SELECTED HEALTH RELATED FITNESS IN FEMALE UNDERFRADUATE STUDENTS

by

NAZIRAH BINTI GULAM MOHAMED

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CERTIFICATE

This is to certify that the dissertation entitled *Selected Health Related Fitness among Female Undergraduate Students* is the bonafide record of research work done by *Nazirah Binti Gulam Mohamed* [*89076*] during the period of *July 2007* to *April 2009* under my supervision. This dissertation submitted in partial fulfillment for the degree of Bachelor of Health Sciences (Exercise and Sports Science). Research work and collection of data belong to Universiti Sains Malaysia.

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ABSTRAK

OBEJEKTIF: Untuk menerangkan dan membandingkan kesihatan berasaskan kecergasan di kalangan wanita muda berdasarkan klasifikasi indeks jisim badan (BMI).

KAEDAH: Indeks anthropometrik, termasuk tinggi, jisim badan, ukur lilit pinggang dan pinggul telah diukur dalam kajian rentas yang melibatkan 35 wanita muda yang berumur antara 20-22 tahun dan sedang mengikuti program ijazah sarjana muda. Tekanan darah diukur dengan menggunakan sphygmomanometer manakala kecergasan kardiorespiratori ditentukan dengan menggunakan ujian larian ulang-alik 20m berperingkat.

KEPUTUSAN: BMI para pelajar diklasifikasikan menurut klasifikasi BMI untuk masyarakat Asia dan dua kumpulan telah dikenalpassti iaitu kumpulan jisim badan kekurangan (n= 10) dan kumpulan jisim badan normal (n= 25). Antara dua kumpulan BMI tersebut terdapat perbezaan signifikan pada, jsim badan ($p = 0.001$, $eta^2 = 0.297$), peratusan lemak badan ($p < 0.001$, $eta^2 = 0.442$), ukur lilit pinggang ($p = 0.004$, $eta^2 = 0.225$), ukur lilit pinggul $p = 0.006$, $eta^2 = 0.208$), dan kadar denyutan jantung maksima ($p = 0.001$, $eta^2 = 0.301$). Manakala, tiada perbezaan signifikan diperhatikan pada nisbah pinggang kepada pinggul $p = 0.225$, $eta^2 = 0.044$) dan kecergasan kardiorepiratori ($p = 0.348$, $eta^2 = 0.027$).

KESIMPULAN: Kedua-dua kumpulan BMI, kumpulan jisim badan kekurangan dan jisim badan normal mempunyai peratusan lemak badan yang tinggi dan puncak VO_2 yang rendah daripada nilai yang disyorkan. Keputusan kajian ini menyokong dan mengembangkan keputusan kajian-kajian lepas iaitu, masyarakat Asia mempunyai peratusan lemak badan yang tinggi berbanding dengan orang putih pada paras BMI yang sama.

ABSTRACT

OBEJECTIVE: To describe and compare the health-related physical fitness of young females based on body mass index (BMI) classifications.

METHODS: Anthropometric indices, including height, weight, waist and hip circumferences were assessed in a cross-sectional study of 35 healthy female undergraduate students aged 20-22 years. Blood pressure was measured using a sphygmomanometer, while cardiorespiratory fitness (CRF) was estimated using the 20m multi-stage fitness test.

RESULTS: The BMI of the students was classified according to cut-off points for Asians and two groups were identified: underweight (n= 10) and normal weight (n= 25). Between the BMI groups, weight ($p = 0.001$, $eta^2 = 0.297$), percent body fat ($p < 0.001$, $eta^2 = 0.442$), waist girth ($p = 0.004$, $eta^2 = 0.225$), hip circumference ($p = 0.006$, $eta^2 = 0.208$), and maximum heart rate ($p = 0.001$, $eta^2 = 0.301$) were significantly different. However, there was no difference in height ($p = 0.390$, $eta^2 = 0.022$), waist-to-hip ratio ($p = 0.225$, $eta^2 = 0.044$) and aerobic fitness ($p = 0.348$, $eta^2 = 0.027$).

CONCLUSIONS: Both underweight and normal weight groups had a higher percent body fat and lower VO_2 peak than the recommended levels. These results support and extend previous studies that Asians have a higher body fat percentage at the same BMI level as Caucasians.

CHAPTER I

INTRODUCTION

"Health is a reflection of your ability to use the intrinsic and extrinsic resources related to each dimension of health to participate fully in activities that contribute to your growth and development, with the goal of feeling a sense of well-being as you evaluate your progress through life" (Payne et al., 2005: p. 21). This definition deviates from that of the general public who assumes good health to be the absence of sickness or disease only (Jackson, 1999; Payne et al., 2005). Physical fitness refers to "the total dynamic physiological state of the individual ranging on a continuum from optimal human performance to severe debilitation and death" (Hazeldine, 1985: p. 3). It can simply be understood as the degree to which someone is suitable for a particular situation or purpose. A combination of health and physical fitness is also known as health-related fitness. It is one aspect of fitness that is focused on areas affecting health and our ability to perform daily tasks and activities. The components of health-related physical fitness are cardiorespiratory fitness (CRF), morphological, musculoskeletal, motor and metabolic fitness (Jackson, 1999; Shephard, 1994).

1.2. BACKGROUND OF THE STUDY

Today, obesity is the major cause of negatively affecting one's health and fitness. According to the World Health Organization, obesity is defined as "an abnormal and excessive fat accumulation that may be hazardous to health" (WHO, 2000). It is an excess of subcutaneous fat in proportion to lean body mass, which is caused by an increase in the size and number of adipose tissue (Payne et al., 2005).

Once the amount of fat in the body exceeds the normal physiological limit, it causes a negative impact on health-related fitness such as hypertension, hypercholesterolemia, type-2-diabetes mellitus, cardiac infarction, certain cancers, sleep apnea, infertility and osteoarthritis and other orthopedic disorders (Payne et al., 2005; WHO, 2000)

The prevalence of obesity among the world population is one of the most problematic epidemics. Each year the statistic in both developed and developing countries increases. Today, there are approximately 1 billion adults, who are overweight and at least 300 million of them are clinically obese (WHO, 2008). Childhood obesity has increased over the years. According to the WHO (2008), global comparable estimates showed that Cook Islands, Nauru, Niue, Federated States of Micronesia, and Tonga were the top five countries which were identified as having the highest prevalence of obesity in their populations (WHO, 2008).

The scenario in Asia is different, where the double burden of under- and over-nutrition exerts different pressures on public health. In some countries, under nutrition predominates, while in others, such as China, Japan, Malaysia and Singapore, where the state of socioeconomic transition is more advanced, the prevalence of obesity and overweight is rising at an alarming rate (Florentino, 2002). In China, for instance, the prevalence of obesity is reported to be 28.9% in 2001 where 22.7% of males and 27.2% of females were obese (WHO, 2008). Bell et al. (2002) described motorized transportation as one of the factors contributing to obesity in China. Even though Japan is undergoing a fast socioeconomic transition in the region compared to other countries in Asia, the prevalence of obesity is the lowest (WHO, 2008).

Globally, obesity and overweight are more prevalent in females than in males (WHO, 2000). In a national survey conducted in United States, women were found to have a higher prevalence of obesity compared to men (Brown et al., 2000). Kelly (2007) reported that among African-American collegiate students, females (49%) were more obese than males (11%). Despite socioeconomic differences, Pimenta et al. (2008) showed that obesity is more prevalent among females than in males in a rural Brazilian population.

The situation in Asia seems to be similar. Erem et al. (2004) also reported comparable findings in Turkey, where the prevalence of obesity was higher in women (29.4%) than in men (16.5%). In Philippines, the prevalence of overweight and obesity among women increased nearly sixfold, over sixteen years of rapid socioeconomic changes (Adair, 2004). In 2000, China reported approximately 99 million women whom were classified as overweight and obese (Kristi et al., 2007). Cuong et al. (2007) reported that

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prevalence of overweight and obesity in females (33.6%) in Ho Chi Minh City, Vietnam, was slightly higher than in males (31.6%).

In Malaysia, The Third National Health and Morbidity Survey (NHMS III) in 2006, reported that the prevalence of overweight (BMI 25.0-29.9 kg/m^2) had increased to 29.1% compared to 16.6% in the Second Health and Morbidity Survey (NHMS II) in 1996 (Noor Safiza et. al, 2008). Of the adults, who participated in the Survey, 29.1% and 14.0% were classified as overweight and obese, respectively (BMI > 30 Kg/m^2) (Noor Safiza et. al, 2008). In addition, women were reported to have a higher prevalence of obesity (17.4%) compared to men (10.0%) (Noor Safiza et. al, 2008). Among the ethnic groups, Indians and Malays had a higher rate of overweight and obesity compared to Chinese (Noor Safiza et. al, 2008). However, the percentage of underweight (BMI < 18.5 Kg/m^2) in NHMS III is lower (8.5%) compared to the previous NHMS (25.2%) (Noor Safiza et. al, 2008.

Ismail et al. (1995) showed that even though the percentage of overweight in Malaysian males and females was similar, the percentage of obese grade II was higher in females. Ismail et al. (1995) also showed that the prevalence of obesity in urban areas in 1991-94 was 29% (including 5% of obese grade II) for males and 26 % (including 8% of obese grade II) for females. Narayanan and Khan (2007) reported the same trend for rural areas, where 24.3% of males were overweight and 12.4%, obese, while 27.3% of females were overweight and 21.2% obese. Rampal et al. (2007) showed that the prevalence of overweight in urban areas was 10.6% in males and 6.0% in females. The Malays ranked highest with 10.7% being overweight, followed by the Indians (7.1%) and Chinese (5.9%).

Contrary to studies on overweight and obesity relative to health-related risks in Asia, those on underweight and normal weight subjects are scarce. For instance, Khan (2007) reported more fat in normal weight Malaysian females but no difference in blood pressure. In Korean female adolescents with a BMI of 20.2, 53% had a waist circumference equal to or larger than the 90^{th} percentile (Lee, 2008). Stevens (2003) suggested that for a BMI of 20 to less than 22, the risk of diabetes in white women was 1.38 when compared to those with a BMI < 20.

1.3. PROBLEM STATEMENT

Although overweight and obesity in Malaysia have been studied before, there is a lack of information relative to being underweight and normal weight and their health-related fitness correlates. Thus, this study is conducted to assess health and fitness among female undergraduate students as they are related to being underweight and normal weight.

1.4. RESEARCH QUESTION

Does being underweight and normal weight have consequences for health-related fitness?

1.5. LIMITATIONS

Limitations of this study include variability in the association of BMI, waist-to-hip ratio, body fat percentage and blood pressure by heredity, diet and exercise, which are known to influence them. Since the subject pool was small and not population based, generalizations are not warranted. Observations from this study are limited to females of similar age. Although the shuttle run was found to be reliable and valid in predicting VO_2 peak (Leger and Lambert, 1982), direct and more precise measurements to estimate aerobic fitness would have enhanced the internal validity of this study.

1.6. ASSUMPTIONS

Since participants of this study did not undergo medical examination, the researcher assumed that all the subjects were in good mental and physical health.

1.7. SIGNIFICANCE OF THE STUDY

Several studies have shown that low cardiorespiratory fitness (CRF) and anatomical distribution of fat were risk factors for cardiovascular disease morbidity and mortality (Miller et al., 2005; Li et al., 2006). Chang et al. (2000) reported that central obesity in Chinese women was one of the independent and significant cardiovascular disease risk

factors. However, less is known about the effect of being underweight or normal weight on health-related physical fitness. In addition, a similar study has not been conducted in Malaysia.

1.8. OPERATIONAL DEFINITIONS

1. "Body composition is the relative amount of body fat and lean body tissue. Body composition is interchangeably used with percent body fat" (Jackson, 1999: p. 6).

2. Cardiorespiratory fitness is defined as "circulatory and respiratory systems that affect the ability to persist in strenuous tasks or moderate to vigorous activities for extended periods of time" (Jackson, 1999: p. 6).

3. Arterial Blood Pressure / Blood Pressure (BP)

   "Lateral pressure exerted by the contained column of blood on the wall of arteries when the blood flows through the arteries" (Sembulingam and Sembulingam, 2004: p. 492).

4. Systolic blood pressure (SBP)

   "Maximum pressure exerted in the arteries during the systole (contraction) of the heart. The normal SBP is 120 mm Hg and it ranges between 110 and 140 mm Hg" (Sembulingam and Sembulingam, 2004: p. 492).

5. Diastolic blood pressure (DBP)

"Minimum pressure exerted in the arteries during the diastole (relaxation) of the heart. The normal value of DBP is 80mm Hg and it varies between 60 and 80 mm Hg". (Sembulingam and Sembulingam, 2004: pp. 492).

6. Hypertension

Systolic blood pressure $\geq$ 140 mm Hg and diastolic blood pressure $\geq$ 90 mm Hg (Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure, 2004)

7. Waist-to-Hip ratio (WHR)

Waist circumference divided by hip circumference. Females with a WHR of $\geq$ 0.8 and males with a WHR of $\geq$ 0.9 are at risk of obesity-related comorbidities, which are increased at these cut-off points (Inoue and Zimmet, 2005).

CHAPTER II

LITERATURE REVIEW

2.1. HYPERTENSION

One of the major obesity-related health hazards is hypertension. Table 1 displays the classification of blood pressure for adults as defined by the Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure (2004).

Category	Systolic (mm Hg)		Diastolic (mm Hg)
Normal	<120	and	<80
Pre-hypertension	120-139	or	80-89
Stage 1 Hypertension	140-159	or	90-99
Stage 2 Hypertension	≥160	or	≥100

Table 1: Classification of blood pressure for adults as defined by Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure (2004)

There is a strong relationship between obesity and hypertension, irrespective of age, gender and race (Chen et al., 2006). Brown et al (2000) reported in a national survey in United States that body mass index (BMI) and mean systolic and diastolic blood pressure have a positive relationship in both genders regardless of ethnicity and age. Even though the positive association between blood pressure and BMI is present in all age groups, the relationship was steeper in younger age groups. Women who are younger than 60 years old and with a BMI $\geq$ 27 had a higher prevalence of hypertension compared to women with a BMI of $<$ 25 (Brown et al., 2000).

The Third Health and Nutrition Examination Survey in United States showed that being overweight ($25 \leq$ BMI ≥ 29.99) had no significant association with hypertension (Okusan et al., 2001). However, Harris et al. (2000), who studied white and African American men and women aged between 45 and 64 years, reported that participants with hypertension had a higher BMI compared with non-hypertensive counterparts. Pimenta et al. (2008) showed that body fat percentage had a positive relationship with hypertension in a rural population in Brazil.

Normal weight (BMI=21.8) first year female students from South Africa recorded a systolic blood pressure (SBP) of 101 mmHg, which was classified as normal. However, 1.7% of the total sample was considered to have high SBP ($\geq$ 130 mmHg). Diastolic blood pressure (DBP) of the females was 60 mmHg, while 1.9% was considered to have high DBP ($\geq$ 85 mmHg) (Cilliers et al., 2006).

2.2. CARDIORESPIRATORY FITNESS (CRF)

Several studies have shown that low physical fitness and physical activities are independent predictors in overweight and obese people (Deforche et al., 2003; Nordin et al., n.d.; Ortega et al., 2007). For instance, Fogelholm et al. (2006) reported impaired CRF as a negative consequence of obesity. Duvigneaud et al. (2008) studied Flemish youth and observed that BMI and CRF negatively correlated in both males and females. Loftin et al. (2001) reported that obese girls had a higher percentage of body fat and relatively low max VO_2 compared to the normal weight girls.

Ekelund et al. (2004) observed that max VO_2 in both Swedish male and female obese adolescents was lower than that of the normal weight group peers. A report on Spanish adolescents showed overweight and obese participants to both have lower CRF and daily physical activity (Ortega et al., 2007). Deforche et al. (2003) revealed that obese Flemish school children aged 12-18 years performed worse in the shuttle run and sports index compared with their non-obese counterparts in all age groups. The modified Baecke Questionnaire was used to estimate physical activity which resulted in two indices reflecting physical activity during sport (sport index) and during leisure time excluding sport (leisure time index). Grassi et al. (2006) observed that Italian adolescents with a higher BMI had a relatively low CRF.

Increased body weight has a negative relationship with aerobic endurance (Chen et al., 2006; Nakhostin-Roohi et al., 2008; Pua et al., 2006). The 1992-2002 National Health

and Nutritional Survey showed that cardiorespiratory fitness among those aged 12-19 years in United States youth was lower among the at risk of overweight (males: 43.5 ± 0.6 ml/kg.min; females: 37.6 ± 0.7 ml/kg.min) and obese groups (males: 41.6 ± 1.0 ml/kg.min; females: 35.9 ± 0.6ml/kg.min ml/kg.min) independent of ethnicity (Pate et al., 2006). Normal weight adolescent Spanish girls with a BMI of 21.5 recorded a peak VO_2 of 42.1 ± 8.0 ml/kg/min (Ortega et al., 2007).

2.3. FAT DISTRIBUTION

Besides percentage of body fat, anatomical fat distribution also has a significant effect on hypertension. Accumulation of fat around the trunk and abdominal areas is known as central obesity (Pieter, 2001a; WHO 2000), indicating increased visceral adipose tissue which is metabolically more active, releasing free fatty acids, adipokines and cytokines and leading to glucose tolerance and insulin resistance (Malnick and Knobler, 2006; Pieter, 2001a). According to Pi-Sunyer (2002), men are more likely to have abdominal or upper body obesity, while women are more likely to have gluteofemoral or lower body obesity. However, as women gain weight they also develop abdominal and upper body obesity similar to men (Pi-Sunyer, 2002).

Numerous longitudinal studies reported that abdominal obesity is independently associated with a higher risk of developing hypertension (Ghosh and Bandyopadhyay, 2007; Pimenta et al., 2008). Although there are many sophisticated methods to measure

abdominal fat, such as computed tomography (CT), dual-energy x-ray absorptiometry (DEXA) and magnetic resonance imaging (MRI), the waist circumference was found to be an accurate field measure of abdominal fat (Payne et al., 2005). Several studies revealed a positive linear association between adiposity and blood pressure, where the risk of hypertension was increased in both obese and centrally obese individuals (Bose et al., 2003; Doll et al., 2002). Hence, many researchers have investigated the waist circumference in relation to hypertension. Waist circumferences of more than 102 cm for men and 88 cm for women are classified as centrally obese for Caucasians (Inoue and Zimmet, 2000; Payne et al., 2005; WHO, 2000).

2.3.1. WAIST CIRCUMFERENCE (WC)

Chan et al. (2003) showed that WC is a better predictor for distribution of fat compared to BMI or waist-to-hip ratio (WHR). Abdominal obesity was found to be the most powerful phenotype associated with hypertension comorbidity in women (Okusan et al., 2001). The Atherosclerosis Risk in Communities Study (ARIC) reported that BMI had a positive and high correlation with WC in both African American and white men and women (Harris et al., 2000).

Janssen et al. (2002) observed that participants with high BMI readings were more likely to have a WC within the high range. 71.6% and 97.5% of women in the overweight and the obese class I categories, respectively, had a WC within the high range. In addition,

27.6% and 84.8% of the men in the overweight and obese class I group, respectively, had a WC within the high range. Besides, participants within the BMI sub-group with a WC in the high range (men, >102 cm; women, > 88 cm) were more likely to have higher blood pressure compared with the other sub-groups with a lower range of WC (men, ≤ 102 cm; women, ≤ 88 cm).

Doll et al. (2002) found that both BMI and WC were moderately but statistically significantly correlated with blood pressure in both developing and developed countries (Seychelles Island and Switzerland) independent of age. An increase of 1.7 kg/m^2 in BMI and of 4.5cm in WC in men and of 1.25 kg/ m^2 in BMI and 2.5cm of WC in women causes an increase of 1 mm Hg in SBP. Pimenta et al. (2008) reported that WC had a positive association with hypertension in a rural Brazilian population in both genders.

2.3.2. WAIST-TO-HIP RATIO (WHR)

Other than waist circumference, waist-to-hip ratio (WHR) is also a good indicator of visceral adipose tissue. A WHR ≥1.0 in men and ≥ 0.85 in women were classified as centrally obese (Payne et al., 2005; WHO, 2000) in Caucasians. In a study on a Caribbean population, 65.9% of women had a WHR higher than the recommended level (WHR ≥ 0.80) compared to men (WHR ≥ 0.95) with only 24.6% (Grievink et al., 2004). Researchers also found that the waist-to-hip ratio is superior to BMI and has a significant association with cardiovascular disease (CVD) (De Koning et al., 2007; Li et al., 2006). Harris et al.

(2000) reported that BMI and WHR were moderately correlated in both men and women. Doll et al. (2002) revealed that the WHR had a modest but significant correlation with blood pressure. An increase of 1.7 kg/m^2 in BMI and of 3.4% in WHR in men and of 1.25 kg/ m^2 in BMI and 1.8% of WHR in women causes an increase of 1 mm Hg in SBP.

American women with a WHR < 0.80 had a BMI of 24.3, while those with a WHR ≥ 0.80 recorded a BMI of 28.0 (Ricciardi et al., 2009). Tehranian women 18-34 years increased their WHR with age but their BMI remained constant between 35-74 years (Mirmiran et al., 2004).

2.4. FAT DISTRIBUTION AND CRF

2.4.1. WAIST CIRCUMFERENCE AND CRF

A study of African-American and whites using DEXA and abdominal CT scans showed that youth with low CRF had higher visceral and adipose tissue compared to moderate and high CRF youth in both genders (Lee and Arslanian, 2007). Similar results were also observed in young Finnish adult men, where the WC was used as a surrogate for abdominal adiposity (Fogelholm et al., 2006). Duvigneaud et al. (2008) reported a negative relationship as well between WC and CRF in Flemish youth.

Ortega et al. (2007) revealed that after adjusting for age, maturation and other confounding factors, adolescents (age 13 to 18.5 years) with moderate and high levels of CRF showed a negative relationship with abdominal adiposity in both genders.

2.4.2. WAIST-TO-HIP RATIO AND CRF

Jetté et al. (1992) reported that Canadian women with higher cardiorespiratory fitness were younger (38.9 years) compared to those with moderate (40.3 years) and low fitness levels (40.4 years) and they had a significantly lower WHR compared to the other two groups.

2.5. HEALTH-RELATED FITNESS HAZARDS IN ASIA

Most of the research about health-related fitness hazards is based on data from Western societies. Although the scenario is similar in Asia, the concern is that Asians are facing health-related adverse effects at a lower BMI level (He et al., 2001). Deurenberg et al. (2003) and Chang et al. (2003) revealed that for a given BMI, Asians have a higher percentage of body fat compared to Caucasians, which was also confirmed by others (Deurenberg-Yap et al., 2001; He et al., 2001; Wang et al., 1994). Besides increased body fat at a lower BMI, studies also revealed that at a lower BMI, Asians have a higher WC

(Misra et al., 2006), WHR (Pieter, 2001a), increased risk of CVD and diabetes (Snehalatha et al., 2003).

2.5.1. INDIA

Vikram et al. (2003) reported 89.2% of women with BMI < 25 kg/m^2 and WC of 73.2 cm had at least one risk factor for CVD, while 88% of the non-obese women had more than one cardiovascular risk factor. Liew et al. (2003) reported lean non-diabetic Asian Indians living in Singapore to have a lower insulin sensitivity compared to age, BMI and physical activity matched Chinese and Caucasians. Asian Indians living in Singapore also had a higher percentage body fat, waist circumference, and diastolic blood pressure, compared to Malays and Chinese despite living in a similar environment.

Large epidemiological studies also revealed that Asian Indian immigrants worldwide have a higher incidence of type-2 diabetes and coronary heart disease (Raji, Gerhard-Herman et al., 2008). Raji, Seely et al. (2008) reported normal weight healthy migrant Asian Indians in Boston were profoundly insulin resistant and hyperinsulinemic compared with age- and BMI-matched Caucasians of European origin in both genders. They also had higher subcutaneous and visceral fat than Caucasians at a lower BMI level, although the differences were not statistically significant. Raji, Gerhard-Herman et al. (2008) also revealed that normal weight non-diabetic migrant Asian Indians had increased markers of cardiovascular risk.

2.5.2. SINGAPORE

Deurenberg-Yap et al. (2001) reported 53% of women with a BMI below 25kg/m^2 and 68% of women with a WHR below the lower cut-off point (<0.85) had at least one of the five risk factors (elevated total cholesterol (TC), elevated TC/HDL ratio, elevated triglyceride, hypertension and diabetes mellitus) of CVD. In non-diabetic, normal weight women, aged 38.8 years with a BMI of 22.6 kg/m^2, insulin resistance and plasma leptin were highly correlated with generalized adiposity (BMI, total fat mass and body fat percentage), while triglyceride positively correlated with WHR (Tai et al., 2000).

2.5.3. JAPAN

Ito et al. (2004) reported that 40% of healthy Japanese with a BMI between 20 and 23.5 kg/m^2 had dyslipidemia. Since the distribution of most of the risk factors was not significant across the BMI tertiles, the authors concluded that accumulation of fat mass, especially in the upper body was related to dyslipidemia in normal weight Japanese. In females, the number of subjects with SBP ≥140 mm Hg, DBP ≥ 90 mm Hg, triglyceride and LDL-C ≥140 mg/dl, hypertension and dyslipidemia were significantly increased across the tertiles of WC and WHR compared to tertiles of BMI where less of the risks factors were significantly increased.

2.5.4. TAIWAN

Chang et al. (2003) reported that Taiwanese had a higher body fat percentage compared to Caucasians at any given BMI. Younger Taiwanese had a lower BMI but a higher body fat percentage for any BMI level in each age-stratified group (20-39, 40-59, and 60-79 years). The body fat percentage at BMI $\geq$ 25 kg/m^2 in Taiwanese is similar to that of BMI $\geq$ 30 kg/m^2 in Caucasians. The authors also reported that a body fat of 38% could be the cut-off for obesity in female Taiwanese.

2.5.5. HONG KONG

Ko et al. (2001) found that Hong Kong Chinese had higher body fat percentage despite a lower BMI level. The authors found that the corresponding BMI to the upper limit for normal body fat percentage was 22.5-23.1 kg/m^2 and the BMI corresponding to the 90th percentile of body fat percentage was 25.4-26.1 kg/m^2. Hence, BMI cut-off points of 23 kg/m^2 and 26 kg/m^2 were proposed to define overweight and obesity in Hong Kong.

2.5.6. HYPERTENSION

Chen et al. (2006) reported that overweight/obese Taiwanese children and adolescents had significantly higher systolic and diastolic blood pressure in both genders. The risk of hypertension positively correlates with weight (Czernichow et al., 2002). Studies in Asia among Ethiopian, Indonesian and Vietnamese populations reported that rural and peri-urban subjects showed a significant positive correlation between BMI and, SBP and DBP across the three countries (Tesfaye et al., 2007). SBP increased at the second BMI quintile for the Indonesians and Vietnamese in both genders. In Ethiopian men SBP increased at around the third quintile and for the Ethiopian and Vietnamese women a marked increase occurred only after the fourth quintile. DBP started to increase around the third quintile, except for the Vietnamese and Ethiopian women, where a marked increase started after the fourth BMI quintile (Tesfaye et al., 2007). This research also indicated that SBP in the three groups seemed to increase markedly at lower quintiles compared to lean populations (Tesfaye et al., 2007).

Ghosh and Bandyopadhyay (2007) in a cross-sectional study of adult Bangalee Hindu men found BMI significantly and positively correlated with blood pressure. From the National Health Survey of Pakistan, 46.3% of overweight and obese participants were classified as hypertensive (Jafar et al., 2006). In a rural Japanese population, BMI was reported to be significantly associated with blood pressure (Kawada, 2002).

2.5.7. FAT DISTRIBUTION

2.5.7.1. WAIST CIRCUMFERENCE

Erem et al. (2004) reported that central obesity was about twice as high in Turkish females (38.9%) than males (18.1%). However, there was no significant difference in waist circumference between the groups.

A study on Bengalee male jute workers aged 18 years and over showed that centrally obese individuals had significantly higher SBP and DBP compared to centrally non-obese individuals (Bose et al., 2003). Yap et al. (2006) also found the same relationship between waist circumference and blood pressure in young Chinese adults. Ghosh and Bandyopadhyay (2007) reported that WC explained 13.0% and 8.6% of the variance in SBP and DBP, respectively, in Bengalee Hindu men. In Bengaleee female undergraduate students, WC was positively correlated with SBP and DPB as opposed to BMI (Bhadra et al., 2002).

Thomas et al. (2004), reported central adiposity to contribute to a higher risk of cardiovascular diseases compared to general adiposity in Hong Kong Chinese. In non-obese subjects, cardiovascular risk factors significantly increased with increasing WC quartiles. Subjects in the fourth WC quartile had a higher chance of having hypertension, dyslipidemia and diabetes. Normal weight Chinese female women (20-24 years) showed a

WC of 0.65, which was positively associated (r = 0.71) with total body fat (Lei et al., 2006).

2.5.7.2. WAIST-TO-HIP RATIO

Since previous WHR cut-off points were based on Caucasians studies, it was suggested to use a WHR ≥0.90 in men and ≥0.80 in women as values for Asians (Inoue and Zimmet, 2000). Rosenthal et al. (2004) reported that central obesity was a stronger risk factor for diabetes than general obesity, while WHR could be a better risk indicator of diabetes than BMI in Chinese women. Chang et al. (2000) reported a significant positive association between WHR and centrality index in Chinese women. Ghosh and Bandyopadhyay (2007) showed that WHR explained 8.2% and 5.3% of the variance in SBP and DBP, respectively, in Bangalee Hindu men.

Pieter (2001a) revealed that the conicity index of Filipino obese males was higher than that of the lean, normal and obese females. There was no difference in central adiposity among lean, normal and obese females. Collapsed over gender, Pieter and Bercades (2005) reported a lower WHR (0.74) for underweight Filipino university students compared to their normal weight counterparts (0.76). Both were significantly lower than those of the overweight and obese students, whose WHR ranged from 0.80-0.84. In an earlier study, Pieter and Bercades (2003) found a WHR of 0.74 for normal weight Filipino female university students.

2.5.8. CARDIORESPIRATORY FITNESS (CRF)

Other than hypertension, CRF is also adversely affected by obesity. For instance, overweight/obese children and adolescents in Taiwan had a lower CRF compared to the normal weight individuals using a 3-minute step test to assess CRF (Chen et al., 2006). In a one-mile walk test by Iranian female college staff, subjects with elevated BMI and fat percentage tended to have lower CRF (Nakhostin-Roohi et al., 2008), while normal weight Nepalese women had a peak VO_2 of 44.88 ml/kg/min (Prajapati et al., 2008).

Bercades and Pieter (1998) revealed that Filipino obese males took a longer time to complete the 1.5-mile run, as a proxy for aerobic fitness, compared to lean and normal counterparts, while no significant difference was found in run time for females between the lean, normal and obese groups. The Filipino females scored lower peak VO_2 values than their Hong Kong Chinese counterparts (Pieter, 2001b). However, in a later study, normal weight Filipino female university students recorded peak aerobic fitness (49.1 ml/kg/min) at the pre-test that was higher than the upper limit of the Healthy Fitness Zone (35-43 ml/kg/min) (Pieter and Bercades, 2003).

2.5.9. FAT DISTRIBUTION AND CRF

2.5.9.1. WAIST CIRCUMFERENCE AND CRF

Individuals with higher visceral and subcutaneous adipose tissue also have lower CRF compared to moderate and high CRF individuals (Lee and Arslanian, 2007). Similar findings in women were apparent in the Health Care System. Pua et al. (2006) reported that of those female employees of a tertiary hospital in Singapore with a higher CRF for a given BMI also had a smaller WC.

2.5.9.1. WAIST-TO-HIP RATIO AND CRF

Pieter (2001b) showed that Filipino male and female lean and normal groups had a lower WHR and there also was a significant negative correlation between WHR and estimated peak VO_2 in both genders.

2.6. HEALTH-RELATED FITNESS HAZARDS IN MALAYSIANS

Malaysia has been undergoing a fast economic transition over the past few decades, which caused rapid social, economic and demographic changes. Dietary habits and physical activity changes have caused the risks of mortality and morbidity to increase over the