71% patients with lipid disorder, in 76% with hypertension and in 75% with diabetes.[59] Aye and Malek also noted WC was a better predictor than BMI of metabolic risk factors for developing going by the IDF definition of Metabolic Syndrome.[58] The optimal cut-off point of WC they found to predict individual metabolic risk was 84.5-91.0 cm in females and 86.5-91.0 cm for males.

In Caucasian populations the recommended cut-off points for waist circumference are, Waist Action Level 1 (overweight): ≥94 cm for men and ≥80 cm for women; and Waist Action Level 2 (obese) ≥102 cm for men and ≥88 cm for women. Using data from 32,773 subjects who participated in the NHMS III, Kee *et al.* found that the ROC analyses showed that the appropriate screening cut-off points for WC to identify overweight subjects with BMI ≥25 kg/m^2 was 86.0 cm for men (sensitivity=83.6%, specificity=82.5%), and 79.1 cm for women (sensitivity=85.0%, specificity=79.5%). The cut-off points to identify obese subjects with BMI ≥30 kg/m^2 was 93.2 cm for men (sensitivity=86.5%, specificity=85.7%) and 85.2 cm for women (sensitivity=77.9%, specificity=78.0%).60

Prevalence of AO

Using standard WC cut-offs of >102 cm in men, >88 cm in women (WHO 1998) Kee *et al.* found the overall national prevalence of AO among Malaysian adults in the NHMS III was 17.4%.[61] The prevalence was much higher in women (26.0%) than in men (7.2%) (OR: 4.2). The prevalence of AO increased steadily with age until the age of 50 to 59 years, after which the prevalence declined. The prevalence was higher among the Indians (OR: 3.0) and Malays (OR: 1.8) compared to others. With regard to marital status, respondents who were ever married had the higher risk of AO compared to not married (OR: 1.4). As with obesity measured by BMI, an inverse relationship was observed between the level of education and prevalence of AO. Respondents who received no formal education had the highest prevalence at 23.7%, followed by those with primary education (21.2%), secondary education (15.2%) and tertiary education (12.1%). By occupational status, housewives had the highest prevalence of AO compared to other occupations (OR: 1.4, 95% CI: 1.1, 1.7). Among the household income categories, prevalence of AO was lowest in households with greater than RM5000 (13.7%) Income groups between RM1000-3000 had highest rates (18.2-18.4%).

The prevalence of abdominal obesity among the elderly (≥60years) in the NHMS III in 2006 was 21.4%, 33.4% for women and 7.4% for men.[10]

A normal BMI may hide individuals with health risks due to excess fat present as AO. Norafidah *et al.* noted that being female and non-Malay were factors that were found to be associated with abdominal obesity in the normal BMI population.[62]

Body Fat Percentage

In a study excluding underweight individuals, Goonasegaran et al. put forward the case that body fat percentage (BFP) measuring neck, waist and hip circumference and using the US Navy formula, was a superior measure of obesity to BMI better at differentiating between lean mass and adipose tissue in those mildly obese or overweight.[63]

Morbid Obesity

Obesity is recognised as a risk factor, increasing an individual's chance of having several major diseases. However, marked obesity of a BMI >40 kg/m^2 is commonly termed morbid obesity, and a disease in its own right. In 1996, 0.3% of the population were found to have a BMI of greater than 40.0 kg/m^2. Women (0.4%) had a high rate than men (0.2%). Malay women (0.6%) had the highest prevalence of super obesity.[4] Data from the NMHS III showed the overall prevalence of morbid obesity had increased to 1.0%.8 The peak age of morbid obesity was 45-49 years (1.3%). Indians (1.6%) were the ethnic groups with the highest rate, and housewives (1.5%) the occupation group most morbidly obese. By 2011 the overall prevalence of morbid obesity had risen to 1.3%. Females (1.7%) continued to outnumber males (1.0%).[9] Indians (2.7%) continued to be most affected, followed by Malays (1.9%) but Chinese (0.3%) appeared to be significantly less affected.

RISK FACTORS

Obesity develops when energy intake exceeds expenditure. While recognising that genetic factors and human metabolism can modify the development of obesity, it is obvious that the two greatest driving forces for the rising prevalence of obesity in Malaysia today are the increase of food availability and resulting food consumption linked with inadequate physical activity.

The end of the twentieth century saw economic development in Malaysia that made food easily available. The per capita gross national product of Malaysia grew an average of 8% per annum between 1980 and 2000.[64] Urbanisation rose from 25% in 1969 to 41% in 1990 and is expected to reach 60% by 2020.[65] Poverty rates fell. The opportunity to become overweight opened up for many.

Food Intake

The quantity and type of food available in Malaysia over the last several decades allow us to understand the rise in prevalence of obesity in the population. Total availability of calories per capita per day in Malaysia was estimated at 2430 kcal in 1961 and increased to 2923-2990 kcal in 2007, a 20% increase over 40 years.[66,67] Although food availability actually fluctuates from year to year, Davey *et al.* point out that in no year after 1992 was there less than 2780 kcal available per capita per day.[68] The FOA food balance sheet shows that available food calories has not continued to rise the last 10 years (Figure 7). Rising prosperity meant the proportion of

household income spent on food and non-alcoholic beverages declined from 23.8% in 1992-4 to 20.3% in 2009-10 periods, even though in absolute terms the amount spent was RM1161 in 1992-4 compared to RM2190 in 2009-10 periods.[66]

Calories available from animal products per capita per day rose from 267 kcal in 1967 to 485 kcal in 2007, a rise of 82%, but Figure 7 shows that according to FAO food balance sheet the amount of fats and protein available per capita has also remained stable. The amount of available sugar and sweeteners per capita per year rose from 28.8 kg to 48.7 kg between 1967 and 2007, a rise of 70%. On the other hand, the proportion of calories obtained from cereals decreased from 61% to 41% (Figure 8). For a long time while the price of sugar rose in the world market, its price to the consumer in Malaysia was kept low by a hefty subsidy from the government which was only removed in the year 2014.[69] Given there exists some inequality of distribution, the abundance of food explains why almost any segment of the population can become obese.

Data about what the actual energy intake of individuals are is less clear. The mean calorie intake in poor villages, in the 1980s and 1990s, was noted to be 1870 kcal per person per day.[70] A 3-day food record survey of 409 adults with normal BMI across Malaysia in 1992-3 recorded a mean energy intake of 2163 kcal/day among the men and 1718 kcal/day among women respectively.[71] Overall, 14% of the total energy was derived from protein, 23% from fat and 63% from carbohydrate, but urbanites consumed a higher proportion of energy in fats (29%) compared to rural subjects (20%). The energy intake of Indians, surprisingly, was significantly lower than that of other ethnic groups. Malay women recorded a significantly higher energy intake than other ethnic groups. Urban male subjects consumed significantly more energy (2275 kcal) than their rural counterparts (2024 kcal), but this was not the case in women. In both men and women, fat intake was significantly higher in Chinese and urban subjects.[71] Among three similar studies of urban post-menopausal Malay and Chinese women, the investigators reported similar energy distribution of their subjects' dietary intake, which consisted of 53-55% carbohydrate, 15-17% protein and 29-30% fat. Malay women reported a higher daily calorie intake (mean values 1649-1747 kcal) compared to Chinese women (mean values 1550-1591 kcal).[72,73,74]

Among Malay women Employee Provident Fund (EPF) office workers in Kuala Lumpur and Selangor, Lee *et al.* found that the mean energy intake for normal weight, overweight and obese subjects was 1685±199 kcal/day, 1810±166 kcal/day and 2119±222 kcal/day, respectively.[20] Evidence that the economic transformation of Malaysia from a rural agrarian economy to an urban commercial society has impacted dietary habits can be seen in a dietary survey of selected women electronic factory workers by Lim *et al.* in 2000. Even though it was only a selected/invited sample of 122 women, of whom one third each was normal/underweight, overweight and obese, it revealed that such women tended to eat meals at irregular hours (61.5%) and nearly half thought healthy foods did not taste nice (47.5%) or were expensive (45.1%). They had a high frequency of taking foods high in fat content and of a diet lacking in variety. Living in a hostel, surprisingly, was a factor associated with less risk of obesity, but the similarity of frequency of pattern of food consumption led the investigators to believe they shared the risk of being obese in the future. Exercise, even when reported, did not reach an intensity to be of benefit. Only 39.3% reported ever trying to lose weight. However, their preference was for slimming products rather than a healthier lifestyle or dietary changes.[44]

Suriani *et al.* surveyed overweight and obese working women regards barriers they faced controlling food intake. As regards not eating healthily more frequently the commonest reasons were 'lack of knowledge' (79.3%), followed by 'lack of motivation' (72.1%) and 'family commitment' (71.4%). As regards controlling the quantity of food the commonest responses were 'attend meetings often' (60.0%), followed by 'difficult when eating out' (57.9%).[75]

Secondary analysis of the NHMS III food label study of 4,565 obese respondents found they claimed to read and understand the food label. 74.5% read the expiry date but less than 20% read information about food component content.[76]

The consumption of soft drinks was reported to be a significant risk factor that is associated with being overweight among medical student.[77] Choong *et al.* found no correlation between preference for and frequency of consumption of salty food and being overweight among 300 university students.[78] Swarna Nantha argues that the increasing rate of sugar consumption in Malaysia should be viewed as sugar addiction and addictive behaviour considered in relation to health policy development regarding obesity.[79]

Physical Activity

The NMHS surveys, and other large surveys like the MANS, and MyNCDS-1 have reported physical activity data of Malaysian adults, and have wide ranging values (Table IX). It would go beyond the scope of this review to report these findings in depth and review all studies on physical activity.

Poh *et al.* have examined the physical activity status of 7,349 respondents of the MANS study of 2003, which covered all states and ethnic groups in Malaysia.[80]

Transport: In that study, 74.4% used passive modes of transport such as cars and motorcycles as their main mode of transport. 9.2% used public transport, (which involves slightly more physical activity) and 17.7% walked or cycled. Not surprisingly the rural population walked more (23% vs. 14% urban). The *bumiputra* of Sabah, Sarawak and Orang Asli walked much more (45-50%) than the Malays, Chinese and Indians (11-15%). More women (24.3%) walked than men (13.8%).[80]

Exercise: Poh *et al.* found that 31.3% of the population had engaged in some form of exercise in the two weeks prior to the interview (ever-exercised) (40.0% of men, 22.3% of women). 14.2% of the respondents reported adequate exercise, defined as at least 20 minute sessions at least three times a week. In both these measures of exercise the rate was higher in urban compared to rural adults. The East Coast states had an unusually low rates of exercise among the

different regions. Young adults (18-19years) reported the highest rates of exercise. The overweight group reported most exercise, even exceeding the normal and underweight. The obese exercised least.[80]

Physical Activity Pattern: Physical activity level (PAL) was calculated as the ratio of total energy expenditure (TEE) to basal metabolic rate (BMR). Across the population the PAL was 1.6-1.7 and did not differ much between urban or rural areas, between men and women, between ethnic groups, or between normal or overweight group.[80] The desirable PAL score to avoid obesity is one above 1.75. A low score reflecting a very sedentary lifestyle is 1.4.

The WHO study on non-communicable disease risk factors and socioeconomic inequalities found that men in rural area were more likely to be engaged in occupations with a high level of physical activity (33.7%) compared to urban dwellers (23.5%), similarly for women (19.7%rural vs 15.9% urban). The lower income men (<RM1000) also had a higher level of occupational physical activity (31.2%) compared to high income earners (>RM3999) (22.2%) and the same was true for women (16.4% high income vs. 12.1% low income). On the other hand, higher education and higher income was associated with more leisure time physical activity for both men and women. Indian men had an unusually low rate of leisure time physical activity.[81]

Kabir *et al.* surveyed 945 post-graduate students in University Putra Malaysia (UPM), with a mean age of 27 years and found 32% had a BMI >25 kg/m^2. 44% had low physical activity and they were twice as likely to be overweight or obese.[41]

A study of 136 security guards and their wives in Kuala Lumpur found that only 39.2% ever-exercised and 13.8% exercised adequately.[82] Hazizi *et al.* determined that among 210 Malay employees in the Federal Government Building in Penang that 64.8% had low physical activity, measured by an accelerometer clipped to the subjects belt/skirt/trousers at the waist.[39]

Among women working in corporate companies in Petaling Jaya, aged between 18-55 years, 48.8% were found to be moderately active and 28.8% were highly active according to the International Physical Activity Questionnaire-short form (IPAQ, 2005) in a study by Siti Affira *et al.* These rates were higher than in larger population surveys and they found monthly income correlated positively with physical activity. There was however no significant association between job category and physical activity.[21] Lim *et al.* found that 29.5% of women working in electronic factories in Selangor had adequate exercise.[44]

Wan Nudri *et al.* found that men who reported having no exercise were significantly more overweight than men who regularly exercised and sportsmen who actively participated in competition, in a cross-sectional study of randomly selected men from government departments in Kota Bharu.[83] Low physical activity also correlated to obesity in studies among staff in a military hospital and individuals attending health clinics in Sepang, by Ayiesah *et al.*[40] and Hejar *et al.*[84] respectively, and also in government employees in Penang.[39]

Among the obese pre-diabetics in Negeri Sembilan, Ibrahim et al. found 60.8% were physically inactive using the IPAQ, 2005.[85]

ASSOCIATION OF OBESITY WITH OTHER DISEASES

Metabolic Syndrome

Central obesity, raised blood lipids, hypertension and a raised fasting blood sugar have been collective recognised as manifestation of an insulin resistant state. The prevalence of metabolic syndrome has been addressed in a separate article.[86] This section will only highlight the various elements of metabolic syndrome as they are related to obesity. In any population of obese individuals, each of these other factors can be expected to be high.

For example, Mafauzy reported in a study of 1,099 diabetic clinic patients across 19 public hospitals (Ministry of Health and University Hospitals) in Peninsular Malaysia) that 66.9% of males and 82.1% of females had a waist circumference (Asian WC) >90 cm (males) and >80 cm (females).[87] Abougalambou et al. found that 81.5% of their patients at the diabetic outpatient clinics from Hospital Universiti Sains Malaysia were obese.[88] 66.8% of diabetics were found overweight and 15.8% obese in a study of 196 type 2 diabetic patients the University Malaya Medical Centre primary health clinic.[89] Eid *et al.* noted that a BMI value above target level was observed in 66% (140/211) of their diabetic patients.[90] Foo *et al.* found that 75% (121/161) of their diabetic subjects were centrally obese using the Asian WC criteria.[91] They showed a predominance of insulin resistance over secretory dysfunction using the Homeostatic Model Assessment (HOMA) proposed by Matthews *et al.*[92] Lim *et al.* have confirmed a bimodal peak of blood glucose distribution with BMI in all ethnic groups in Malaysia.[93]

Among 268 semi-urban pre-diabetics (individuals with blood glucose concentrations higher than normal but not high enough to be classified as diabetic) attending two primary care clinics, Ibrahim *et al.* found 21.6% were overweight and 71.3% obese. Using a health-related quality of life (HRQOL) survey they found those overweight and obese had a lower HRQOL score compared to the small number (7.1%) of normal weight individuals.[85]

Hypertension has been noted to be more prevalence among the obese in numerous studies in Malaysia as well.[94-97] even in rural Kedah[35] and Sarawak.[32] The same higher prevalence of raised blood cholesterol among the overweight and obese.[32,35,38,94,95]

Cardiovascular Diseases

Su et al. found that although obesity as measured by BMI did not correlate to cardiovascular risks (r=0.038 p=0.26), as measured by the Framingham Risk Score (FRS), among urban Malaysians (n=882), other measures of obesity; namely waist-hip ratio (WHR) (r=0.44, p<0.001) waist circumference (WC) (r=0.28, p<0.001) and Waist to Height Ratio (WHtR) (r=0.23, p<0.001) were correlated to cardiovascular risks.[98] Moy *et al.* noted a weak but significant correlation between the FRS for coronary heart disease and three measure of obesity (BMI, WC and Weight-Height-Ratio) among Malay men working as security guards.[99]

In a cross-sectional study of 36 lean and 36 obese subjects, Al-Tahami *et al.* found that endothelial dependent vasodilatation was lower in obese compared to lean subjects (40.53±6.59 vs. 71.03±7.13 AU).[100] They also found lower adiponectin levels (8.80±0.43 vs. 25.93±0.40 µg/ml) in obese compared to lean subjects. Sanip *et al.* found serum adiponectin levels positively correlated with the HOMA insulin sensitivity index but no correlation with microvascular endothelial function indices in a sample of 91 overweight and obese females with no other metabolic syndrome markers.[101] Nafikudin *et al.* found that the intima-media thickness of common carotid arteries measured by ultrasound were thicker among subjects with some obesity indices, especially those with familial hypercholesterolemia.[102]

Surgeons at Hospital Universiti Sains Malaysia, Kubang Kerian reported that there was no significant difference in the surgical outcome of isolated coronary artery bypass graft between overweight and normal weight individuals in a study of 141 of their patients between 2001 and 2004.[103]

Psychiatric Disorders

Norelelawati *et al.* found that among their schizophrenic patients attending follow-up at clinic 32% (69/216) were overweight and 28% (60/216) were obese. Again women were more obese than men. No particular type of antipsychotic agent was associated with a higher prevalence of obesity.[104] Ainsah *et al.* found 74.2% (72/97) of their patients on antipsychotics were overweight or obese (by Asian classification of overweight >23kg/m^2), 71.4% (45/63) of those on atypical antipsychotics and 79.4% (27/34) of those on conventional antipsychotics. The mean WC of those on conventional antipsychotics (93.4cm) was significantly higher than for those on atypical antipsychotics (88.2cm). Those receiving a combination of depot antipsychotics also had a significantly higher WC than those who did not. However, being on concomitant antidepressants was not associated with any significant difference.[105] Binge eating disorder was not significantly higher among overweight and obese patients with schizophrenia compared to normal weight schizophrenics, in a study of 97 patients.[106] There was no significant difference in dietary intake and exercise scores between overweight and non-overweight schizophrenics either.

Reversing the view, Loo *et al.* surveyed 102 overweight or obese (BMI >23 kg/m^2) patients referred for dietary advice to a dietician clinic and found using the 30 question General Health Questionnaire that 15.7% had psychiatric illness.[107] Abdollahi and Abu Talib also showed that obese individuals with sedentary behaviour and poor body esteem were more likely to show social anxiety.[108]

A study on whether stress and depression had a causal link to abdominal obesity across 17 countries, in which Malaysia was included, found that stress and depression had no independent effect on abdominal obesity.[109]

Night eating syndrome (NES) describes a condition characterised by morning anorexia, evening hyperphagia and insomnia. Nocturnal food ingestion is >50% of daily calories intake and occurs at least three times a week for a period of three months. Ainsah and Osman reported the case of a 65-year-old Malay widower, whose wife and son had earlier left him; a retired army sergeant, with multiple medical problems and was chronically feeling depressed. He was morbidly obese with a BMI of 45 kg/m^2 and had problems with excessive weight gain since the age of 41years. He responded to diet and behaviour therapy and reduced his weight from 123kg to 91kg over 18 months.[110]

Pregnancy Induced Hypertension

In a small case-control study of 30 cases attending antenatal clinic matched with controls in the three selected health centres in Alor Gajah, Melaka, Adinegara and Razzak found that pregnancy induced hypertension (PIH) was significantly associated with obesity and being a housewife. However, there was no association at all between consumption of the varied food items and the development of PIH.[111]

Spontaneous Cerebrospinal Fluid Rhinorrhoea

Gendeh and Salina reported clinical data of eight patients diagnosed with spontaneous cerebrospinal fluid rhinorrhoea who had been treated at their tertiary referral centre between 1998 and 2007 and noted all of them were overweight (mean BMI 32.5 kg/m^2) seven out of the eight were female. Central obesity raises intra-abdominal and intrathoracic pressure, increasing the cardiac-filling pressure which in turn impedes the venous return from the brain leading to raised intracranial pressure. Obese patients are also more prone to exaggerated oscillations in intracranial pressure and therefore more at risk of developing a CSF leak.[112]

Breast Cancer

Three studies have examined the nutritional status of breast cancer patients.[18,19,22] Norsa'adah *et al.* noted that 48% of their women with breast cancer in Kelantan were overweight/obese and they thought that the rate was higher than the general population, compared to the NHMS II data.[18] However, in view of the general rise in prevalence of obesity of that period around the year 2000, that may not be true.

A case-control study of breast cancer patients in Kuala Lumpur matched for their age and menopausal status with volunteers at the National Cancer Society in 2006 found that 71% of breast cancer patients had a waist circumference >80 cm compared to 40% among controls. Premenopausal breast cancer patients were four times more likely to have abdominal obesity.[113]

Yong *et al.* found that in the year preceding diagnosis of breast cancer women on average lost weight (mean loss=0.7 kg).[19] However after diagnosis till the time of study these women had a mean gain in weight of 3.5 kg. Less than 20% of women actually lost weight with their encounter with breast cancer. Excluding those who lose weight on account of advanced breast cancer, women tend to over compensate nutritionally in the course of having breast cancer. Lua *et al.* found that 70% of their breast cancer patients were meeting more than their individual daily energy requirements.[22] However, only 31.7% achieved the recommended daily intake of fruits and vegetable.

Colorectal Cancer

Metabolic syndrome, of which obesity is a factor is a known risk factor for colorectal cancer and affirmed in Malaysia.[114] It has also been suggested that obesity is a risk factor for colorectal adenoma. In a case-control study of 59 patients with colorectal adenomas matched with controls, waist circumference was the only factor that was found to significantly increase the risk for colorectal adenoma, and only in women. A waist circumference of >88 cm carried a six-fold increased risk of having an adenoma.[115]

Chronic Periodontitis

Obesity has been identified as a risk factor of chronic periodontitis (CP). A study using convenience sampling of 165 participants from various clinics in University Malaya Medical Centre, above 30years old and with a BMI >27.5kg/m^2 found that 73.9% had CP, 55% of them moderate or severe CP.[116]

MANAGING OBESITY

Recognising the seriousness and magnitude of the growing problem of obesity, Clinical Guideline for the Management of Obesity were drawn up together and published by the Ministry of Health, the Academy of Medicine and several specialist medical societies under the chairmanship of Ikram SI in 2004. In addition to defining the problem, the document recommended strategies for weight loss. It outlined dietary therapy as well as physical therapy. It discussed the role of pharmacotherapy and surgery. It also acknowledges the role of counselling and behaviour therapy.[117] The Malaysian Association for the Study of Obesity in Malaysia also produced a document on strategies to prevent obesity in 2005 under the chairmanship of Mohd Ismail N. Besides elucidating the role of diet and physical activity, the report recognised that managing obesity was a shared responsibility involving government, industry, professional bodies, non-governmental organisations, communities and individuals. It proposed that a National Steering Committee for the Prevention of Obesity be established. It recommended that working groups be formed in communities, schools, health care facilities and workplaces to educate the population and take action.[118]

Behavioural Factors

Poh *et al.* found that working women in Kuala Lumpur were fairly knowledgeable concerning healthy body weight management. They found no difference between the normal weight and overweight women. School teachers were significantly more knowledgeable than civil servants in weight management matters. More overweight women (20%) had high knowledge level scores (75%) compared to normal weight women (15%).[119]

The management of obesity is intricately intertwined with behavioural change. Besides a minor role for medication and surgery, the mainstay of weight reduction is modification of dietary intake and physical activity. In a study of native Sarawakians living in villages who were overweight or obese, Chang found that 76.8% perceived that they were overweight/obese. As regards behaviour change, 60.5% (164/271) were in the pre-contemplation stage, which means they were not even thinking of behaviour change. The commonly used Transtheoretical Model of change (TTM), views change as a process that involves five stages. Pre-contemplation is the first stage. Contemplation is the second stage, where an individual is considering change within the next six months. 20.7% (56/271) of the overweight native Sarawakian villagers were in that stage. The remaining 18.9% (51/271) were in either the preparation stage (intending to take action within 30 days), the action stage (overt modification of behaviour of less than six months duration) or maintenance phase (behaviour change longer than six months). A higher level of education was the only factor that correlated with a higher level of preparedness for behavioural change.[120] On the other hand, in a survey of university staff across the spectrum of weight distribution, done as a baseline for behaviour intervention, Ang *et al.* found that 50.7% (172/339) were in the preparation stage for change; 30.0% (101/337) were either in the action or maintenance stage of change, 14.5% (49/337) were in the contemplation stage and only 5.0% (17/337) were in pre-contemplation.[121]

Intervention Programmes

Moy *et al.* conducted an intervention programme involving Malay male security guards working in a public university in Kuala Lumpur, of whom 34% were overweight. The group received intensive individual and group counselling on diet, physical activity and quitting smoking, but they found at the end of two years there was no change in the BMI of the group.[122] Ramli *et al.* reported a six-month-long obesity health programme/study, which consisted of two weekly unsupervised exercise sessions and monthly dietary/health education sessions, conducted among overweight civil servants during office hours. Unfortunately, there was no significant change in body weight, although the subject did show some improvement in indices of physical fitness.[123]

Al-Qalah *et al.* surveyed 639 Malaysian working women in Putrajaya and Bangi to identify those who had successfully lost weight. Successful weight loss was defined as losing at least 10% of their highest lifetime body weight. They found 18.8% (120/639) experienced successful weight loss. The commonest dietary weight loss strategy used was to eat more fruits and vegetables (50.8%), followed by reducing the amount of food eaten (49.2%) and reducing fatty food intake (42.5%).[124]

A total of 28 obese (BMI >30 kg/m^2) subjects at Obesity Clinic, Hospital Universiti Sains Malaysia, Kelantan completed a 12-week weight loss programme consisting of dietary and exercise interventions. There was a significant mean weight change from 89.27±2.78 kg to 83.11±2.42 kg. Four subjects (14.3%) lost more than 10% of their body weight. There was also a significant reduction of waist circumference, BMI and fat-free mass. The investigators also found a significant decline in the levels of plasminogen activator inhibitor (PAI-1), plasminogen activator (t-PA) levels, thrombin activatable fibrinolytic inhibitor (TAFI) and fibrinogen alongside the weight reduction. They noted a significant correlation between BMI with fibrinogen and all three fibrinolytic markers suggesting a beneficial effect of this program on the haemostatic burden particularly on the fibrinolytic biomarkers.[125]

Suriani *et al.* investigated two dietary control programmes for overweight and obese women in Putrajaya and Seremban. The first was a standard programme promoting food quantity control based on the national dietary guidelines. The faith-based programme, in addition contained relevant Islamic information to motivate participants. 84 Malay Muslim women chose the former and 56 chose the latter. The programme began with Ramadan and continued for three months after Ramadan. At that point in time, the mean BMI reduction in the standard dietary intervention was 0.16 kg/m2 (from 31.14±4.26 kg/m^2 to 30.98±4.28 kg/m^2; p = 0.16; CI: –0.06 to 0.38) while it was 0.49 kg/m^2 in the faith-based dietary intervention group (from 31.01±4.07 kg/m^2 to 30.52±4.03 kg/m^2; p ≤0.01; CI: 0.22 to 0.75).[126,127,128]

Teng *et al.* investigated the weight reduction effects of caloric restriction combined with two days a week of Muslim Sunnah fasting in a 12-week trial, among Malay men who had BMI between 23.0-29.0 kg/m^2. The 28 men in the intervention group, who were provided food guidelines, log books and contacted once a week, reduced caloric intake from a mean of 1707 kcal by about 300 kcal and lost an average of 2.8 kg. The control group on the other hand saw their mean intake increase slightly from 1755 kcal by about 60 kcal. DNA damaged, assessed by the alkaline comet assay and fluorescence microscopy decreased significantly in the intervention group, as did oxidative stress measured by plasma malondialdehyde.[129]

In a small study of 25 obese patients, Christopher *et al.* noted that a period of supervised regular exercise improved pulmonary function of obese patients and independent of the amount of weight loss.[130]

The Malaysian Health Promotion Board funds projects run by non-governmental organisations, such as *Kominuti Sihat Perkasa Negara* (KOSPEN), Healthy Eating Campaigns, Nutrition Month campaigns, Ruzita *et al.* evaluated the effectiveness of 22 such projects on obesity conducted in the year 2010 by examining their final reports. 18 projects were of less than three months duration and four longer than three months. They judged 21 project to be of moderate quality and one of poor quality base on their achievement in health literacy.[131] In a study of 56 university employees assigned to either a 12-week programme of physical activity and dietary intervention or a control group, Soon *et al.* found no significant difference in obesity indices. In fact, although the lipid profile improved slightly in the intervention group, their weight and hip circumference increased.[132]

In previous times and cultures being 'plump' or 'chubby' may have been perceived positively. However as in most cultures today, being obese is perceived negatively in Malaysia.[133] Action for weight loss is popular among the general population, even among the normal weight, and not only the obese. 37.7% of 1032 people surveyed in shopping centres in Kuala Lumpur admitted they have taken such action before. Only 32.6% of them were actually overweight or obese. 50.4% of those who have attempted to lose weight mistakenly perceived their weight category. The normal and underweight tend to be lower in weight than they imagined, while the overweight and obese tended to be heavier then they perceived. Dieting (89.5%) and exercise (81%) were the most popular weight loss measures, followed by slimming teas (24.9%), vitamins (21.9%) and chitosan (19.0%).[134]

Pharmaceutical Agents

Suraya and Azmawati found that 41.6% (62/149) of overweight and obese (149/258) university students surveyed used non-prescription substances for weight loss management.[135]

Liraglutide an analogue of Glucagon-like peptide-1 (GLP-1), stimulates insulin secretion, inhibits appetite centres in the brain as well as delays gastric emptying. It is used in the management of type 2 diabetes as well as obesity management. In a randomised controlled trial of 44 obese binge eaters divided into two groups for 12 weeks, Robert et al. found participants who received liraglutide in addition to diet and exercise, showed significant improvement in binge eating, accompanied by reduction in body weight (94.54±18.14 kg to 90.14±19.70 kg, p <0.001), BMI (36.15±3.84 kg/m^2 to 34.40±4.77 kg/m^2, p <0.001), and waist circumference (103.9±13.7 cm to 100.2±14.0 cm, p =0.004). On the other hand, the control group showed slight but not significant changes in these parameters.[136]

Robert *et al.* studied the effect of untreated fenugreek (halba in Malay) seed powder (5.5g) on a small sample (n=14) of overweight and obese individuals and reported that it decreased the post-prandial glycaemic response and increased satiety.[137]

Sibutramine is a serotonin-noradrenaline reuptake inhibitors (SNRI) related to amphetamines that suppresses appetite and is a prescribed weight reduction agent. It has been withdrawn in several countries due to concerns regarding its cardiovascular effects. A case of non-ischemic dilated cardiomyopathy in a man who lost approximately 10 kg in total in four months has been reported locally.[138]

BIOMARKERS

Although over-eating and under-exercising are the main drivers for obesity, the physiological trigger to stop eating, that one might expect to govern this, appears not to be effective enough to overcome the tendency for humans to deviate from the ideal healthy body weight. The satiety effect of homeostatis is not coping with the socio-economic success that has produced abundance of food supply. Understanding the genes and biological pathways that control eating behaviour may provide a key to managing obesity.

A vast array of genes and their products including adiponectin, β2-adrenoceptor (ADRB2), carnitine palmitoyltransferase-1 (CPT1), cholecystokinin, fat mass and obesity associated (FTO), ghrelin, glucagon-like-peptide-1 (GLP1), insulin-induced gene 2 (INSIG2), leptin, long-chain fatty acyl-coenzyme A (LCFA-CoA), melanocortin-4 receptor (MC4R), N-acylphosphatidylethanolamine (NAPE), neuropeptide Y(NPY), oleoylethanolamide (OEA), oxyntomodulin (OXM), peptide YY (PYY), resistin, syndecan 3 (SDC3), and others act on the gut or brain to promote either anorexia or satiety. Many of these biomarkers may be

associated with obesity related traits, even if they are not significantly associated with obesity itself measured by BMI.

In addition, inflammation, indicated by its various markers such as C-reactive protein, tumour necrosis factor and others also affect metabolism and obesity. Gut microbiota also plays a role.

Leptin is a satiety signal. Fan and Say investigated the prevalence of the leptin genes LEP(A19G) and LEP(G2548A) single nucleotide polymorphisms (SNPs) and the leptin receptor genes LEPR(K109R) and (Q223R) SNPs. The prevalence of the variant allele of the genes were 0.74, 0.67, 0.61 and 0.79 respectively. Indians had the lowest rates of the variant genes and Chinese had the highest. The variant genes were not associated with obesity, but the LEPR (109R) SNP (rs1137100) variant was protective against obesity and subjects with the variant had lower plasma leptin levels than their wild-type allele counterparts. Chinese had the highest frequency of the variant.[139] The leptin haplotype designated as GCCGGAA in a study by Apalasamy, was associated with obesity in Malaysian Malays. Levels of leptin in plasma were also linked to obesity and metabolic abnormalities.[140]

Apalasamy also found blood adiponectin levels associated with obesity, but resistin appeared have less effect on obesity.[140] Adiponectin levels in blood are highly associated with the ADIPOQ gene. Apalasamy found a significant association between the ADIPOQ (rs17366568) gene variant and obesity among Malays. The frequencies of AG and AA genotypes were significantly higher in the obese group (11%) than in the non-obese group (5%). However, no significant association was found between allelic frequencies of the ADIPOQ (rs3774261) variant gene.[141] Apalasamy found no association between the SNP (rs34861192) and (rs3219175) of the resistin (RETN) gene and obesity among Malay men.[142]

The melanocortin-4 receptor (MC4R) mediates the effects of leptin in its anorexigenic pathway, and a defective gene that fails to suppress appetite is associated with obesity. Chua *et al.* found only a 0.02 frequency (10/498) of the Valine>Isoleucine variant (V103I) of the MC4R among subjects in Kampar and no significant difference related to obesity measurements.[143] Apalasamy *et al.* found no significant association of the SNPs variants of MC4R; (rs571312), (rs2229616), (rs7227255) with obesity, even though the (rs571312), (rs2229616) SNPs were associated with obesity related parameters.[144]

The Fatty Acid Binding Protien2 (FABP2) is associated with insulin resistance and obesity in many populations. Among diabetics, Lee found the Alanine>Threonine variant of the FABP2 (Ala54Thr), was significantly associated with obesity among Indians(n=146), but not Chinese (n=133) and Malays (n=161).[145]

Pro-opiomelanocortin (POMC) is a peptide that is cleaved to produce several food intake suppressing peptides. Lee *et al.* investigated the prevalence of the RsaI SNP in the 5′-untranslated region (UTR) of the POMC gene among Malaysians in Kampar, and found that the (-/-) variant occurred in 8.9% (27/302) of the subjects, and the frequency of the (-) allele was 0.31. There was no association of the (-) allele with obesity, nor gender or ethnicity.[146]

The cocaine- and amphetamine-regulated transcript prepropeptide gene (*CARTPT*, Gene ID: 9607) encodes for a protein which modulates the anorectic pro-opiomelanocortin (POMC)/CART neurons in the hypothalamus. Some genetic variants of the *CARTPT* gene have been found to be associated with obesity. The *CARTPT* (rs2239670) variant gene has been shown to be associated with alcoholism among Koreans. Lisa et al. investigated that variant and found it is not a predictor for obesity among the Malaysian subjects.[147]

Common variants in the fat mass- and obesity-associated *(FTO)* gene have been previously found to be associated with obesity in various adult populations. Apalasamy *et al.* found no significant allelic or genotypic type frequency difference for 31 *FTO* geneSNPs between 158 obese and 429 non-obese Malay Malaysian subjects.[148] One of these genes, *FTO* (rs9939609), was also examine by Chey *et al.* in a multi-ethnic population sample and reported that subjects with allele A had marginally but significantly higher waist circumference which was abolished when adjusted for age, gender and ethnicity.[149]

The insulin-induced gene 2 (INSIG2) plays a role in cholesterol me-tabolism, lipogenesis, and glucose homeostasis and studies have shown that INSIG2 polymorphisms were associated with obesity and weight gain. However, Apalasamy *et al.* found no significant association between the (rs7566605) tagging SNP of INSIG2 with obesity or other metabolic parameters in the Malaysian Malay population.[150]

Peptide Tyrosine-Tyrosine (PYY) is a hormone released in the intestinal tract to suppress pancreatic secretions and eventually reduce appetite. The R72T variant in the PYY gene (rs1058046) has been associated with increased susceptibility to obesity. Chan *et al.* found a 0.45 frequency for the variant T allele among 197 subjects in Kampar. Indians had the highest rates of the T allele (61.3%) and Chinese the lowest (32.5%). The rate in Malays was 49.3%. They found no association of genotype with obesity measured by BMI, but the TT genotype was associated with a higher waist circumference and visceral fat level.[151]

β2-Adrenergic receptors (ADRB2) play a role in blood pressure regulation, lipoprotein metabolism, energy expenditure and hence obesity. Apalasamy *et al.* however found the gene variant ADRB2 (Gln27Glu) SNP (rs1042714), not significantly associated with BMI among Malays.[152]

Osteocalcin, an osteoblast-specific protein, is a marker of bone formation but also influence body fat. Lack of osteocalcin has been associated with obesity. Chin *et al.* demonstrated that serum osteocalcin level was significantly associated with obesity and serum HDL cholesterol level in a sample of 373 Malaysian men.[153]

Oxidative stress is induced in obesity. It is present when there is an imbalance between the antioxidant defence system and free radical production. Plasma total antioxidant

capacity(TAC) is a biomarker derived to assess cumulative action of all the antioxidants present in plasma. Lim *et al.* measured the Trolox equivalent antioxidant capacity (TEAC) among 362 Malaysian subjects and determined that it was significantly associated with obesity.[154]

The soluble form of the urokinase plasminogen activator surface receptor (suPLAUR) enhances leukocyte migration and adhesion, and its circulatory level is increased in inflammatory states. Of three variants, Ng *et al.* found that only suPLAUR (transcript variant 2) increases in omental adipose tissues in obese individuals, suggesting it has a role recruiting immune cells to adipose tissue in the pathogenesis of obesity.[155]

Peroxisome proliferator-activated receptors (PPARs) are nuclear receptor proteins that play a role in the expression of genes that regulate metabolism. Chia *et al.* found none of the SNPs of PPAR they investigated were associated with obesity and Met-S in the suburban population of Kampar, Malaysia.[156]

The uncoupling proteins (UCP) 1-3 are mitochondrial inner membrane proteins that can dissipate the proton gradient before it can be used to provide the energy. Lee *et al.* found that Chinese with the T allele of the UCP3-55C/T single nucleotide polymorphism had significantly lesser risk to be centrally obese (OR=0.69).[157]

SECTION 2: RELEVANCE OF FINDINGS FOR CLINICAL PRACTICE

It is clear that the effort to combat the high prevalence of obesity has been and is a national priority and resources must be allocated appropriately.[158] The Ministry of Health may educate and counsel its patients and contacts in all its health facilities and designate various professions, from doctor to nurses and dieticians to different roles in the course of regular work. It may also consider strategic programmes and campaigns. However, the national effort must be wider than that. Non-governmental organisation, schools, other government agencies and bodies, corporate firms, and community associations and societies and even religious groups can raise awareness as well as run programmes. This can be done when they are given motivational and technical assistance. The need is to educate the masses about what constitute healthy living and probably the mass media is the most powerful channel today. Radio, television, magazines and the internet have the most penetrating reach into all strata of society. Health is for all and proper nutrition is truly a matter in which every individual is a stakeholder.

The two main areas for action are food intake and physical activity. The low education and low income segment of the population need to be taught how to eat healthily and if they have issues concern access to such food, they should be given assistance. Housewives are obviously the key target population. They are not only one of the most obese occupational group, they control how the rest of the family eats. They should be taught what foods to buy and how many calories each meal should contain. The marketing and advertisement of cheap unhealthy food should be addressed.

The level of physical activity among Malaysians might be addressed by focusing on the mode of transport of the average Malaysian. Transportation constitutes a significant part of daily activity and if instead of cars and motorcycles, more of the population can be encouraged to bicycle and use public transport, their level of physical activity would increase. Sporting activity in leisure time can be promoted and families can be involved together. Programmes on achieving exercise targets can be disseminated through the mass media and devices that help individuals track their physical activity level utilised more widely.

SECTION 3: FUTURE RESEARCH DIRECTION FOR OBESITY IN MALAYSIA

The prevalence of obesity in Malaysia has been fairly well established by numerous studies over the past decade but this should be followed up with well-timed surveys to monitor the changing trends. Prevalence studies in special groups should only be done and interpreted with reference to the overall data and have a clear interest, such as to identify groups with a particularly high prevalence and risk factors or problems such as dual malnutrition which require targeted intervention.

Alongside the programmes to manage obesity research needs to be conducted to monitor the outcome of obesity reduction programmes.

The MASO identified several areas of research needs in their report. They included measures for prevention of overweight and obesity in the local situation. They mentioned studies to determine the environmental, behavioural, social and ecological factors that contribute to obesity in different segments of the population. They listed studies to assess the economic burden of overweight and obesity in the population and behavioural research to identify culturally appropriate techniques to motivate people to increase and maintain physical activity and make healthier food choices. They also listed research on the influence of marketing practices in food industry and food outlets and cost-effectiveness of community-directed measures to prevent and manage overweight and obesity. The report also mentioned the need to assess community insights in relation to their understanding, perceptions, and expectations on weight maintenance.[119]

Childhood obesity, which is outside the scope of this review also needs to be addressed, and the school setting plays an important role.

Researchers in Malaysia should keep abreast with new findings about biomarkers and where relevant study the significance of these biomarkers in our population.

ACKNOWLEDGEMENTS

I would like to thank KL Lam for technical help with the figures, and Prof Winnie Chee for advice and comments. We would like to thank the Director General of Health Malaysia for his permission to publish this article

REFERENCES

1. Teng CL, Zuhanariah MN, Ng CS, Goh CC. Bibliography of clinical research in Malaysia: methods and brief results. Med J Malaysia 2014; 69(Suppl A): 4-7.
2. WHO Expert Committee on Physical Status. Physical status: the Use and Interpretation of Anthropometry: report of a WHO expert committee. WHO technical report series; 854, 1995.
3. Ng M, Fleming T, Robinson M, Thomson B, Graetz N, Margono C, *et al.* Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet 2014; 384(9945): 766-81.
4. Fatimah S, Tahir A, Siti Sa'adiah HN, Maimunah AH. Nutritional Status of Adults Aged 18 Years and above. National Health and Morbidity Survey 1996, Volume 14. Institute of Public Health, Ministry of Health: Malaysia, 1999.
5. Lim TO, Ding LM, Zaki M, Suleiman AB, Fatimah S, Siti S, *et al.* Distribution of body weight, height andbody mass index in a national sample of Malaysian adults. Med J Malaysia 2000; 55(1): 108-28.
6. Azmi MY, Junidah R, Siti Mariam A, Safiah MY, Fatimah S, Norimah AK, et al. Body Mass Index (BMI) of adults: findings of the Malaysian Adult Nutrition Survey (MANS). Malays J Nutr 2009; 15(2): 97-119.
7. Rampal L, Rampal S, Khor GL, Zain AM, Ooyub SB, Rahmat RB, *et al.* A national study on the prevalence of obesity among 16,127 Malaysians. Asia Pac J Clin Nutr 2007; 16(3): 561-6.
8. Institute for Public Health. The Third National Health and Morbidity Survey (NHMS III) 2006, Nutritional Status. Ministry of Health, Malaysia 2008.
9. Institute for Public Health. National Health and Morbidity Survey 2011 (NHMS 2011) Vol II, Non-communicable Diseases; 2011.
10. Suzana S, Kee CC, Jamaludin AR, Noor Safiza MN, Khor GL, *et al.* The Third National Health and Morbidity Survey: prevalence of obesity, and abdominal obesity among the Malaysian elderly population. Asia Pac J Public Health 2012; 24(2): 318-29.
11. Shahar S, Ibrahim Z, Fatah AR, Rahman SA, Yusoff NA, *et al.* A multidimensional assessment of nutritional and health status of rural elderly Malays. Asia Pac J Clin Nutr 2007; 16(2): 346-53.
12. Suzana S, Boon PC, Chan PP, Normah CD. Malnutrition risk and its association with appetite, functional and psychosocial status among elderly Malays in an agricultural settlement. Malays J Nutr 2013; 19(1): 65-75.
13. Gopalakrishnan S, Ganeshkumar P, Prakash MV, Christopher, Amalraj V. Prevalence of overweight/obesity among the medical students, Malaysia. Med J Malaysia 2012; 67(4): 442-4.
14. Chee HL, Kandiah M, Khalid M, Shamsuddin K, Jamaluddin J, Nordin NA, et al. Body mass index and factors related to overweight among women workers in electronic factories in Peninsular Malaysia. Asia Pac J Clin Nutr 2004; 13(3): 248-54.
15. Hossain MG, Wee AS, Ashaie M, Kamarul T. Adult anthropometric measures and socio-demographic factors influencing age at menarche of university students in Malaysia. J Biosoc Sci 2013; 45(5): 705-17
16. Sidik SM, Rampal L. The prevalence and factors associated with obesity among adult women in Selangor, Malaysia. Asia Pac Fam Med 2009; 8(1): 2.
17. Poh BK, Sia PH, Norimah AK, Mohd Ismail N. Pengetahuan pengurusan berat badan di kalangan wanita bekerja di Kuala Lumpur. Jurnal Sains Kesihatan Malaysia 2006; 4(1): 71-84.
18. Norsa'adah BB, Rusli BN, Imran BAK, Naing L. Profile of breast cancer among women in Kelantan. Malaysian Journal of Public Health Medicine 2004; 4(2): 24-9.
19. Yong HY, Kandiah M, Shafiff ZM, Mun CY, Hashim Z, Yusof RM, *et al.* Pattern of weight changes in women with breast cancer. Asian Pac J Cancer Prev 2010; 11(6): 1535-40.
20. Lee CL, Norimah AK, Ismail MN. Association of energy intake and macronutrient composition with overweight and obesity in Malay women from Klang Valley. Malays J Nutr 2010; 16(2): 251-60.
21. Siti Affira K, Mohd Nasir MT, Hazizi AS, Kandiah M. Socio-demographic and psychosocial factors associated with physical activity of working woman in Petaling Jaya, Malaysia. Malays J Nutr 2011; 17(3): 315-24.
22. Lua PL, Salihah NZ, Mazlan N. Nutritional status and health-related quality of life of breast cancer patients on chemotherapy. Malays J Nutr 2012; 18(2): 173-84.
23. Hasnah H, Amin I, Suzana S. Bone health status and lipid profile among post-menopausal malay women in Cheras, Kuala Lumpur. Malays J Nutr 2012; 18(2): 161-71.
24. Yusof HM, Ching TS, Ibrahim R, Lola S. Anthropometric indices and life style practices of the indigenous Orang Asli adults in Lembah Belum, Grik of Peninsular Malaysia. Asia Pac J Clin Nutr 2007; 16(1): 49-55
25. Haemamalar K, Zalilah MS, Neng Azhanie A. Nutritional status of Orang Asli (che wong tribe) adults in Krau wildlife reserve, Pahang. Malays J Nutr 2010; 16(1): 55-68.
26. Azuwani A, Noor Khairiah K, Cheong YZ, Kok CC, Aw NSL, Nadiah Mhd S, *et al.* Body fat percentage distribution of an Orang Asli group (Aborigines) in Cameron Highlands, Malaysia. Malays J Nutr 2013; 19(2): 205-14
27. Phipps ME, Chan KK, Naidu R, Mohamad MW, Hoh BP, Quek KF, *et al.* Cardio-metabolic health risks in indigenous populations of Southeast Asia and the influence of urbanization. BMC Public Health 2015; 15: 47
28. Mohd Yunus A, Sherina MS, Nor Afiah MZ, Rampal L, Tiew KH. Prevalence of cardiovascular risk factors in a rural community in Mukim Dengkil, Selangor. Malays J Nutr 2004; 10(1): 5-11.
29. Nawawi HM, Nor IM, Noor IM, Karim NA, Arshad F, Khan R, *et al.* Current status of coronary risk factors among rural Malays in Malaysia. J Cardiovasc Risk 2002; 9(1): 17-23
30. Rampal L, Rampal S, Azhar MZ, Sherina MS, Ambigga D, Rahimah A. A population-based study on the prevalence and factors associated with obesity in Selangor. Malaysian Journal of Medicine and Health Sciences 2006; 2(2): 89-97.
31. Nazri SM, Imran MK, Ismail IM, Faris AA. Prevalence of overweight and self-reported chronic diseases among residents in Pulau Kundur, Kelantan, Malaysia. Southeast Asian J Trop Med Public Health 2008; 39(1): 162-7.
32. Chang CT, Lee PY, Cheah WL. The prevalence of cardiovascular risk factors in the young and middle-aged rural population in Sarawak, Malaysia. Malays J Med Sci 2012; 19(2): 27-34.
33. Mohamud WN, Musa KI, Khir AS, Ismail AA, Kadir KA, Kamaruddin NA, *et al.* Prevalence of overweight and obesity among adult Malaysians: an update. Asia Pac J Clin Nutr 2011; 20(1): 35-41.
34. Akter SF, Fauzi AR, Nordin MS, Satwi S, Mohamd A, Aznan MA, *et al.* Prevalence of cardiovascular risk factors in a selected community at Kuantan, Pahang, Malaysia. International Journal of Medicine and Medical Sciences 2010; 2(10): 322-8.
35. Narayan KA, Khan AR. Body mass index and nutritional status of adults in two rural villages in northern Malaysia. Malays J Nutr 2007; 13(1): 9-17.
36. Jan Mohamed HJ, Mitra AK, Zainuddin LR, Leng SK, Wan Muda WM. Women are at a higher risk of metabolic syndrome in rural Malaysia. Women Health 2013; 53(4): 335-48.
37. Rampal L, Saeedi P, Aminizadeh Bezenjani S, Salmiah MS, Norlijah O. Obesity and associated health related factors among university staff in Serdang, Malaysia. Malaysian Journal of Medicine and Health Sciences 2012; 8(2): 23-32.
38. Chew WF, Masyita M, Leong PP, Boo NY, Choo KB, Yap SF. Prevalence of obesity and its associated risk factors among Chinese adults in a Malaysian suburban village. Singapore Med J 2014; 55(2): 84-91.
39. Hazizi AS, Aina MB, Mohd NM, Zaitun Y, Hamid JJ, Tabata I. Accelerometer-determined physical activity level among government employees in Penang, Malaysia. Malays J Nutr 2012; 18(1): 57-66.
40. Nor Afiah MZ, Suriani I, Abdul Hakim MS, Simmadorai R, Nor Shahida Akhma MS. Influence of eating behaviours and psychosocial factors on overweight and obesity among medical students in a public university in Malaysia. International Journal of Public Health and Clinical Sciences 2014; 1(1): 151-9.
41. Kabir S, Salmiah MS, Suriani I. Prevalence and factors associated with overweight and obesity among Malaysian post graduate students in a public university. International Journal of Public Health and Clinical Sciences 2014; 1(1): 131-40.
42. Ayiesah R, Leonard JH, Vijaykumar P, Mohd Suhaimy R. Obesity and habitual physical activity level among staffs working in a Military Hospital in Malacca, Malaysia. The International Medical Journal Malaysia 2013; 12(1): 53-8.
43. Mohd Nazri S, Tengku MA, Winn T, Choudhury SR. The association of shift work and coronary heart disease risk factors among male factory workers in Kota Bharu, Kelantan. Jurnal Kesihatan Masyarakat 2004; 10: 72-8.
44. Lim HM, Chee HL, Kandiah M, Shamsuddin K, Jamaluddin J, Nordin N, *et al.* Dietary and other factors associated with overweight among women workers in two electronics factories in Selangor. Malays J Nutr 2003; 9(2): 105-24.
45. Moy FM, Hoe VCW, Tan CPL, Rosmawati M. Cardiovascular risks among shift and non-shift workers in a public medical centre in Kuala Lumpur. JUMMEC 2010; 13(1): 45-9.
46. Tan AK, Yen ST, Feisul MI. Determinants of body weight status in Malaysia: an ethnic comparison. Int J Public Health 2012; 57(2): 279-88.
47. Shariff ZM, Khor GL. Obesity and household food insecurity: evidence from a sample of rural households in Malaysia. Eur J Clin Nutr 2005; 59(9): 1049-58.
48. Ihab AN, Rohana AJ, Manan WM, Suriati WN, Zalilah MS, Rusli AM. The coexistence of dual form of malnutrition in a sample of rural malaysia. Int J Prev Med 2013; 4(6): 690-9.

49. Dunn RA, Tan AK, Nayga RM. Obesity inequality in Malaysia: decomposing differences by gender and ethnicity using quantile regression. Ethn Health 2012; 17(5): 493-511.
50. Janssen I, Katzmarzyk PT, Ross R. Waist circumference and not body mass index explains obesity related health risk. Am J Clin Nutr 2004; 79: 379-84.51.
51. Deurenberg P, Yap M, van Staveren WA. Body mass index and percent body fat: a meta-analysis among different ethnic groups. Int J Obes Relat Metab Disord 1988; 22(12): 1164-71.
52. Shashikiran U, Sudha V, Jayaprakash B. What is obesity? Med J Malaysia 2004; 59(1): 130-3.
53. Zaher ZM, Zambari R, Pheng CS, Muruga V, Ng B, Appannah G, *et al.* Optimal cut-off levels to define obesity: body mass index and waist circumference, and their relationship to cardiovascular disease, dyslipidaemia, hypertension and diabetes in Malaysia. Asia Pac J Clin Nutr 2009; 18(2): 209-16.
54. Cheong KC, Yusoff AF, Ghazali SM, Lim KH, Selvarajah S, Haniff J, *et al.* Optimal BMI cut-off values for predicting diabetes, hypertension and hypercholesterolaemia in a multi-ethnic population. Public Health Nutr 2013; 16(3): 453-9.
55. Deurenberg-Yap M, Yian TB, Kai CS, Deurenberg P. van Staveren WA. Manifestation of cardiovascular risk factors at low levels of body mass index and waist-to-hip ratio in Singaporean Chinese. Asia Pac J Clin Nutr 1999; 8(3): 177-83.
56. Hsieh SD, Yoshinaga H, Muto T, Sakurai Y, Kosaka K. Health risks among Japanese men with moderate body mass index. Int J Obes Relat Metab Disord 2000; 24(3): 358-62.
57. Zaher ZM, Zambari R, Pheng CS, Muruga V, Ng B, Appannah G, *et al.* Optimal cut-off levels to define obesity: body mass index and waist circumference, and their relationship to cardiovascular disease, dyslipidaemia, hypertension and diabetes in Malaysia. Asia Pac J Clin Nutr 2009: 18: 209-16.
58. Aye M, Sazali M. Waist circumference and BMI cut-off points to predict risk factors for metabolic syndrome among outpatients in a district hospital. Singapore Med J 2012; 53(8): 545-50.
59. Zaki M, Robaayah Z, Chan SP, Vadivale M, Lim TO. Malaysia Shape of the Nation (MySoN): a primary care based study of abdominal obesity in Malaysia. Med J Malaysia 2010; 65(Suppl A): 143-9.
60. Kee CC, Jamaiyah H, Geeta A, Ali ZA, Safiza MN, Suzana S, *et al.* Sensitivity and specificity of waist circumference as a single screening tool for identification of overweight and obesity among Malaysian adults. Med J Malaysia 2011; 66(5): 462-7.
61. Kee CC, Jamaiyah H, Noor Safiza MN, Khor GL, Suzana S, Jamalludin AR, *et al.* Abdominal obesity in Malaysian Adults: National Health and Morbidity Survey III (NHMS III, 2006). Malays J Nutr 2008; 14(2): 125-35.
62. Norafidah AR, Azmawati MN, Norfazilah A. Factors influencing abdominal obesity by waist circumference among normal BMI population. Malaysian Journal of Public Health Medicine 2013; 13(1): 37-47.
63. Goonasegaran AR, Nabila FN, Shuhada NS. Comparison of the effectiveness of body mass index and body fat percentage in defining body composition. Singapore Med J 2012; 53(6): 403-8.
64. Department of Statistics Malaysia. Yearbook of Statistics Malaysia. Kuala Lumpur: Department of Statistics Malaysia, various years from 1980-2010.
65. Mohd Ismail N. The nutrition and health transition in Malaysia. Public Health Nutrition 2002; 5:191-195. (Government of Malaysia. Sixth Malaysia Plan, 1991-1995. Kuala Lumpur: National Printing Press, 1991).
66. Khor GL. Food availability and the rising obesity prevalence in Malaysia. IeJSME 2012; 6(Suppl 1): S61-8.
67. Food and Agriculture Organization (FAO). Food Balance Sheet (1961-1997). Rome: FAO, various years from 1961 to 1997.
68. Davey TM, Allotey P, Reidpath DD. Is obesity an ineluctable consequence of development? A case study of Malaysia. Public Health 2013; 127(12): 1057-62.
69. Budget 2014: GST, sugar subsidy removal foremost on Malaysians' minds. http://www.thestar.com.my/News/Nation/2013/10/25/Budget-2014-reax-GST-sugar/
70. Chong YH, Tee ES, Ng TKW, *et.al.* Status of community nutrition in poverty kampongs. Bullettin No.22 Institute for Medical Research: Kuala Lumpur. 1984.
71. Chee SS, Ismail MN, Ng KK, Zawiah H. Food intake assessment of adults in rural and urban areas from four selected regions in Malaysia. Mal J Nutr 1997; 3: 91-102.
72. Chee WS, Suriah AR, Zaitun Y, Chan SP, Yap SL, Chan YM. Dietary calcium intake in post-menopausal women: Comparison between the food frequency questionnaire and three-day food records. Asia Pacific J Clin Nutr 2002; 11(2): 142-6.
73. Rahman SA, Chee WS, Yassin Z, Chan SP. Vitamin D status among postmenopausal Malaysian women. Asia Pacific J Clinical Nutr 2004; 13(3): 255-60.
74. Hasnah H, Amin I, Suzana S. Bone health status and lipid profile among post-menopausal Malay women in Cheras, Kuala Lumpur. Malays J Nutr 2012; 18(2): 161-71.
75. Suriani I, Khadijah S, Khalib AL, Hazizi AS, Fadlan MO. Barriers to food quantity intake control and healthy eating among overweight and obese working Malay women in public service. International Journal of Public Health and Clinical Sciences 2015; 2(3): 81-93.
76. Rashidah A, Balkish MN, Md Azahadi O, Nor Azian MZ, Syafinaz MS, Tahir A. Food label reading and understanding among obese adults: a population study in Malaysia. International Journal of Public Health Research 2014; 4(2): 449-56.
77. Boo NY1, Chia GJ, Wong LC, Chew RM, Chong W, Loo RC. The prevalence of obesity among clinical students in a Malaysian medical school. Singapore Med J 2010; 51(2): 126-32.
78. Choong SS, Balan SN, Chua LS, Say YH. Preference and intake frequency of high sodium foods and dishes and their correlations with anthropometric measurements among Malaysian subjects. Nutr Res Pract 2012; 6(3): 238-45.
79. Swarna Nantha Y. Addiction to sugar and its link to health morbidity: a primer for newer primary care and public health initiatives in Malaysia. J Prim Care Community Health 2014; 5(4): 263-70.
80. Poh BK, Safiah MY, Tahir A, Siti Haslinda MD, Siti Norazlin N, Norimah AK, et al. Physical activity pattern and energy expenditure of Malaysian adults: Findings from the Malaysian Adult Nutrition Survey (MANS). Malays J Nutr 2010; 16(1):13-37.
81. Bauman A, Phongsavan P, Schoeppe S, Chey T, Kong L, Ma G, *et al.* Noncommunicable disease risk factors and socioeconomic inequalities – what are the links? A multicountry analysis of noncommunicable disease surveillance data. Report to the WHO Regional Office for the Western Pacific. 2010.
82. Moy FM, Atiya AS. Lifestyle practices and prevalence of obesity in a community within a University campus. JUMMEC 2005; 8(1): 33-8.
83. Wan Nudri WD, Wan Abdul Manan WM, Mohamed Rusli A. Body mass index and body fat status of men involved in sports, exercise, and sedentary activites. Malays J Med Sci 2009; 16(2): 21-6.
84. Hejar AR, Shaza Wahieda MS, Junainah S, Zaiton A, Chin LS. The prevalence of physical activity, smoking and obesity among the attendees of health clinics in Sepang District. Malaysian Journal of Public Health Medicine 2003; 3(1): 16-22.
85. Ibrahim N, Moy FM, Awalludin IA, Ali Z, Ismail IS. The health-related quality of life among pre-diabetics and its association with body mass index and physical activity in a semi-urban community in Malaysia- a cross sectional study. BMC Public Health 2014; 14(1): 298.
86. Lim KG and Cheah WK. A Review of Metabolic Syndrome Research in Malaysia. Med J Malaysia 2015: 70:s...
87. Mafauzy M. Diabetes Control and Complications in Public Hospitals in Malaysia. Med J Malaysia 2006; 61(4): 477-83.
88. Abougalambou SSI, Mohamed M, Sulaiman SAS, Abougalambou AS, Hassali MA. Current clinical status and complications among type 2 diabetic patients in Universiti Sains Malaysia hospital. International Journal of Diabetes Mellitus. 2010; 2(3): 184-8.
89. Moy FM, Rahman S. Anthropometry and dietary intake of type 2 diabetes patients attending an outpatient clinic. Malays J Nutr 2002; 8(1): 63-73.
90. Eid M, Mafauzy M, Faridah AR. Non-achievement of clinical targets in patients with type 2 diabetes mellitus. Med J Malaysia 2004; 59(2): 177-84.
91. Foo SH, Chan SP, Bahari S, Bulgiba A. Insulin resistance is the predominant pathophysiologic feature of hyperglycemia in newly diagnosed overweight and obese type 2 diabetes mellitus in two university hospitals in Malaysia. Journal of the ASEAN Federation of Endocrine Societies 2012; 26(2): 143-9.
92. Matthews DR, Hosker JP, Rudenski AS, Naylor BA, Treacher DF, Turner RC. Homeostatic Model Assessment: Insulin resistance and beta cell function from fasting plasma glucose and insulin concentration in man. Diabetologia. 1985; 28(7): 412-9.
93. Lim TO, Bakri R, Morad Z, Hamid MA. Bimodality in blood glucose distribution: is it universal? Diabetes Care 2002; 25(12): 2212-7.
94. Khoo KL, Tan H, Liew YM, Sambhi JS, Aljafri AM, Hatijah A. Blood pressure, body mass index, heart rate and levels of blood cholesterol and glucose of volunteers during National Heart Weeks, 1995-1997. Med J Malaysia 2000; 55(4): 439-50.
95. Akter SFU, Fauzi ARM, Nordin MS, Satwi S, Mohamed A, Aznan MA, et al. Prevalence of cardiovascular risk factors in a selected community at Kuantan, Pahang, Malaysia. International Journal of Medicine and Medical Sciences 2010; 2(10):322-8.
96. Abdul Rahman H. Body mass index and its associated morbidity among elderly patients attending Klinik Kesihatan Parit Jawa, Muar. Dissertation, Universiti Kebangsaan Malaysia, 2000.
97. Aniza I, Hayati K, Juhaida MN, Ahmad Taufik J, Idayu Badilla I, Khalib L. Obesity related hypertension – gender specific analysis among adults in Tanjung Karang, Selangor, Malaysia. Malaysian Journal of Public Health Medicine 2015; 15(1): 41-52.

98. Su TT, Amiri M, Mohd Hairi F, Thangiah N, Dahlui M, Majid HA. Body composition indices and predicted cardiovascular disease risk profile among urban dwellers in Malaysia. Biomed Res Int 2015; 2015: 174821.
99. Moy FM, Atiya AS, Wong ML. Framingham risk scores and anthropometric measurements in predicting cardiovascular risks among Malay men. Malays J Nutr 2008; 14(1): 57-63.
100. Al-Tahami BA, Bee YT, Ismail AA, Rasool AH. Impaired microvascular endothelial function in relatively young obese humans is associated with altered metabolic and inflammatory markers. ClinHemorheol Microcirc 2011; 47(2): 87-97.
101. Sanip Z, Ariffin FD, Al-Tahami BA, Sulaiman WA, Rasool AH. Obesity indices and metabolic markers are related to hs-CRP and adiponectin levels in overweight and obese females. Obes Res Clin Pract 2013; 7(4): e315-20.
102. Nafikudin M, Nawawi H, Muid S, Annuar R, Yusoff K, Khalid BA. Measurement of intima-media thickness of common carotid arteries using ultrasound in patients with familial and non-familial hypercholesterolaemia and correlation of intima-media thickness to obesity. Med J Malaysia 2003; 58(5): 647-52.
103. Azhar AH, Zulkarnain H, Ziyadi G, Rahman MNG. A study of relationship between body mass index and short term outcome of isolated coronary artery bypass graft surgery. Journal of Surgical Academia 2011; 1(2): 41-8.
104. Norlelawati AT, Kartini A, Ramli M, Norsidah K, Wan Azizi WS, Tariq AR. Obesity in multiracial schizophrenia patients receiving outpatient treatment in a regional tertiary hospital in Malaysia. East Asian Arch Psychiatry 2012; 22(2): 49-56.
105. Ainsah O, Salmi R, Osman CB, Shamsul AS. Relationships between antipsychotic medication and anthropometric measurements in patients with schizophrenia attending a psychiatric clinic in Malaysia. Hong Kong Journal of Psychiatry 2008; 18(1): 23-7.
106. Ainsah O, Salmi R, Osman CB. Binge eating and lifestyle factors in relation to obesity in schizophrenia. Malaysian Journal of Psychiatry 2008; 17(1): 13-22.
107. Loo TH, Maniam T, Ainsah O. Psychiatric morbidity, personality profile and saliva cortisol levels in overweight and obese patients referred to dietician clinics in UKMMC. Malaysian Journal of Psychiatry 2011; 20(1): 4-15.
108. Abdollahi A, Abu Talib M. Sedentary behaviour and social anxiety in obese individuals: the mediating role of body esteem. Psychol Health Med 2015; 20(2): 205-9.
109. Rosengren A, Teo K, Rangarajan S, Kabali C, Khumalo I, Kutty VR, *et al.* Psychosocial factors and obesity in 17 high-, middle- and low-income countries: The Prospective Urban Rural Epidemiologic (PURE) study. Int J Obes (Lond) 2015; 39(8): 1217-23.
110. Ainsah O, Osman CB. Night eating syndrome with morbid obesity and dysthymia: a case report - a psychobiological approach. Medicine & Health 2007; 2(2): 154-7.
111. Adinegara LA, Razzak MS. Does lifestyle increase the incidence of pregnancy-induced hypertension? Med J Malaysia 2004; 59(1): 39-44.
112. Gendeh BS, Salina H. Observation of spontaneous cerebrospinal fluid rhinorrhoea to body mass index: a preliminary report. Med J Malaysia 2007; 62(5): 368-9.
113. Rabeta MS, Suzana S, Fatimah A, Ahmad Rohi G, Normah H, Nor Fadilah R. Abdominal obesity increased breast cancer risk. Jurnal Sains Kesihatan Malaysia 2007; 5(2): 17-28.
114. Ulaganathan V, Kandiah M, Zalilah MS, Faizal JA, Fijeraid H, Normayah K, et al. Colorectal cancer and its association with the metabolic syndrome: a Malaysian multi-centric case-control study. Asian Pac J Cancer Prev 2012; 13(8): 3873-7.
115. Ramadas A, Kandiah M, Zarida H, Yunus Gul AG, Faizal JA. Obesity and risk of colorectal adenomatous polyps: a case-control study in Hospital Kuala Lumpur. Malays J Nutr 2009; 15(1): 1-10.
116. Khan S, Saub R, Vaithilingam RD, Safii SH, Vethakkan SR, Baharuddin NA. Prevalence of chronic periodontitis in an obese population: a preliminary study. BMC Oral Health 2015; 15: 114.
117. Clinical Practice Guidelines: Management of Obesity. Kuala Lumpur: Ministry of Health, Malaysia, 2004.
118. Strategy for the Prevention of Obesity - Malaysia. Malaysian Association for the Study of Obesity, 2005.
119. Poh BK, Sia PH, Norimah AK, Mohd Ismail N. Pengetahuan pengurusan berat badan di kalangan wanita bekerja di Kuala Lumpur. [Malaysian Journal of Health Sciences] 2006; 4(1): 71-84.
120. Chang CT. Applicability of the stages of change and Weight Efficacy Lifestyle Questionnaire with natives of Sarawak, Malaysia. Rural Remote Health 2007; 7(4): 864.
121. Ang YK, Mirnalini K, Zalilah MS. A workplace email-linked website intervention for modifying cancer-related dietary and lifestyle risk factors: rationale, design and baseline findings. Malays J Nutr 2013; 19(1): 37-51.
122. Moy F, Sallam AA, Wong M. The results of a worksite health promotion programme in Kuala Lumpur, Malaysia. Health Promot Int 2006; 21(4): 301-10.
123. Ramli A, Henry LJ, Liang YF, Beh JY. Effects of a Worksite Health Programme on the Improvement of Physical Health among Overweight and Obese Civil Servants: A Pilot Study. Malays J Med Sci 2013; 20(5): 54-60.
124. Al-Qalah SAAJ, Ghazi HF, Zaleha MI, Karim NA. Dietary weight loss practice among government working women who successfully lose weight in Malaysia. Pakistan Journal of Nutrition 2014; 13(8): 486-91.
125. Aziz CB, Omar N, Abdullah WZ, Jalil RA, Nik WS, Zakaria R. Reduced fibrinogen, fibrinolytic biomarkers, and physical parameters after a weight-loss program in obese subjects. N Am J Med Sci 2014; 6(8): 377-82.
126. Ismail S, Shamsuddin K, Latiff KA, Saad HA, Majid LA, Othman FM. Voluntary fasting to control post-Ramadan weight gain among overweight and obese women. Sultan Qaboos Univ Med J 2015; 15(1): e98-e104.
127. Suriani I, Shamsuddin K, Abdul Latif K, Saad HA. The effect of the Malaysian Food Guideline guidance on a group of overweight and obese women during Ramadan. Saudi Med J 2015; 36(1): 40-5.
128. Suriani I, Shamsuddin, Khalib AL, Hazizi AS, Latifah AM. Ramadan fasting and voluntary fasting - potential weight loss and weight maintenance opportunity for overweight and obese Muslims. International Journal of Public Health and Clinical Sciences 2014; 1(2): 29-38.
129. Teng NI, Shahar S, Rajab NF, Manaf ZA, Johari MH, Ngah WZ. Improvement of metabolic parameters in healthy older adult men following a fasting calorie restriction intervention. Aging Male 2013; 16(4): 177-83.
130. Christopher LK, Kosai NR, Reynu R, Levin KB, Taher MM, Sutton PA, *et al.* Effect of Exercise on Pulmonary Function Tests in Obese Malaysian Patients. Clin Ter 2015; 166(3): 105-9.
131. Ruzita AT, Chan CL, Ismail MN, Thavaraj S. [Evaluation of effectiveness projects on obesity in 2010 funded by the Malaysian Health Promotion Board]. [Malaysian Journal of Health Sciences] 2013; 11(1): 49-53.
132. Soon HK, Saad HA, Taib MN, Rahman HA, Mun CY. Effects of combined physical activity and dietary intervention on obesity and metabolic parameters in adults with abdominal obesity. Southeast Asian J Trop Med Public Health 2013; 44(2): 295-308.
133. Chang CT, Chang KH, Cheah WL. Adults' perceptions of being overweight or obese: a focus group study. Asia Pac J Clin Nutr 2009; 18(2): 257-64.
134. Wai-Theng Kong, Siew-Siang Chua, Syireen Alwi. Weight loss practices among Malaysian adults. Asia Pac J Public Health 2002; 14(2): 99-104.
135. Suraya HS, Azmawati MN. Use of nonprescription substances among university students in Malaysia. Malaysian Journal of Public Health Medicine 2014; 14(2): 86-98.
136. Robert SA, Rohana AG, Shah SA, Chinna K, Wan Mohamud WN, Kamaruddin NA. Improvement in binge eating in non-diabetic obese individuals after 3 months of treatment with liraglutide - A pilot study. Obes Res Clin Pract 2015; 9(3): 301-4.
137. Robert SD, Ismail AA, Wan Rosli WI. Trigonellafoenum-graecum seeds lowers postprandial blood glucose in overweight and obese individuals. J Nutr Metab 2014; 2014: 964873.
138. Ibrahim O, Maskan O, Liang TE, Hassan H, Rahman M. A case report on sibutramine induced cardiomyopathy. Internet Journal of Cardiology 2012; 10(2).
139. Fan SH, Say YH. Leptin and leptin receptor gene polymorphisms and their association with plasma leptin levels and obesity in a multi-ethnic Malaysian suburban population. J Physiol Anthropol 2014; 33(1): 15
140. Apalasamy YD. Obesity study in Malaysian Malays with focus on candidate genes and biomarkers. PhD Thesis, University of Malaya, 2012.
141. Apalasamy YD, Rampal S, Salim A, Moy FM, Bulgiba A, Mohamed Z. Association of ADIPOQ gene with obesity and adiponectin levels in Malaysian Malays. Mol Biol Rep 2014; 41(5): 2917-21.
142. Apalasamy YD, Rampal S, Salim A, Moy FM, Su TT, Majid HA, *et al.* Polymorphisms of the Resistin Gene and their association with obesity and resistin levels in Malaysian Malays. Biochem Genet 2015; 53(4-6): 120-31.
143. Chua HN, Fan SH, Say YH. Prevalence of melanocortin receptor 4 (MC4R) V103I gene variant and its association with obesity among the Kampar Health Clinic cohort, Perak, Malaysia. Med J Malaysia 2012; 67(2): 234-5.
144. Apalasamy YD, Ming MF, Rampal S, Bulgiba A, Mohamed Z. Association of melanocortin-4 receptor gene polymorphisms with obesity-related parameters in Malaysian Malays. Ann Hum Biol 2013; 40(1): 102-6.
145. Lee CS. The association of Fatty Acid Binding Protein polymorphism with obesity and type 2 diabetes mellitus in Malaysian subjects. Master of Medical Science Dissertation, University of Malaya, 2010.
146. Lee HM, Fan SH, Say YH. Prevalence of RsaI polymorphism in the 5' untranslated region (UTR) of proopiomelanocortin (POMC) gene and its association with obesity in the Kampar Health Clinic Cohort, Malaysia. Malaysian Journal of Medicine and Health Sciences 2012; 8(1): 61-8.

147. Lisa Y, Sook- HF, Yee- HS. Association of the cocaine- and amphetamine-regulated transcript prepropeptide gene (CARTPT) rs2239670 variant with obesity among Kampar Health Clinic Patrons, Malaysia. Malays J Med Sci 2012; 19(1): 43-51.
148. Apalasamy YD, Moy FM, Rampal S, Bulgiba A, Mohamed Z. Genetic association of SNPs in the FTO gene and predisposition to obesity in Malaysian Malays. Braz J Med Biol Res 2012; 45(12): 1119-26.
149. Chey WW, Fan SH, Say YH. Association of fat mass and obesity-associated (FTO) gene Rs9939609 variant with obesity among multi-ethnic Malaysians in Kampar, Perak. Sains Malaysiana 2013; 42(3): 365-71.
150. Apalasamy YD, Moy FM, Rampal S, Bulgiba A, Mohamed Z. Genetic associations of the INSIG2 rs7566605 polymorphism with obesity-related metabolic traits in Malaysian Malays. Genet Mol Res 2014; 13(3): 4904-10.
151. Chan PM, Fan SH, Say YH. No association of peptide tyrosine-tyrosine (PYY) gene R72T variant with obesity in the Kampar Health Clinic cohort, Malaysia. Malays J Nutr 2011; 17(2): 201-12.
152. Apalasamy YD, Moy FM, Rampal S, Bulgiba A, Mohamed Z. Gender-dependent association of α β(2)- adrenergic gene variant with obesity parameters in Malaysian Malays. Asia Pac J Public Health 2015; 27(2): 154-65.
153. Chin KY, Ima-Nirwana S, Mohamed IN, Ahmad F, Ramli ES, Aminuddin A, *et al.* Serum osteocalcin is significantly related to indices of obesity and lipid profile in Malaysian men. Int J Med Sci 2014; 11(2): 151-7.
154. Lim SH, Fan SH, Say YH. Plasma total antioxidant capacity (TAC) in obese Malaysian subjects. Malays J Nutr 2012; 18(3): 345-54.
155. Ng HF, Chin KF, Chan KG, Ngeow YF. The mRNA expression of soluble urokinase plasminogen activator surface receptor in human adipose tissue is positively correlated with body mass index. Genome 2015; 58(6): 315-21.
156. Chia PP, Fan SH, Say YH. Screening of Peroxisome Proliferator-Activated Receptors (PPARs) alpha, gamma and alpha Gene Polymorphisms for Obesity and Metabolic Syndrome Association in the Multi-Ethnic Malaysian Population. Ethn Dis 2015; 25(4): 383-90.
157. Lee KH, Chai VY, Kanachamy SS, Say YH. Association of UCP1 -3826A/G and UCP3 -55C/T gene polymorphisms with obesity and its related traits among multi-ethnic Malaysians. Ethn Dis 2015; 25(1): 65-71.
158. Narimah A, Azmi MY, Tee ES, Khor GL, Mohd Ismail N, Cavalli-Sforza LT. National Plan of Action for Nutrition for Malaysia (1996-2000). National Coordinating Committee on Food and Nutrition. 1995.