한국인의 고지혈증과 비만지표

연세대학교 보건대학원

역학 및 건강증진학과

안 진 아

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지도 서 일 교수

이 논문을 보건학석사 학위논문으로 제출함

2001년 6월 일

연세대학교 보건대학원

역학 및 건강증진학과

안 진 아

안진아의 보건학석사 학위논문을 인준함

심사위원 서 일

심사위원 남 정 모

심사위원 임 승 길

연세대학교 보건대학원

2001년 6월 일

감사의 말씀

부족한 저에게 학업의 길을 열어주시고 성취시켜 주신 하나님께 감사 드립니다. 오늘의 결실이 지식에 대한 헛된 욕심으로 그치지 않고 겸허한 마음으로 이웃을 위해 봉사할 수 있는 발판이 되기를 바라면서 이 논문이 완성되기까지 도와주신 모든 분들께 감사를 드립니다.

논문의 시작부터 방향을 지도해주시고 영어로 작성되기까지 이끌어 주신 존경하는 서일 교수님께 먼저 깊은 감사를 드립니다. 바쁘신 중에도 좋은 논문이 되도록 처음부터 끝까지 세심하게 도와 주신 남정모 교수님 그리고 임상적인 측면에서 많은 조언을 주신 임승길 교수님께 감사 드립니다. 또한 자료를 구할 수 있도록 협조해 주신 한국보건사회연구원에 신창우 선생님께 감사 드립니다.

그동안 대학원 과정에서 저에게 가르침을 주신 존경하는 교수님들과 학생의 신분으로 만나 서로를 격려하며 용기를 북돋아 주었던 역학 및 건강증진학과의 원우들 그리고 항상 친절하게 도와주셨던 교학과 선생님들께도 모두 깊은 감사를 드립니다.

저를 위해 기도해주신 저의 교회의 고등부 선생님들과 아이들, 의료선교회 회원들, 그리고 멀리 있는 가족들에게 감사 드립니다.

끝으로 만학으로 꿈을 키워가는 아내를 곁에서 인내로 지켜준 남편과 부족한 엄마를 위하여 기도하는 사랑하는 사라와 이삭 그리고 사무엘에게 감사하는 마음으로 이 논문을 바치고 싶습니다.

2001 년 6 월
안진아 올림

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국문요약

본 연구는 1998년 한국보건사회연구원에서 실시한 국민건강 영양조사의 자료를 기초로 한국인의 비만의 실태에 관해 알아보았으며 비만지표를 이용하여 과체중 및 비만과 심혈관계 질환의 원인이 되는 고지혈증과의 관련성을 파악하였다. 이에 특정 비만지표와 혈청지질의 수치와 관련성이 있는지를 알아보고 한국인의 고지혈증을 가장 잘 예측할 수 있는 비만지표를 확인하였다.

본 연구의 대상자는 국민건강 영양조사를 받은 대상자 9771명 중에서 혈청지질검사와 보건의식행태의 면접을 받은 대상자를 선택하였다. 그 중 임산부 67명 및 높은 백혈구 수치 등의 outliers를 제외하고 만 20세에서 79세의 남자 3444명과 여자 4174명으로 총 7618명의 검진자료를 기초로 실시되었다.

본 연구에서는 비만지표로 흔히 쓰이는 체 질량지수, 허리둘레, 및 허리와 둔부둘레의 비와 혈청지질의 수준과의 관련성을 파악하고 이들 중에서 어떠한 비만지표가 고지혈증을 가장 잘 예측할 수 있는지를 분석하였다. 또한 비만과 밀접한 관련이 있으며 심혈관계질환의 주요 위험 요인인 혈청지질의 수치를 Total Cholesterol (TC), High Density Lipoprotein Cholesterol (HDL-cholesterol), Low Density Lipoprotein Cholesterol (LDL-cholesterol), Triglycerides (TG), TC/HDL-cholesterol ratio, TG/HDL-cholesterol ratio로 나타내었으며 그 수치에 대한 기준은 미국의 국립보건원 (National Institutes of Health)에서 제시한 성인을 위한 콜레스테롤 교육지침서를 참고로 구분하였다.

이 연구는 심혈관계의 지표인 고지혈증의 사정(assess) 및 관리에 필요한

기초자료 및 건강증진을 위한 심혈관 질환의 예방프로그램의 개발을 위한 기초자료를 제공하기 위하여 실시되었으며 다음과 같은 결과를 얻었다.

1. 연구 대상자의 혈청지질의 수준을 비만지표인 체 질량지수, 허리둘레, 허리와 둔부둘레의 비에 따라서 TC, HDL-cholesterol, LDL-cholesterol, TG, TC/HDL-cholesterol ratio, TG/HDL-cholesterol ratio로 측정하였다. 각 비만지표에 따른 혈청지질의 수준은 모두 통계학적으로 유의한 차이를 나타냈다.($p<0.05$) 즉, 성별 혹은 연령과 무관하게 체 질량지수, 허리둘레, 허리/둔부둘레 비의 비만 지표들과 혈청지질의 수준이 관련이 있음을 나타냈다.

2. 국제보건기구에서 제시한 체 질량지수 및 허리둘레의 기준점에 따라서 고지혈증의 유병율을 알아 보았다. 고지혈증의 기준은 위에 언급한 콜레스테롤 교육지침서를 참고하였다. TC는 200 mg/dL 미만 (desirable), 200-239 mg/dL (borderline high), 240 mg/dL이상 (high)으로, HDL-cholesterol은 40 mg/dL 미만 (low), 40-59 mg/dL (acceptable), 60 mg/dL이상 (high) 으로, LDL-cholesterol은 100 mg/dL미만 (optimal), 100-129 mg/dL (near optimal/above optimal), 130-159 mg/dL (borderline high), 160-189 mg/dL (high), 190 mg/dL이상 (very high) 으로, triglycerides는 150 mg/dL미만 (normal), 150-199 mg/dL (borderline high), 200-499 mg/dL (high), 500 mg/dL이상 (very high)의 수준으로 구분되어 분석되었다. 연구 대상자 가운데 체 질량지수가 35kg/m^2 이상 혹은 TG가 500 mg/dL이상인 대상자는 없었다. 그러나 체 질량지수가 정상범위에 속하면서 혈청지질의 수준은 정상 범위를 벗어난 대상자들이 있음을 확인하였다.

3. 정상 범위로 간주되는 체 질량지수인 18.5kg/m^2 에서 25kg/m^2 미만에 해당하는 대상자 가운데 TC의 위험경계수준인 200-239 mg/dL를 나타내는 대상자는 남녀 각각 23.2%, 23.8% 였으며 240 mg/dL이상은 각각 5.5%, 7.7%로 나타났다. HDL-cholesterol에서도 40 mg/dL 미만인 대상자는 남녀 각각 21.3%, 15.3% 였으며, LDL-cholesterol의 수치에서는 위험경계수준에 해당하는 대상자는 남녀 각각 17.9%, 18.2%였으며 위험수준은 5.6%, 7.6%로 나타났다. TG는 남녀 각각 위험경계수준에서 18.8% 12.8%, 위험수준은 12.6%, 5.8%로 나타났다.

4. 허리둘레의 정상범위인 남자 102cm이하, 여자 88cm이하에서 TC가 위험수준을 나타내는 대상자는 남녀 각각 25.4%, 23.6%였으며 위험경계수준은 7.7%, 7.5%였다. HDL-cholesterol에서는 40mg/dL미만이 남녀 각각 24.8%, 14.8%였으며 LDL-cholesterol에서는 남녀 각각 위험경계수준에서 19.9%, 18.2%였으며 고 위험수준은 각각 7.4%, 7.5%를 나타냈다. TG의 위험경계수준에서는 남녀 각각 20.9%, 12.3%였으며, 위험수준은 남녀 각각 15.4%, 5.8%를 나타냈다.

5. 허리와 둔부둘레의 비에서는 남자는 0.9이하, 여자는 0.8이하를 정상범위로 분석하였다. 이 기준에서 TC의 위험수준에 대한 유병율은 남녀 각각 24.2%, 20.9%가 위험경계수준에서는 6.8%, 4.8%가 각각 높은 수준으로 나타났다. HDL-cholesterol에서는 40 mg/dL미만이 남녀 각각 23.6%, 12.1%를 나타냈으며 LDL-cholesterol에서는 남녀 각각 위험경계수준에서 18.7%, 16.0%를 나타냈으며 고위험수준은 각각 6.8%, 4.5%를 나타냈다. TG의

위험경계수준은 남녀 각각 19.6%, 8.7%를, 위험수준은 남녀 각각 14.0%, 3.7%를 나타냈다.

6. 어떤 종류의 비만지표가 고지혈증을 가장 잘 예측할 수 있는지를 파악하기 위하여 로지스틱 회귀분석을 실시하였다. 고지혈증에 영향을 미치는 요인들을 파악하기 위하여 유의한 관련성을 나타내는 체 질량지수, 허리둘레, 허리/둔부둘레의 비를 회귀모형에 첨가하였다. 연령에 따라서 비만지표와 혈청지질의 관련성에 차이가 있는지를 확인하기 위하여 연령을 20세 단위로 구분하여 로지스틱 회귀분석을 실시하였다. 표준편차가 1 증가 할 때에 비차비를 구하기 위해서 각 비만지표를 표준편차로 나누어서 분석하였다.

고지혈증의 기준은 TC를 200 mg/dL이상, HDL-cholesterol을 40 mg/dL 미만, LDL-cholesterol을 100 mg/dL 이상, triglycerides를 150 mg/dL이상으로 정했다. 그 결과 성별과 연령에 따라서 혈청지질을 예측하는 비만지표의 종류가 차이가 있었다. 남자에서는 60세 이전에 체 질량지수와 허리둘레가 혈청지질과 관련이 많았으며 여자에서는 60세 이전에 TG와 허리둘레와 허리/둔부둘레의 비와 관련이 많은 것으로 나타났다.

따라서 본 연구 결과에서는 체 질량지수, 허리둘레 및 허리/둔부둘레의 비가 혈청지질과 관련이 있는 것으로 나타났으며 이들 비만지표는 혈청지질을 예측할 수 있는 것으로 나타났다. 고지혈증을 예측할 수 있는 비만지표로는 연령에 따라서 다소 차이가 있었으나 남자에서는 체 질량지수와 허리둘레와 관련이 있었으며 여자에서는 허리둘레와 허리/둔부둘레의 비와 유의한 관련성을 나타냈다.

향후 이에 대한 보다 체계적이고 반복적인 연구가 계속 이루어져야 하겠으나 몸무게와 키 이외에 간단하면서도 경제적인 허리둘레와 둔부둘레의 측정은 심혈관질환의 위험요인을 예측하기 위한 건강 사정도구에 항상 포함되어져야 할 것을 제언한다. 또한 한국인을 위한 비만지표의 기준 설정을 위하여 심혈관계 질환과 같은 만성질환의 유병율을 기준으로 할 것인지 혹은 그와 관련된 사망율이 기준이 되어야 할 것인지 국민의 건강을 위해서 가장 적절한 기준설정을 위하여 보다 체계적인 연구가 지속적으로 이루어져야 할 것이다.

I. Introduction

Obesity can be defined as a disease in which excess body fat has accumulated such that health may be adversely affected (Kopelman, 2000). The prevalence of obesity has increased substantially over the past 2-3 decades in developed and developing countries (Hodge, 1994; Seidell, 1999). The health impact of weight gain is so marked that obesity has now been classified as a major global public health problem (WHO, 1998). Obesity is now so common within the world’s population that it is beginning to replace nutrition and infectious diseases as the most significant contributor to ill health (Kopelman, 2000). The presence of overweight and obesity in a patient is of medical concern because it increases the risk for several diseases, particularly cardiovascular diseases and diabetes mellitus, certain forms of cancer, and sleep-breathing disorders (Ford, 1997), and it increases all-cause mortality (NHLBI, 1998). In addition to suffering poor health and increased risk of illnesses, obese individuals may also suffer from social stigmatization and discrimination. Therefore, obesity should no longer be regarded simply as a cosmetic problem affecting certain individuals, but an epidemic that threatens global well-being (Kopelman, 2000). Yet, it is unclear whether the relationship between adiposity indices and cardiovascular risk factors observed in predominantly obese individuals also apply to a population of lean Koreans.

Based on body mass index defined by the World Health Organization, the prevalent rates of overweight and obesity are 23.89% of men and 2.37 % of women in Korea (MHSW, 1999) and about 35% of men and 26% of women (NHANES, 1998) in the United States. There is a difference in the frequency and prevalence rates of obesity between Koreans and American adults, particularly in a body mass index of greater than 30 kg/m^2 (obesity) category.

Unfortunately, scant data are available on the association between adiposity indices and cardiovascular risk factors, such as blood lipids among the general population of Koreans. From literature reviews, majority of the studies conducted was based on individual medical facility or on small sample sizes. Not many studies were conducted based on data collected on the national population.

Therefore, this study was conducted to identify the relationship between adiposity indices and blood lipid concentrations in Korean adults. The measures for the adiposity indices were body mass index, waist circumference, and waist/hip ratio. This study used the categories of each adiposity index determined by the World Health Organization. The result of this study will provide a set of baseline epidemiological data that can be used to develop basic educational materials for a prevention program of cardiovascular diseases for health promotion.

The objectives of this study are:

First; To identify the distribution of serum lipid levels of the study population by the adiposity indices and age.

Second; To identify the prevalence rates of hyperlipidemia of the study population by the adiposity indices.

Third; To determine the adiposity indices that predict hyperlipidemia the most.

II. Theoretical Background

1. Obesity

Obesity is associated with a significant increase in morbidity and mortality and is a major public health problem. Obesity is defined as excessive accumulation of body fat, usually caused by the consumption of more calories than the body can use. The excess calories are then stored as fat, or adipose tissue (Britannica, 2000). Obesity is a complex, multifactorial disease that develops from the interaction between genotype and the environment. Our understanding of how and why obesity occurs is incomplete; however, it involves the integration of social, behavioral, cultural, physiological, metabolic, and genetic factors (NRC, 1989). For reasons that are not fully known, obesity is associated with an increased risk of hypertension, heart disease, diabetes and cancer. Obesity is largely preventable through changes in lifestyle (Gibbs, 1996). Even modest weight loss ameliorates these associated conditions.

Throughout most of human history, a wide girth has been viewed as a sign of healthy and prosperity. It seems both ironic and fitting that corpulence now poses a growing threat to the health of many inhabitants of the richest nations (Gibbs, 1996). In many countries more than half the population is overweight and levels of obesity are rising rapidly. Recent estimates suggest around 250 million people world-wide are obese; the World Health Organization estimates at least 300 million will be obese by 2025 (WHO, 2000).

The causes of obesity are many, but there is little doubt that genetic factors play an important role in its etiology. Humans carry probably dozens of genes that are directly related to body size. If a specific gene plays a role in the determination of a given phenotype, the gene and the phenotype will be transmitted together across generations. The fact that the etiology of obesity is so complex underscores the need for better understanding of genetic determinants as a basis for more rational interventions to treat obesity.

The discovery of leptin, a natural hormone that cures gross obesity when injected into mutant mice that lack it, raised hopes of a better quick fix. However, those hopes faded, as subsequent studies have found that no fat people share the leptin-related mutations seen in mice. But the identification of leptin is only one of many important advances over the past several years that have opened a new chapter in the understanding of obesity. Chromosomal sites of genes responsible for several rare familiar human obesity syndromes have been identified, but none to date has been linked to obesity in the general population. Although multiple genetic influences on obesity phenotypes are suggested, in most cases, the responsible gene variants, their pathophysiological effects, and their interactions with other genes and environmental factors remain to be determined.

Environmental as well as genetic factors greatly affect the expression of obesity across the lifespan. The relative contribution of each of these factors to the phenotypic variance of obesity is not fully understood. Knowledge of the non-genetic determinants of obesity-cardiovascular disease (CVD) risk factor clustering is essential for planning effective multidisciplinary interventions focused on primary prevention of CVD (Krauss, 1998).

Today, public health experts are encouraged to play a greater role in the management of obesity. Many health care providers are seeking guidance in effective methods of treatment (NHLBI, 1998).

2. Obesity and Hyperlipidemia

Obesity is a chronic disease whose successful treatment requires a lifelong effort. Therefore, obesity poses a major public health challenge (Kuczmarski, 1997). In addition, obesity is significant as a risk factor for serious noncommunicable diseases, including cardiovascular disease (CVD), hypertension and stroke, diabetes mellitus, and various forms of cancer (WHO, 2001). In overweight patients, control of cardiovascular risk factors deserves the same emphasis as weight loss therapy. Reduction of risk factors will reduce the risk for CVD, whether or not weight loss efforts are successful. In overweight and obese persons weight loss is recommended to accomplish lower elevated levels of total cholesterol, LDL-cholesterol, and triglycerides, and raise low levels of HDL-cholesterol in those with dyslipidemia (NHLBI, 1998).

Hyperlipidemia is associated with an increased prevalence of cardiovascular disease (Ushiroyama, 1993) and is defined as an excess of fats or lipids in the blood (American Heritage Dictionary, 2000) or as an undesirable level of plasma lipids. The major lipids are cholesterol and triglycerides (TG), which are transported in the plasma by lipoproteins. Hyperlipidemia is a strong risk factor for the development of atherosclerosis. Therefore, lowering cholesterol is fundamental in reducing the morbidity and mortality from coronary artery disease (CAD), particularly in high risk patients. Treatment of hyperlipidemia involves primary prevention (identification and treatment of elevated lipids in patients without documented CAD) and secondary prevention (treatment of patients with documented atherosclerotic cardiovascular disease).

The link between total serum cholesterol and CHD is largely due to low-density lipoprotein (LDL). A high risk LDL-cholesterol is defined as a serum concentration of greater than or equal to 160 mg/dL (ATP III). This lipoprotein is the predominant atherogenic lipoprotein and is therefore the primary target of cholesterol-lowering therapy. Cross-sectional data suggest that LDL-cholesterol levels are higher by 10 to 20 mg/dL in relation to a 10 unit difference in BMI, from levels of 20 to 30 kg/m^2 (Denke, 1994). Changes in LDL-cholesterol roughly parallel the changes in serum cholesterol but that changes in high-density lipoprotein cholesterol (Hegsted, 1993). A study suggested that calculation of low-density lipoprotein-cholesterol, although less accurate than desirable, is the only way of evaluating this in clinical practice because total cholesterol alone may be misleading in the assignment of coronary heart disease risk (Branchi et al, 1994).

Obesity is commonly accompanied by elevated serum triglycerides. Triglycerides are generally higher in obese persons and are associated with weight gain. Triglyceride-rich lipoproteins may be directly atherogenic, and they are also the most common manifestation of the atherogenic lipoprotein phenotype (high triglycerides, small LDL particles, and low HDL-cholesterol levels) (NIH, 1993). In the presence of obesity, high serum triglycerides are commonly associated with a clustering of metabolic risk factors known as the metabolic syndrome. Thus, in obese patients, elevated serum triglycerides are a marker for increased cardiovascular risk (NHLBI, 1998). And high plasma TG and low HDL-cholesterol levels have been documented in Asian Indians worldwide (Yagalla, 1996).

The strong association of triglycerides levels with BMI has been shown in both cross-sectional and longitudinal studies, for both sexes and all age groups (Denke, 1988). In a study, three adult age groups, 20 to 44, 45 to 59, and 60 to 74 years, higher levels of BMI, ranging from 21 kg/m^2 or less to more than 30 kg/m^2, have been associated with increasing triglycerides levels; the difference in triglycerides ranged from 61 to 65 mg/dL in women (Denke, 1994) and 62 to 118 mg/dL in men (Denke, 1993).

There is a study that emphasized the importance of considering high-density lipoprotein cholesterol when assessing coronary heart disease risk (Freedman, 1994). The study suggested that even at levels of total and low-density lipoprotein cholesterol considered desirable, high-density lipoprotein cholesterol was inversely related to disease severity. Men with low levels of both LDL-cholesterol (< 110 mg/dL) and HDL-cholesterol (≤ 30 mg/dL) had as much occlusive coronary artery disease as did men with high levels of both lipoprotein fractions. In contrast, a study on lipids and coronary artery disease (CAD) in women showed that neither serum total cholesterol nor triglycerides levels had any correlation with the presence of CAD. The mean total/high-density lipoprotein (HDL) cholesterol ratio was higher among women with CAD than without CAD. In women with total cholesterol less than 200 mg/dl, the mean total/HDL-cholesterol ratio was higher in women with CAD than without CAD. Higher total/HDL-cholesterol ratio was the variable most predictive of the presence of CAD (Hong, 1991).

In a smaller sample, higher body weight is associated with higher levels of total serum cholesterol in both men (Denke, 1993) and women (Denke, 1994) at levels of BMI>25 kg/m^2. Several large longitudinal studies also provide evidence that overweight, obesity and weight gain are associated with increased cholesterol levels (Ashley, 1981). In women, the incidence of hypercholesterolemia also increases with increasing BMI (Manson, 1990). In addition, the pattern of fat distribution appears to affect cholesterol levels independently of total weight. Total cholesterol levels are usually higher in persons with predominant abdominal obesity, defined as a waist to hip circumference ratio of greater than 0.8 for women and greater than 1.0 for men (Reeder, 1992).

Abnormal lipid values can sometimes have genetic causes and, in these cases, may not respond to weight loss. However, blood lipid levels are often abnormal in obese persons. The protective high density lipoprotein cholesterol is lower in obese persons. HDL-cholesterol levels at all ages and weights are lower in men than in women. Low HDL-cholesterol in this study is defined as <35 mg/dL in men and <45 mg/dL in women. Cross-sectional studies have reported that HDL-cholesterol levels are lower in men and women with higher BMI (Glueck, 1980). Longitudinal studies have found that changes in BMI are associated with changes in HDL-cholesterol. A BMI change of one unit is associated with an HDL-cholesterol change of 1.1 mg/dL for young adult men and 0.69 mg/dL for young adult women (Anderson, 1987).

A study of young adults 18-30 years of age found that body mass index was positively and significantly associated with total cholesterol and low density lipoprotein cholesterol and inversely associated with high density lipoprotein cholesterol across all race-sex groups (Horn, 1991). A study on plasma lipids and lipoproteins in elderly Japanese-American men reported that total cholesterol tended to significantly increase with increasing body mass index but was not significantly related with systolic blood pressure, cigarettes per day, or alcohol intake. Among those variables HDL-cholesterol decreased significantly with increasing body mass index (Curb, 1986).

A study showed that the lowering of LDL-cholesterol was significantly affected by BMI in women but not in men. Also the lowering of LDL-cholesterol had no effect on the waist-hip ratio in men (Hannah, 1997). According to extensive epidemiological data, a 10 mg/dL rise in LDL-cholesterol corresponds to approximately a 10 percent increase in CHD risk over a period of 5 to 10 years (Law, 1994).

A cross sectional study reported that lower waist to hip ratio was associated with higher levels of high-density lipoprotein cholesterol and lower levels of low-density lipoprotein cholesterol. The study also suggested that use of waist to hip ratio in the primary prevention of coronary heart disease is a simple and cost-effective measure to predict development of abnormal lipoprotein profiles in young men (Mansfield, 1999). The study reported that the waist to hip ratio showed the highest correlations with the cardiovascular risk factors in women, but no consistent pattern was found for males (Yasmin, 2000).

The complete lipoprotein profile is thought to give more information about the individual risk of coronary heart disease than total cholesterol alone. Although total cholesterol has a low sensitivity in the correct assessment of the risk of coronary heart disease, it may be of value in screening programs because of its low cost (Branchi, 1994). Little is known about the relative ability of different measures of change in cholesterol to assess coronary heart disease risk. It also suggested that clinicians selecting treatments for intervention should include among their considerations the treatment's effect on both LDL and HDL-cholesterol rather than their effects on LDL-cholesterol levels alone (Kinosian, 1995).

Based on the literature review, obesity is related to plasma lipids and their relationship with a variety of different aspects. However, scant data are available from studies conducted in Korean

III. Research Methods

1. Research Framework

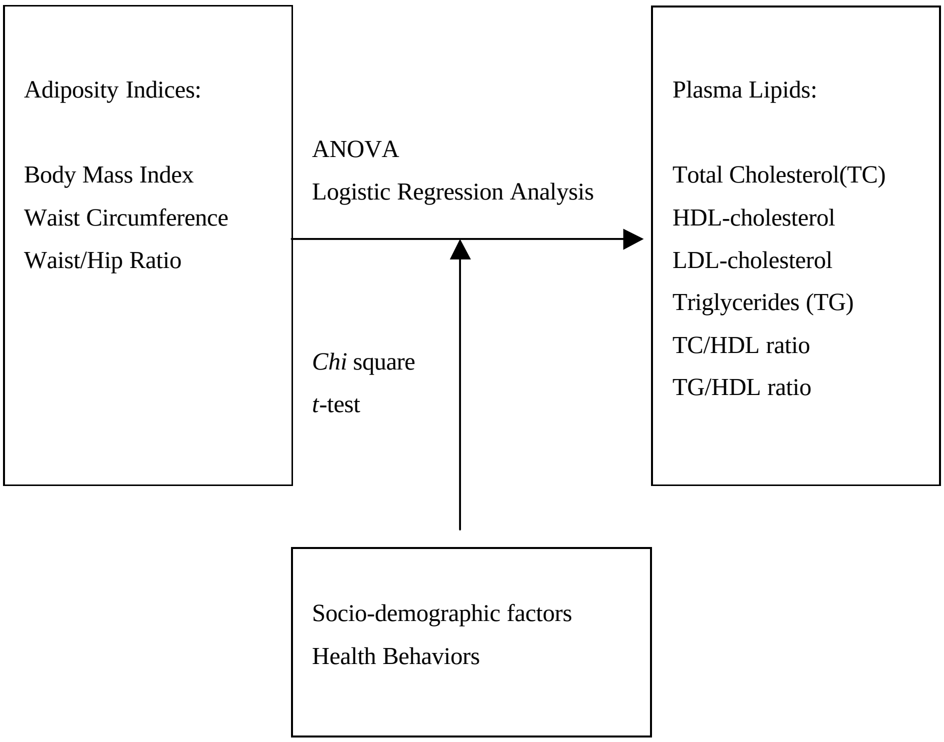

Figure 1. Research Framework

2. Study Population and Measures

This cross-sectional study was designed to identify the prevalence of hyperlipidemia according to adiposity indices and to determine the relationship between adiposity indices and hyperlipidemia. The subjects included 7618 cases, 20-79 years old, who received a health examination, including lipid profiles, and interviewed on health behavior components during a nation-wide Health and Nutrition Examination Survey in 1998. The sample was selected from the actual people who were surveyed, excluding pregnant women and those who showed high white blood cell count that might cause an artifact of the study result.

The Korea Institute for Health and Social Affairs (KIHSA) performed a National Health and Nutrition Examination Survey in November 1998 (KIHSA, 1998). In 1998, a nutrition surveillance component was added and the survey name was changed to the National Health and Nutrition Examination Survey, which was based on the Health Promotion Law revised in 1995. The purpose of the survey was to collect the total prevalence of certain chronic diseases as well as the distributions of various physical and physiological measures, including serum lipid levels and blood pressures.

The survey design was a multistage, stratified probability sample of clusters of persons in land-based segments. The sample areas consisted of 200 primary sampling units (clusters of households) from the 200 geographic units excluding islands. The trained technicians collected all data from the subjects, and the data were aggregated and coded accordingly by the KIHSA.

The purpose and the procedures of the National Health and Nutrition Examination Survey conducted in Korea were similar to that conducted in the United States.

3. Statistical Analysis

The Statistical Analysis System (SAS), a statistical package program, was used for analysis of the data. This study applied chi-square, t-test and ANOVA to obtain frequencies, mean, standard deviation, and differences between means of serum lipids to obtain the baseline characteristics of the study population. Body mass index, waist/hip ratio, total cholesterol/HDL-cholesterol, and triglycerides/HDL-cholesterol ratios were calculated based on the data collected.

This study applied the cutoff points from the World Health Organization to measure the body mass index, waist circumference, and waist/hip ratio. Total cholesterol, high density lipoprotein cholesterol, low density lipoprotein cholesterol and triglycerides were categorized according to the National Cholesterol Education Program, Clinical Practice Guidelines on the prevention and management of high cholesterol in adults (ATP III). Logistic Regression Analysis was used to identify the independent variables that predict the level of the plasma lipids the most. The Logistic Regression model included age, body mass index, waist circumference, waist/hip ratio, amount of smoking, systolic and diastolic blood pressures and fasting blood glucose to control the effects of confounders.

Ⅳ. Results

1. Baseline Characteristics

Table 1. Baseline Characteristics of Study Population

Baseline Characteristics	Unit	Men N=3,444	Women N=4,174
		Mean±SD	Mean±SD
Age	Year	44.3 ±14.8	45.1 ±15.8
Height	cm	168.6 ±6.3	155.8 ±6.3
Weight	kg	65.9 ±10.0	56.4 ±8.7
BMI	kg/m^2	23.1 ±3.0	23.2 ±3.3
Waist circumference	cm	82.9 ±8.5	78.4 ±9.6
Hip circumference	cm	93.5 ±6.4	93.4 ±6.8
Waist to Hip Ratio	ratio	0.9 ±0.1	0.8 ±0.1
Systolic blood pressure	mmHg	128.0 ±18.3	124.1 ±21.0
Diastolic blood pressure	mmHg	80.9 ±11.9	76.4 ±12.2
Total cholesterol	mg/dL	187.4 ±36.7	188.5 ±37.6
HDL-cholesterol	mg/dL	48.1 ±12.4	51.5 ±12.5
LDL-cholesterol	mg/dL	112.0 ±33.8	114.7 ±33.6
Triglycerides	mg/dL	136.4 ±65.9	111.6 ±55.4
TC/HDL ratio	ratio	4.1 ±1.3	3.9 ±1.2
TG/HDL ratio	Ratio	3.1 ±1.0	2.4 ±1.6
Fasting blood glucose	mg/dL	102.0 ±31.0	100.8 ±32.9

BMI; Body Mass Index , WHR; Waist to Hip Ratio, TC; Total Cholesterol, HDL-cholesterol; High Density Lipoprotein cholesterol, LDL-cholesterol; Low Density Lipoprotein cholesterol, TG; Triglycerides

Table 1 shows the baseline characteristics of the study population age 20 to 79 years old. As shown in the table, the mean BMI was 23.1 kg/m ^{2} ±3.0 for men and 23.2 kg/m ^{2} ±3.3 for women. The mean of Waist circumference was 82.9± 8.5 for men and 78.4±9.6 for women. Both measures were less than the reference cutoff points of risk measures (102 cm for men and 88 cm for women) from the World Health Organization. The mean of waist to hip ratio was 0.9±0.1 for men and 0.8±0.1 for women and both showed average ranges.

The mean of plasma lipid levels and ratios are shown in the table 1. The mean of total cholesterol was 187.4±36.7 for men and 188.5±37.6 for women. The mean of high density lipoprotein cholesterol was 48.1±12.4 for men and 51.5±12.5 for women. The mean of low density lipoprotein cholesterol was 112.0±33.8 for men and 114.7±33.6 for women. The mean of triglycerides was 136.4±65.9 for men and 111.6±55.4 for women.

The total cholesterol to high density lipoprotein ratio did not meet the optimal ratio of 3.5 recommended by the American Heart Association. However, the mean ratio in both gender showed below 5.0. The mean of total cholesterol/high density lipoprotein cholesterol ratio for men and women were 4.1±1.3 and 3.9±1.2 respectively. In addition, the mean of triglycerides/high density lipoprotein cholesterol ratio was 3.1±1.0 for men and 2.4±1.6 for women.

Table 2. Plasma Lipid Levels of the Study Population by Age Group for Men

Age (year)	N	Plasma Lipids					
		TC Mean(SD)	TG Mean(SD)	HDL Mean(SD)	LDL Mean(SD)	TCHR Mean(SD)	TGHR Mean(SD)
20-29	621	174.0(33.7)	115.0(58.2)	49.1(11.0)	102.0(30.9)	3.7(1.1)	2.6(1.7)
30-39	891	187.2(36.7)	136.5(64.1)	46.7(11.7)	113.1(32.8)	4.2(1.2)	3.2(1.9)
40-49	741	194.7(35.9)	152.7(72.6)	47.4(12.5)	116.7(34.2)	4.4(1.3)	3.6(2.3)
50-59	552	193.4(36.5)	143.5(62.9)	48.7(12.5)	116.0(34.7)	4.2(1.2)	3.2(1.9)
60-69	431	188.6(38.2)	135.1(65.8)	49.6(13.9)	111.9(35.8)	4.1(1.3)	3.0(1.9)
70-79	184	184.7(34.8)	124.7(59.3)	50.0(14.4)	109.8(31.5)	4.0(1.3)	2.9(2.1)
	F value	26.37*	25.37*	5.85*	16.18*	21.42*	19.72*

* $p < 0.05$, TC; Total Cholesterol TG; Triglycerides HDL; High Density Lipoprotein Cholesterol LDL; Low Density Lipoproteing Cholesterol TCHR; Total Cholesterol to HDL-cholesterol Ratio TGHR; Total Cholesterol to LDL-cholesterol Ratio

As shown in the tables 2 and 3, changes in lipid and lipoprotein concentrations occurred with age and increased the risk of developing cardiovascular disease. The plasma total cholesterol, triglycerides and LDL-cholesterol concentrations increased progressively in men, reaching peak values between 40 to 49 years of age, and declining slightly thereafter. In women, the total cholesterol increased throughout their lifetime. HDL-cholesterol concentrations decreased in men during the ages of 30-39 years, and increased thereafter. In women, HDL-cholesterol concentration decreased progressively throughout their lifetime.

Table 3. Plasma Lipid Levels of the Study Population by Age Group for Women

Age (year)	N	TC Mean(SD)	TG Mean(SD)	HDL Mean(SD)	LDL Mean(SD)	TCHR Mean(SD)	TGHR Mean(SD)
		Plasma Lipids					
20-29	767	170.4(33.0)	89.1(46.8)	54.8(12.9)	97.8(28.6)	3.3(0.9)	1.8(1.3)
30-39	1013	176.0(31.0)	94.9(47.5)	52.6(11.9)	104.4(27.5)	3.5(1.0)	2.0(1.4)
40-49	836	186.5(33.3)	109.8(53.2)	50.9(12.0)	113.6(29.8)	3.8(1.0)	2.4(1.6)
50-59	668	205.4(37.1)	129.2(56.5)	50.6(12.6)	128.9(33.9)	4.3(1.2)	2.8(1.8)
60-69	541	208.4(37.9)	141.4(59.3)	48.6(12.7)	131.5(34.8)	4.5(1.3)	3.2(1.8)
70-79	281	209.2(39.4)	136.2(53.1)	48.5(11.9)	133.5(35.7)	4.5(1.3)	3.1(1.7)
	F value	158.65*	112.68*	22.69*	149.94*	154.31*	88.42*

* $p < 0.05$, TC; Total Cholesterol TG; Triglycerides HDL; High Density Lipoprotein Cholesterol LDL; Low Density Lipoproteing Cholesterol TCHR; Total Cholesterol to HDL-cholesterol Ratio TGHR; Total Cholesterol to LDL-cholesterol Ratio

2. Plasma Lipid Levels by the Adiposity Indices

The mean of each plasma lipids and their ratios statistically showed a significant difference by the categories of body mass index, waist circumference and waist/hip circumference ratio in both gender (Table 4 and 5). In this study, the desirable or optimal ranges of the plasma lipids were based on the National Education Clinical Practice Guidelines and the levels for total cholesterol was below 200 mg/dL, HDL-cholesterol below 40 mg/dL cholesterol below 100 mg/dL, and triglycerides below 150 mg/dL. The average adiposity indices based on guidelines from the World Health Organization were body mass index, 18.5-24.9 kg/m2; waist circumference equal or less than 102 cm for men and 88cm for women; and waist/hip ratio equal or less than 0.9 for men and 0.8 for women.

Table 4. Plasma Lipid Levels of the Study Population by the Adiposity Indices for Men

	(N)	TC Mean(SD)	HDL Mean(SD)	LDL Mean(SD)	TG Mean(SD)	TCHR Mean(SD)	TGHR Mean(SD)
Body Mass Index							
<18.5	156	170.1(33.2)	53.5(15.1)	95.2(31.1)	107.2(50.0)	3.4(1.0)	2.2(1.5)
18.5-24.9	2395	183.5(35.4)	49.4(12.6)	108.4(32.4)	128.3(62.9)	3.9(1.2)	2.9(1.8)
25.0-29.9	833	200.4(37.3)	44.0(10.0)	124.1(34.2)	161.7(68.5)	4.8(1.3)	4.0(2.1)
≥ 30.0	60	206.9(35.0)	40.5(7.5)	130.0(33.8)	181.9(63.2)	5.3(1.3)	4.8(2.4)
F value		64.74*	59.28*	66.83*	77.54*	141.32*	94.05*
Waist Circumference							
≤ 102	3395	187.1(36.6)	48.2(12.4)	111.7(33.6)	135.8(65.5)	4.1(1.3)	3.1(2.0)
> 102	49	206.6(41.4)	42.8(7.2)	128.8(38.1)	175.2(78.4)	4.9(1.2)	4.3(2.2)
F value		13.70*	9.25*	12.35*	17.36*	21.37*	16.33*
Waist/Hip Ratio							
≤ 0.9	2930	185.3(35.8)	48.6(12.4)	110.4(33.0)	131.6(63.3)	4.0(1.2)	3.0(1.9)
> 0.9	514	199.2(39.5)	45.2(11.6)	121.5(36.6)	163.8(73.3)	4.6(1.4)	4.0(2.3)
F value		63.31*	32.38*	44.88*	107.66*	108.35*	111.48*

* $p < 0.05$, TC; Total Cholesterol, TG; Triglycerides, HDL; High Density Lipoprotein Cholesterol, LDL; Low Density Lipoproteing Cholesterol, TCHR; Total Cholesterol to HDL-cholesterol Ratio, TGHR; Total Cholesterol to LDL-cholesterol Ratio

Based on the criteria, both men and women in the normal range of BMI, with the exception of LDL-cholesterol, showed acceptable plasma lipid concentrations.

In contrast, those who were in overweight and obesity categories of BMI, showed normal range of plasma lipid concentrations in HDL-cholesterol (greater than 40 mg/dL). Men in a risk category of waist/hip ratio (greater than 0.9) showed acceptable levels of total cholesterol (199.2 mg/dL). Women in an overweight category, a BMI of 25-29.9 kg/m^2, also showed acceptable levels of total cholesterol (198.5 mg/dL).

In the overweight and obesity categories, women showed normal ranges of triglycerides (less than 150 mg/dL), whereas, men in those categories showed borderline high level of triglycerides.

Overall, men showed normal ranges of HDL-cholesterol concentrations regardless of adiposity index categories, whereas women showed normal ranges of HDL-cholesterol and TG concentrations. However, with both men and women, as the BMI, waist circumference, and waist/hip ratio increased, the LDL-cholesterol, TC/HDL-cholesterol and TG/HDL-cholesterol ratios increased while the HDL-cholesterol decreased.

Table 5. Plasma Lipid Levels of the Study Population by the Adiposity Indices for Women

	(N)	TC Mean(SD)	HDL Mean(SD)	LDL Mean(SD)	TG Mean(SD)	TCHR Mean(SD)	TGHR Mean(SD)
Body Mass Index							
<18.5	214	175.0(33.3)	57.2(13.1)	100.2(29.2)	87.9(42.9)	3.2(0.8)	1.7(1.0)
18.5-24.9	2777	185.1(37.0)	52.4(12.6)	111.6(32.9)	105.6(53.6)	3.7(1.1)	2.3(1.6)
25.0-29.9	1050	198.6(37.7)	48.5(11.3)	124.3(33.7)	129.0(57.0)	4.3(1.2)	2.9(1.7)
≥ 30.0	133	202.7(34.2)	46.5(10.5)	128.4(31.5)	139.1(55.2)	4.5(1.2)	3.2(1.7)
F value		49.98*	48.93*	59.68*	72.89*	104.48*	68.62*
Waist Circumference							
≤ 88	3495	185.0(36.5)	52.3(12.6)	111.6(32.5)	105.6(52.8)	3.7(1.1)	2.3(1.6)
> 88	679	206.9(37.6)	47.3(11.1)	131.1(34.1)	142.6(58.7)	4.6(1.2)	3.3(1.8)
F value		202.71*	92.91*	200.99*	270.22*	319.35*	236.68*
Waist/Hip Ratio							
≤ 0.8	2388	179.6(34.0)	53.8(12.7)	106.7(30.0)	95.8(46.9)	3.5(1.0)	2.0(1.4)
> 0.8	1786	200.5(38.8)	48.4(11.5)	125.5(35.1)	132.8(58.8)	4.3(1.2)	3.0(1.8)
F value		342.54*	194.33*	347.88*	513.32*	587.52*	448.60*

* $p < 0.05$, TC; Total Cholesterol, TG; Triglycerides, HDL; High Density Lipoprotein Cholesterol, LDL; Low Density Lipoproteing Cholesterol, TCHR; Total Cholesterol to HDL-cholesterol Ratio, TGHR; Total Cholesterol to LDL-cholesterol Ratio

3. Prevalence Rates of Hyperlipidemia by the Adiposity Indices

Prevalence rates of hyperlipidemia are shown in the table 6 for men and table 7 for women. This study used the Adult Treatment Panel III to determine the criteria of the hyperlipidemia. Regardless of gender, there was a significant difference ($p<0.05$) in prevalence rates by the categories of adiposity indices used in this study.

Table 6. Prevalence of Hyperlipidemia by Adiposity Indices for Men (unit: mg/dL)

	Total Cholesterol			HDL-Cholesterol			LDL-Cholesterol			Triglycerides		
	<200	≥200	total	<40	≥40	total	<100	≥100	total	<150	≥150	total
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
BMI												
<18.5	121 (80.1)	30 (19.9)	151 (100)	26 (17.2)	125 (82.8)	151 (100)	85 (56.3)	66 (43.7)	151 (100)	122 (80.8)	29 (19.2)	151 (100)
18.5 -24.9	1693 (71.2)	685 (28.8)	2378 (100)	507 (21.3)	1871 (78.7)	2378 (100)	971 (40.8)	1470 (59.2)	2378 (100)	1631 (68.6)	747 (31.4)	2378 (100)
25.0 -29.9	440 (53.0)	391 (47.0)	831 (100)	292 (35.1)	539 (64.9)	831 (100)	205 (24.7)	626 (75.3)	831 (100)	395 (47.5)	436 (52.5)	831 (100)
≥ 30.0	24 (40.0)	36 (60.0)	60 (100)	25 (41.7)	35 (58.3)	60 (100)	11 (18.3)	49 (81.7)	60 (100)	19 (31.7)	41 (68.3)	60 (100)
x^2		123.7*			76.8*			102.0*			163.4*	
WC												
≤ 102	2257 (67.0)	1114 (33.0)	3371 (100)	837 (24.8)	2534 (75.2)	3371 (100)	1261 (37.4)	2110 (62.6)	3371 (100)	2148 (63.7)	1223 (36.3)	3371 (100)
> 102	21 (42.9)	28 (57.1)	49 (100)	13 (26.5)	36 (73.5)	49 (100)	11 (22.5)	38 (77.5)	49 (100)	19 (38.8)	30 (61.2)	49 (100)
x^2		12.6*			0.08			4.6*			12.9*	
WHR												
≤ 0.9	2007 (68.9)	905 (31.1)	2912 (100)	687 (23.6)	2225 (76.4)	2912 (100)	1137 (39.1)	1775 (60.9)	545 (100)	1933 (66.4)	979 (33.6)	2912 (100)
> 0.9	271 (53.4)	237 (46.6)	508 (100)	163 (32.1)	345 (67.9)	508 (100)	135 (26.6)	373 (73.3)	508 (100)	234 (46.1)	274 (53.9)	508 (100)
x^2		47.2*			16.7*			28.8*			76.9*	

* $p<0.05$, BMI; Body Mass Index, WC; Waist Circumference, WHR; Waist to Hip Ratio.

As the value of the BMI increased, the plasma lipid concentrations increased; however, a BMI in the normal range of 18.5-24.9 kg/m ^{2}, there was no clear cut effect of hyperlipidemia. The result showed that the prevalence rates of hyperlipidemia at a normal range of BMI was 28.8% for total cholesterol, 21.3% for HDL-cholesterol, 59.2% for LDL-cholesterol, 31.4% for triglycerides for men; and 31.5% for total cholesterol, 15.3% for HDL-cholesterol, 61.4% for LDL-cholesterol, 18.6% for triglycerides for women.

Waist circumference and waist/hip ratio of normal ranges showed prevalence of hyperlipidemia. Prevalence rates of men and women within the normal range of the waist circumference showed levels of total cholesterol, 33.0% and 31.1%; HDL-cholesterol, 24.8% and 14.8%; LDL-cholesterol, 62.6% and 61.3%; and triglycerides, 36.3% and 18.0% respectively. Prevalence rates of men and women within the normal range of the waist/hip ratio showed levels of total cholesterol, 31.1% and 25.7%; HDL-cholesterol, 23.6% and 12.1%; LDL-cholesterol, 60.9% and 55.8%; and triglycerides, 33.6% and 12.4% respectively.

Whether the categories of the adiposity indices are good predictors remains to be determined. However, these result provided distribution of prevalence rates of hyperlipidemia by each adiposity index category for use in further systemic studies.

Table 7. Prevalence of Hyperlipidemia by Adiposity Indices for Women (unit: mg/dL)

	Total Cholesterol			HDL-Cholesterol			LDL-Cholesterol			Triglycerides		
	<200	≥200	total	<40	≥40	total	<100	≥100	total	<150	≥150	total
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
BMI												
<18.5	164 (82.0)	36 (18.0)	200 (100)	10 (5.0)	190 (95.0)	200 (100)	108 (54.0)	92 (46.0)	200 (100)	181 (90.5)	19 (9.5)	200 (100)
18.5-24.9	1873 (68.5)	861 (31.5)	2734 (100)	418 (15.3)	2316 (84.7)	2734 (100)	1056 (38.6)	1678 (61.4)	2734 (100)	2226 (81.4)	508 (18.6)	2734 (100)
25.0-29.9	570 (54.8)	471 (45.2)	1041 (100)	214 (20.6)	827 (79.4)	1041 (100)	248 (23.8)	793 (76.2)	1041 (100)	710 (68.2)	331 (31.8)	1041 (100)
≥ 30.0	65 (49.6)	66 (50.4)	131 (100)	38 (29.0)	93 (71.0)	131 (100)	23 (17.6)	108 (82.4)	131 (100)	76 (58.0)	55 (42.0)	131 (100)
x^2		101.9*			49.3*			122.3*			124.5*	
WC												
≤ 102	2369 (68.9)	1069 (31.1)	3438 (100)	507 (14.8)	2931 (85.2)	3438 (100)	1329 (38.7)	2109 (61.3)	3438 (100)	2818 (82.0)	620 (18.0)	3438 (100)
> 102	303 (45.4)	365 (54.6)	668 (100)	173 (25.9)	495 (74.1)	668 (100)	106 (15.9)	562 (84.1)	668 (100)	375 (56.1)	293 (43.9)	668 (100)
x^2		136.5*			50.3*			127.8*			215.8*	
WHR												
≤ 0.9	1752 (74.3)	607 (25.7)	2359 (100)	285 (12.1)	2074 (87.9)	2359 (100)	1043 (44.2)	1316 (55.8)	2359 (100)	2066 (87.6)	293 (12.4)	2359 (100)
> 0.9	920 (52.7)	827 (47.3)	1747 (100)	395 (22.6)	1352 (77.4)	1747 (100)	392 (22.4)	1355 (77.6)	1747 (100)	1127 (64.5)	620 (35.5)	1747 (100)
x^2		206.2*			80.5*			209.3*			308.9*	

* p<0.05, BMI; Body Mass Index, WC; Waist Circumference, WHR; Waist to Hip Ratio.

4. Relationship between Adiposity Indices and Hyperlipidemia

This study used logistic regression analysis to determine which independent variables were the best predictors of hyperlipidemia.

The cutoff points for hyperlipidemia were 200 mg/dL for total cholesterol, 40 mg/dL for HDL-cholesterol, 100 mg/dL for LDL-cholesterol, and 150 mg/dL for triglycerides. The values of body mass index, waist circumference, and waist/hip ratio were divided by their standard deviations to obtain odds ratio per one standard deviation increment. The result of the analysis shown in the table 8, 9 and 10 indicated that there were differences in predictors of hyperlipidemia by gender and age.

Table 8. Odds Ratio of Related Factors by Gender

	Total Cholesterol		HDL-Cholesterol		LDL-Cholesterol		Triglycerides	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Men								
BMI	*1.26	(1.11, 1.44)	*1.23	(1.08, 1.40)	*1.28	(1.10, 1.49)	*1.31	(1.15, 1.49)
WC	*1.32	(1.13, 1.55)	*1.28	(1.09, 1.51)	*1.37	(1.14, 1.64)	*1.35	(1.15, 1.57)
WHR	1.15	(0.99, 1.32)	0.99	(0.85, 1.15)	1.08	(0.92, 1.28)	1.28	(1.11, 1.48)
Women								
BMI	1.01	(0.90, 1.15)	1.13	(0.98, 1.30)	1.14	(0.98, 1.32)	0.90	(0.78, 1.04)
WC	*1.42	(1.21, 1.67)	1.19	(0.99, 1.43)	*1.35	(1.10, 1.64)	*1.69	(1.40, 2.03)
WHR	*1.42	(1.25, 1.61)	*1.31	(1.14, 1.51)	*1.52	(1.30, 1.77)	*1.69	(1.46, 1.96)

* $p < 0.05$, BMI; Body Mass Index, WC; Waist Circumference, WHR; Waist/Hip Ratio, OR; Odds Ratio, CI; Confidence Interval

The models included all ages of the study population and were stratified into categories of 20-39, 40-59 and 60-79 years of age as well. The result of the analysis showed that it tended to have more association with BMI and waist circumference in men, whereas in women with waist circumference and waist/hip ratio. Odds ratio by age grouped in increments of twenty, from 20 to 79 years old was measured. The result showed that men tended to show more association with BMI in those who were below 60 years of age, whereas women showed statistical association with waist circumference and waist/hip ratio.

In men, the association with BMI showed in the category of 40-59 years of age, and with waist circumference in the category of 20-39 years of age. In women, the association with waist circumference and waist/hip ratio tended to associate with triglycerides, and in the category of 40-59 years of age showed an association with waist/hip ratio.

Table 9. Odds Ratio of Related Factors by Age Group for Men

	Total Cholesterol		HDL-Cholesterol		LDL-Cholesterol		Triglycerides	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Age 20-39								
BMI	*1.39	(1.13, 1.71)	1.17	(0.96, 1.43)	1.18	(0.94, 1.47)	*1.41	(1.15, 1.72)
WC	1.23	(0.97, 1.58)	*1.39	(1.09, 1.78)	*1.54	(1.18, 2.00)	*1.56	(1.23, 1.99)
WHR	*1.37	(1.10, 1.71)	1.01	(0.81, 1.26)	1.15	(0.92, 1.44)	1.08	(0.87, 1.35)
Age 40-59								
BMI	*1.42	(1.16, 1.73)	*1.37	(1.11, 1.69)	*1.62	(1.26, 2.08)	*1.36	(1.11, 1.68)
WC	1.19	(0.93, 1.51)	1.23	(0.95, 1.59)	1.19	(0.88, 1.60)	1.12	(0.87, 1.43)
WHR	0.90	(0.71, 1.14)	0.89	(0.68, 1.15)	0.77	(0.57, 1.05)	1.20	(0.94, 1.52)
Age 60-79								
BMI	0.99	(0.71, 1.38)	1.12	(0.79, 1.58)	1.36	(0.92, 2.01)	1.00	(0.71, 1.42)
WC	*1.92	(1.28, 2.88)	1.23	(0.82, 1.85)	1.25	(0.80, 1.98)	1.30	(0.86, 1.96)
WHR	*0.69	(0.48, 0.99)	1.14	(0.78, 1.65)	0.96	(0.63, 1.45)	*2.06	(1.41, 3.00)

* $p < 0.05$, BMI; Body Mass Index, WC; Waist Circumference, WHR; Waist/Hip Ratio, OR; Odds Ratio, CI; Confidence Interval

As shown in table 9, the category of 20-39 years of age showed statistical significance with BMI and TC, 1.39 (1.13 - 1.71); and TG, 1.41 (1.15-1.72); with waist circumference and HDL-cholesterol, 1.39 (1.09-1.78); LDL-cholesterol, 1.54 (1.18-2.00); and TG, 1.56 (1.23-1.99).

The category of 40-59 years of age showed statistical significance with BMI and TC, 1.42 (1.16-1.73); HDL-cholesterol, 1.37 (1.11-1.69); LDL-cholesterol, 1.62

(1.26-2.08); and TG, 1.36 (1.11-1.68).

In women, as shown in table 10, the categories of 20-39 and 40-59 years of age, a statistical significance was showed between waist circumference and TG, 1.60 (1.11-2.29) and 1.92 (1.45-2.53), respectively. In the category of 20-39 years of age, there was a statistical significance with waist/hip ratio and TG, 1.62 (1.17-2.23). In the category of 40-59 years of age, there was statistical significance with waist/hip ratio and TC, 1.29 (1.08-1.55); LDL-cholesterol,

Table 10. Odds Ratio of Related Factors by Age Group for Women

	Total Cholesterol		HDL-Cholesterol		LDL-Cholesterol		Triglycerides	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Age 20-39								
BMI	1.17	(0.94, 1.46)	*1.42	(1.11, 1.82)	*1.28	(1.04, 1.57)	1.03	(0.79, 1.33)
WC	1.35	(0.99, 1.85)	1.01	(0.71, 1.44)	1.17	(0.88, 1.55)	*1.60	(1.11, 2.29)
WHR	1.01	(0.77, 1.31)	1.24	(0.92, 1.68)	1.15	(0.92, 1.45)	*1.62	(1.17, 2.23)
Age 40-59								
BMI	1.09	(0.89, 1.32)	1.13	(0.90, 1.42)	1.08	(0.84, 1.40)	0.81	(0.65, 1.01)
WC	1.19	(0.93, 1.53)	1.18	(0.88, 1.57)	1.18	(0.84, 1.66)	*1.92	(1.45, 2.53)
WHR	*1.29	(1.08, 1.55)	1.11	(0.90, 1.36)	*1.52	(1.15, 2.00)	*1.35	(1.11, 1.64)
Age 60-79								
BMI	1.16	(0.89, 1.51)	1.04	(0.78, 1.38)	*1.64	(1.05, 2.58)	1.15	(0.88, 1.50)
WC	1.10	(0.78, 1.55)	1.05	(0.73, 1.52)	0.98	(0.55, 1.77)	1.03	(0.72, 1.45)
WHR	1.11	(0.84, 1.47)	*1.50	(1.10, 2.05)	1.18	(0.74, 1.89)	*1.88	(1.40, 2.53)

* $p < 0.05$, BMI; Body Mass Index, WC; Waist Circumference, WHR; Waist/Hip Ratio, OR; Odds Ratio, CI; Confidence Interval

V. Discussion

1. Research Methods

This study was done to identify and determine the relationship between adiposity indices and hyperlipidemia of the target population. Also the results of the study was compared to the NHANES III data of the United States.

The purpose of the study was to provide basic epidemiologic data for health care providers to manage hyperlipidemia and to develop health promotion related educational materials that relate risk factors to cardiovascular disease.

The study sample was based on the result of the Korea National Health and Nutrition Survey conducted by the Korean Health and Social Affair Institutes and Korea Health and Welfare Department in 1998. The study population was selected from the surveyed population, 20-79 years old who were examined for plasma lipid profiles and interviewed for health behaviors component. The total number of the study population was 7618 cases.

Statistical analysis was conducted with *chi* square, t-test, ANOVA and logistic regression analysis in order to identify the biological and sociodemographic characteristics such as gender and age that may affect the degree of adiposity indices, and relationship between adiposity indices and hyperlipidemia.

Strengths of this study include its application of standardized measures of anthropometry and use of the nation-wide population that was a well-stratified sample. In addition, this study sample included many part of Korea, which made it appropriate to generalize about results to Korea. There are scant data available that were studied on relationship between adiposity indices and their relationship with cardiovascular risk factors or comparison of the result with other country. In terms of the cutpoint criteria, standardized measures for the indices from World Health Organization and National Institutes of Health were used. Therefore, use of the study results can be expanded to the international.

Limitations of this study include the errors that may result from indirect data collection by the trained surveyor, and errors that may result from the physical examination and coding process. In addition, adiposity indices used in this study, body mass index, waist circumference, waist/hip ratio, only approximates the distribution of adipose tissue. However, other measures that can more accurately assess visceral adipose mass were impractical for field epidemiology.

Overweight and obesity are risk factors not only for cardiovascular disease, but also for other chronic diseases. Since there is no clear-cut definition of overweight and obesity for the Korean population, this study result can be used for further studies to define ‘obesity’ when it is a characteristic of concern Koreans.

2. Research Results

1) Plasma Lipid Levels

This study measured total cholesterol, HDL (high density lipoprotein) cholesterol, LDL (low density lipoprotein) cholesterol, triglycerides, total cholesterol/HDL-cholesterol ratio, and triglycerides/HDL-cholesterol among plasma lipids.

The mean of plasma lipids is shown in the table 1: mean of total cholesterol 187.4±36.7 mg/dL for men and 188.5±37.6 mg/dL for women; mean of high density lipoprotein cholesterol 48.1±12.4 mg/dL for men and 51.5±12.5 mg/dL for women; mean of low density lipoprotein cholesterol 112.0±33.8 mg/dL for men and 114.7±33.6 mg/dL for women; mean of triglycerides 136.4±65.9 mg/dL for men and 111.6±55.4 mg/dL for women.

The total cholesterol to HDL-cholesterol ratio did not meet the optimal ratio of 3.5 recommended by the American Heart Association. However, the mean ratio in both gender was below 5.0, which is a desirable ratio. The mean of total cholesterol/high density lipoprotein cholesterol ratio was 4.1±1.3 for men and 3.9±1.2 for women respectively. In addition, the mean of total cholesterol/HDL-cholesterol ratio was 3.1± 1.0 for men and 2.4±1.6 for women.

The mean of plasma lipids by age grouped in increments of ten, from 20 to 79 years old was measured. In men, total cholesterol, LDL-cholesterol, TG, TCHR, and TGHR tended to increase before and decrease after age 40. In women, all lipids except HDL-cholesterol increased as age increased. The result showed that the level of plasma lipids seemed to be associated with biological factors such as gender and age.

2) Prevalence of Hyperlipidemia

Prevalence rates of hyperlipidemia were shown in table 6 for men and table 7 for women. This study used the Adult Treatment Panel III (NIH, 1998) to determine the criteria of the hyperlipidemia.

Regardless of the gender of the study population, there was a significant difference ($p<0.05$) in prevalence rates by the adiposity index categories used in this study.

As the value of the BMI increased, the plasma lipid concentrations increased; however, a BMI in the normal range was no clear cut effect of hyperlipidemia. Neither the waist circumference nor waist/hip ratio had a clear cutpoint to define the hyperlipidemia.

The result showed that the prevalence rates of hyperlipidemia at a normal range, a BMI of 18.5-24.9 kg/m^2, for men, total cholesterol was 28.8%, HDL-cholesterol was 21.3%, LDL-cholesterol was 59.2%, triglycerides was 31.4%; and for women, total cholesterol 31.5%, HDL-cholesterol 15.3%, LDL-cholesterol 61.4%, triglycerides 18.6%. However, the subjects showed hyperlipidemia within optimal level of the waist circumference and men and women showed total cholesterol 33.0%, 31.1%; HDL-cholesterol 24.8%, 14.8%; LDL-cholesterol 62.6%, 61.3%;

and triglycerides 36.3%, 18.0% respectively. Within the normal range of the waist to hip ratio, the prevalence rates of the plasma lipids of men and women showed total cholesterol 31.1%, 25.7%; HDL-cholesterol 23.6%, 12.1%; LDL-cholesterol 60.9%, 55.8%; and triglycerides 33.6%, 12.4% respectively. Whether the plasma lipid levels predicted well enough by the adiposity indices remain to be determined. However, this result of prevalence rates for both genders provides the prevalence rates of the plasma lipids by each adiposity index for further systemic studies.

3) Adiposity Indices and Hyperlipidemia

This study result indicated that the mean of each plasma lipids and their ratios showed a significant difference ($p<0.5$) by the categories of body mass index, waist circumference and waist/hip circumference ratio in both genders. Initially, this study used weight, height, body mass index, waist circumference and waist/hip ratios as adiposity indices and decided to focus on those three adiposity indices since body mass index includes weight and height for its calculation. In this study, the adiposity indices categorized by the World Health Organization was used, which was body mass index below 18.5 kg/m^2, 18.5-24.9 kg/m^2 ,25.0-29.9 kg/m^2 ;30.0-34.9 kg/m^2, 35.0-39.9 kg/m^2, and greater or equal to 40 kg/m^2. And the cutoff points for the waist circumference was the equal or less than 102 cm for men and 88 cm for women; waist/hip ratio the equal or less than 0.9 for men and 0.8 for women.

The mean of BMI in men was 23.2 kg/m^2, in women 23.3 kg/m^2. There was a difference in the mean by gender and age group. The mean of BMI of men showed at age 20-29 was 21.6±3.2 kg/m^2; age 30-39, 22.8±3.2 kg/m; age 40-49, 23.9±3.0 kg/m^2; age 50-59, 24.5±3.2 kg/m^2; age 60-69, 24.1±3.3 kg/m^2; age 70-79, 23.4±3.6 kg/m^2; and by age group women showed 21.6±3.2 kg/m^2, 22.8±3.2 kg/m^2, 23.9±3.0 kg/m^2, 24.5±3.2 kg/m^2, 24.1±3.3 kg/m^2, 23.4±3.6 kg/m^2 respectively.

Collectively, there was no difference of BMI by gender; however, age 20-39, women revealed lower mean than men of that age group; age 40's there was no difference by gender; and afterwards women showed higher BMI than men.

This supports the study results that suggested no ethnicity difference in weight gain but hormone changes in women at around 40 years of age.

The mean of waist circumference was 82.9 cm for men and 78.5 cm for women. By age grouped in increments of ten, from 20-79, the mean of the waist circumference for men showed 79.4±8.6 cm, 82.9±7.8 cm, 85.2±8.5 cm, 84.6±8.0 cm, 82.9±8.6 cm, 80.3±8.6 cm; and for women 72.7±9.0 cm, 75.7±8.2 cm, 79.1±8.2 cm, 83.0±8.6 cm, 84.1±9.2 cm, 82.0±10.3 cm respectively. There was a difference in patterns of waist circumference by age group and gender. Men's waist girth increased continuously until 40's and women's until 50's and then decreased after these ages.

The mean of waist/hip circumference ratio showed 0.9 for men and 0.8 for women. The means by tens of age group, from 20-79, showed for men 0.8±0.1, 0.9±0.1, 0.9±0.1, 0.9±0.1, 0.9±0.1, 0.9±0.1, for women 0.8±0.1, 0.8±0.1, 0.8±0.1, 0.9±0.1, 0.9±0.1, 0.9±0.1 respectively. This showed a similar pattern with waist circumference, which for women's waist circumference increases until 50's and decreases afterwards. This result may well be explained by the calculation of waist to hip ratio that includes waist circumference.

The categories of plasma lipid levels were set by the National Education Clinical Practice Guidelines and each level was that total cholesterol below 200 mg/dL, HDL-cholesterol below 40 mg/dL, LDL-cholesterol below 100 mg/dL, and triglycerides below 150 mg/dL. Based on the criteria, subjects who had the adiposity indices of normal categories showed hyperlipidemia.

As a result, there was a relationship between adiposity indices and the level of the plasma lipids. The category of adipose increased, as the plasma lipid level increased. Therefore, this study used logistic regression analysis to determine the independent predictor of hyperlipidemia. The result of the analysis showed that there tended to be more association between BMI and waist circumference, and plasma lipids in men, whereas in women there was more association between waist circumference and waist/hip ratio.

4) Comparison of Prevalence Rates

The prevalence rate of overweight or obesity was compared with the NHANES III of the United States. The result from this study indicated that 28% of Korean adults are either overweight or obese. The rate was approximately 33% lower than the age-adjusted overweight estimated in the United States in 1999. Obesity greater or equal to the body mass index 30 kg/m^2 was 3%. In addition, there was a notable difference in the prevalence of overweight or obesity as shown in the Table 11. Most of this difference was attributable to the obesity rather than overweight category.

Table 11. Comparison of Prevalence Rate of Overweight (BMI 25-29.9) and Obesity (BMI ≥ 30) among Korea and U.S. adults, age 20-74

	Korea	U.S.A.	
	NHANES (1998) (n= 7618*)	NHANES III (1988-94) (n=14,468)	NHANES (1999) (n=1,446)
BMI 25.0-29.9 (Overweight)	25 %	33 %	34 %
BMI ≥ 30.0 (Obese)	3 %	23 %	27 %
(BMI ≥ 25.0) (Overweight or obese)	28 %	56 %	61 %

* Selected study population, age 20-74

VI. Conclusion

This cross-sectional study on Korean adults concluded that adiposity indices such as body mass index, waist circumference, and waist/hip ratio were statistically associated with prevalence of hyperlipidemia. A BMI of greater than or equal to 25 kg/m^2 was clearly associated with the hyperlipidemia. However, it cannot be concluded that a BMI of 18.5-24.9 kg/m^2 was an optimal range for all if the cutoff points for the overweight or obesity are determined by prevalence rate of hyperlipidemia. Use of mortality or morbidity of cardiovascular or related chronic disease to determine the cutoff points of the adiposity indices remained to be determined.

To measure the plasma lipid levels, this study used adiposity indices such as body mass index, waist circumference, and waist/hip ratio. Others have argued that waist circumference, not waist/hip ratio, should be used to assess these relations (Allison, 1995). However, waist circumference is highly correlated with and essentially reflects BMI, whereas waist/hip ratio seems to capture additional predictive information (Folsom, 1998).

The prevalence of hyperlipidemia was compared with the prevalence rate of adiposity from the United States. There was a difference between two populations as shown in the table 11. However, the lower prevalence rates of overweight and obesity do not suggest that the majority of Korean adults are somewhat healthier than American adults. Instead, the result suggests a need for further studies on obesity to determine the cutoff points of the adiposity indices specific to Korean adults based on epidemiologic data including this study result.

In men, the BMI and waist circumference were the greatest predictors of prevalence of hyperlipidemia, whereas in women, waist circumference and waist/hip ratio were the greatest predictors of prevalence of hyperlipidemia. Clearly, continued and more effective population-wide efforts to prevent and treat obesity are needed. Therefore, it is highly suggested that measuring of waist and hip circumferences be added to routine physical examination because it is a simple, convenient and economical assessment tool and a useful method to promote the quality of care by predicting the risk factors of cardiovascular disease. However, further systemic studies are needed to determine the cutoff points of the BMI, waist circumference, and waist/hip ratio specific to Korean adults. In addition, it remains to be determined whether the morbidity or mortality of the cardiovascular diseases or related chronic disease is based on categorizing the adiposity indices.

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ABSTRACT

Hyperlipidemia and Adiposity Indices in Korean

Jeanna An
Graduate School of
Health Science and Management
Yonsei University

(Directed by Professor Il Suh, M. D., Ph. D.)

The major objectives of this study were to identify the relationship of three adiposity indices (body mass index, waist circumference, and waist/hip ratio) and hyperlipidemia of plasma lipids (total cholesterol, high and low-density lipoprotein and ratios of total cholesterol and triglycerides to high-density lipoprotein cholesterol). The purpose of this study was to provide health care workers with basic epidemiological data to develop health promotion educational materials and programs regarding the prevention of cardiovascular diseases and other related chronic diseases.

This cross-sectional study was conducted on a sample of 9771 subjects from Korea National Health and Nutrition Examination Survey conducted by the Korea Health and Social Institutes in 1998. The subjects included 7618 adults, aged 20 to 79 years old, those who were examined blood lipid profiles and interviewed health behavior component of the survey. A total of 2153 outliers including pregnant women and individuals showing a high value of WBC were excluded from the

initial 9771 subject. Therefore, the actual study was conducted on 7618 subjects consisting of 3444 of men and 4174 of women, between the ages of 20 to 79 years old, who were examined for blood lipid profiles and interviewed for the health behavior component of the survey.

This study used the measurement criteria of body mass index, waist circumference and waist/hip ratio that was categorized by the World Health Organization. For the criteria of hyperlipidemia, the Adult Treatment Panel III from the National Institutes of Health was referenced.

The result of the study is as follows:

1. There were differences in the means of each blood plasma lipid level (total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, triglycerides, total cholesterol to high-density lipoprotein cholesterol ratio, and total cholesterol to high-density lipoprotein cholesterol ratio) by the category of body mass index, waist circumference, and waist/hip ratio respectively. ($p<0.05$) The means of plasma lipid concentrations increased as the levels of the adiposity categories increased.

2. The prevalence of hyperlipidemia was measured by the categories of body mass index, waist circumference, and waist/hip ratio. The cutoff points of the body mass index by the World Health Organization were used to measure the prevalence rate of plasma lipids. Adult Treatment Program III was used to categorize the plasma lipid levels. Based on the criteria, no one showed a body mass index of greater than or equal to 35kg/m^2 or triglycerides of greater than or equal to 500 mg/dL. Yet those

who were under the normal range of the body mass index (< 25kg/m^2) showed hyperlipidemia.

3. Study subjects who were under the normal range of the body mass index (18.5-25 kg/ m^2) showed hyperlipidemia.

- 20.5% of men and 7.7% of women showed a high level of total cholesterol (≥ 240 mg/dL).
- 23.3% of men and 23.8% of women showed a borderline high level of total cholesterol (200-239 mg/dL).
- 21.3% of men and 15.3% of women showed a low level of high-density lipoprotein cholesterol (<40 mg/dL).
- 17.9% of men and 18.2% of women showed a borderline high level of low-density lipoprotein cholesterol (130-159mg /dL).
- 5.6% of men and 7.6% of women showed a high level of low-density lipoprotein cholesterol (160-≥190 mg /dL).
- 18.8% of men and 12.8% of the women showed a borderline high level of the triglycerides (150-199mg /dL).
- 12.6% of men and 5.8% of women showed a high level of triglycerides (200-499 mg /dL).

4. Study subjects who were under the normal range of the waist circumference, less than or equal to 102 cm for men and less than or equal to 88 cm for women showed hyperlipidemia.

- 7.7% of men and 7.5% of women showed a high level of total cholesterol.

- 25.4% of men and 23.6% of women showed a borderline high level of total cholesterol.
- 24.8% of men and 14.8% of women showed a low high-density lipoprotein cholesterol.
- 19.9% of men and 18.2% of women showed a borderline high level of low-density lipoprotein cholesterol.
- 7.4% of men and 7.5% of women showed a high level of low-density lipoprotein cholesterol.
- 20.9% of men and 12.3% of women showed a borderline high level of triglycerides.
- 15.4% of men and 5.8% of women showed a high level of triglycerides.

5. Study subjects who were under the average range of the waist/hip ratios, less than or equal to 0.9 in men and less than or equal to 0.8 in women, showed hyperlipidemia or dyslipidemia.

- 24.2% of men and 20.9% of women showed a prevalence of high levels of total cholesterol.
- 6.8% of men and 4.8% of women showed a prevalence of borderline high level of total cholesterol.
- 23.6% of men and 12.1% of women showed a low level of high-density lipoprotein cholesterol.
- 18.7% of men and 16.0% of women showed a borderline high level of low-density lipoprotein cholesterol.
- 6.8% of men and 4.5% of women showed a high level of low-density

lipoprotein cholesterol.

- 19.6% of men and 8.7% of women showed a borderline high level of triglycerides.
- 14.0% of men and 3.7% of women showed a high level of triglycerides

6. An independent predictor of adiposity indices to hyperlipidemia was identified with logistic regression analysis. The model included age, body mass index, waist circumference, and waist/hip ratio. As a result, differences were noted in type of predictors by gender and age groups. It tended to have more association with BMI and waist circumference in men, whereas in women with waist circumference and waist/hip ratio. In men, BMI was the predictor of hyperlipidemia for below 60 years of age; waist circumference and WHR in ages 20-39 and 60-79. In women, there was an association between waist/hip ratio and TG in all age groups; waist circumference and TG in age 20-59.

Therefore, this study concluded that adiposity indices such as body mass index, waist circumference, and waist/hip ratio were statistically associated with the prevalence of hyperlipidemia regardless of gender and age. Yet a normal range of BMI, 18.5-24.9 kg/m^2, was clearly associated with the hyperlipidemia, so it cannot be concluded that a BMI of 18.5-24.9 kg/m^2 was an optimal range for all.

The prevalence of hyperlipidemia was compared with the NHANES III from the United States. There was a big difference between the two populations as shown in the Table 11. Most of the difference was attributable to the obesity rather than overweight category. However, the lower prevalence rates of overweight and obesity do not suggest that the majority of Korean adults are somewhat healthier than American adults. Instead, the study suggest a need for further studies on obesity to determine the cutoff points of the adiposity indices specific to Korean adults based on epidemiologic data including the results of this study. Yet, it remains to be determined whether the morbidity or mortality rates of cardiovascular diseases or related chronic disease can be based on adiposity indices.

Further studies on cutoff points of the adiposity indices remain to be determined. However, based on this study, it is highly suggested that measuring of waist and hip circumferences be added to routine physical examination because it is a simple, convenient and economical assessment tool and a useful method to promote the quality of care by predicting the risk factors of cardiovascular disease.