Adult NZ Chinese
Comparative Study of Body Composition
Measured by DEXA

Jewel Ji Yang WEN

A thesis submitted to
Auckland University of Technology
in fulfilment of the requirements for the degree of
Master of Philosophy (MPhil)

2008

Division of Sport and Recreation

Primary Supervisor: Professor Elaine Rush (PhD)

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Wen, J., Rush, E., Plank, L., & Zinn, C. (2007). Body Size and body composition in NZ Chinese. Abstract was published in *Asia Pacific Journal of Clinical Nutrition* 2007 Volume 16, (Supplement 3), S89. Poster presented at the Joint Annual Scientific Meeting of the Nutrition Society of New Zealand & the Nutrition Society of Australia in Auckland, New Zealand 5-7th December, 2007.

ATTESTATION OF AUTHORSHIP

"I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other research institution of higher learning".

Signed……………………………

Date……………………………….

ACKNOWLEDGEMENTS

With the completion of this thesis, I would like to thank **GOD**, for his love and forgiveness.

A huge thank you to each of the wonderful **participants** for their time and contribution towards the study. A special thanks to my supervisors **Elaine Rush** and **Caryn Zinn** who gave of their time and expertise to help me over the period of the study. My sincere gratitude to **Dr Lindsay Plank** for allowing use of the DEXA machine and for his valuable help during my data collection and data analysis**.** Thank you to the **CPAN team**, including **Purvi Chhichhia, Erica Hinckson, Sunnie Xin, Jennifer Crowley, Riitta Freese, Geoff Kira and Kate White** who offered help during my study in AUT.

Special thanks to my husband **Sage** and children, **Melissa and David** for their love, patience and encouragement during my study. Thank you to my parents **Peter** and **Debby** for their support in many practical ways.

I would like to extend my gratitude to my friends **Kai Hong Tan, Xueyan Chen, Gracie Xiao and Jane Han** for their advice and encouragement during my study.

I would like to acknowledge the generous support of **Faculty of Health and Environmental Science, Auckland University of Technology** postgraduate student's research grant. Ethics approval (number 06/172) was gained from **the Auckland University of Technology Ethics Committee** on the 17th November 2006 for a period of three years.

Finally, but most importantly, many thanks and appreciations to my primary supervisor:

Professor Elaine Rush PhD

ABSTRACT

Body fat, regional body fat and bone mineral mass, are linked to health conditions such as obesity and osteoporosis. The ethnic comparison of body composition may help to explain and understand the difference of health outcomes and health status in different ethnic groups. NZ Chinese is the largest Asian group in New Zealand, however, knowledge about health risks and body composition for NZ Chinese is very limited. Therefore, the aims of this thesis were: 1) To compare the relationships between body mass index (BMI) and percentage body fat (%BF) of European (M29, F37), Maori (M23, F23), Pacific people (M15, F23), and Asian Indian (M29, F25) (existing data) with NZ Chinese aged 30-39 years; 2) To compare fat distribution, appendicular skeletal muscle mass (ApSM), bone mineral density (BMD) and limb bone lengths across these five ethnic groups.

A convenience sample of healthy NZ Chinese (M20, F23) was selected by BMI to cover a wide range of body fatness. Total and regional body fat, fat free mass (FFM) and bone mineral content were measured by whole-body Dual-energy X-ray absorptiometry (DEXA). The main study findings were:

- For a fixed BMI, NZ Chinese had a higher %BF than European and less %BF than Asian Indian. At a %BF equivalent to a BMI of 30 $kg.m^{-2}$ in Europeans (WHO threshold for obesity), BMI values for Asian Indian and NZ Chinese women were 5.8 and 2.2 BMI units lower than European, respectively, and for Asian Indian and NZ Chinese men, 8.2 and 3.0 BMI units lower.
- Abdominal-to-thigh fat ratio of NZ Chinese was significantly higher than that of European ($P<0.001$) and similar to that of Asian Indian. NZ Chinese had a significantly higher central-to-appendicular fat ratio than both Asian Indian and European ($P<0.001$). NZ Chinese was centrally fatter than European and Asian Indian.
- For the same height and weight, NZ Chinese had significantly less FFM (-2.1 kg, P=0.039) and ApSM (-1.4kg, P=0.007) than European. NZ Chinese had significantly more FFM (+3.2 kg, P=0.001) than Asian Indian and similar ApSM to Asian Indian.
- For the same weight, NZ Chinese had a similar BMD as European for female and male. NZ Chinese male had a higher BMD (+0.07 $g.cm^{-2}$, P= 0.001) than Asian Indian male.

- Among the five ethnic groups, NZ Chinese had the shortest leg (-1.5cm, P=0.016) and arm bone lengths (-2.3cm, P=0.001) (measured by DEXA) for the same DEXA height.

Therefore, the relationship between percent body fat and BMI for Asian Indian and NZ Chinese differs from Europeans and from each other, which indicates that different BMI thresholds for obesity may be required for these Asian ethnic groups. Given the relatively high percentage body fat, low appendicular skeletal muscle mass and high central fat to appendicular fat ratio of NZ Chinese aged 30-39 years demonstrated in this study, promotion of healthy eating and physical activity is needed to be tailored for NZ Chinese. The NZ Chinese community should be advised to keep fit, prevent limited movements in older age, and to prevent obesity and obesity-related diseases.

ABBREVIATIONS

%BF	Percentage body fat
A/T ratio	Abdominal-to-thigh fat ratio
AF	Abdominal fat
ApSM	Appendicular skeletal muscle mass
BIA	Bioelectrical impedance analysis
BMC	Bone mineral content
BMD	Bone mineral density
BMI	Body mass index
C/Ap ratio	Central-to-appendicular fat ratio
CI	Confidence intervals
CT	Computer assisted tomography
CVD	Cardiovascular disease
DEXA	Dual-energy X-ray absorptiometry
ESC	Extracellular solids
ECF	Extracellular fluid
FM	Fat mass
FMI	Fat mass index
FFM	Fat free mass
GLU	Fasting glucose
HC	Hip circumference
HDL	High density lipoprotein
INS	Fasting insulin
L/H	Leg length to height ratio
LDL	Low density lipoprotein
LM	Lean mass
MAR	Mass of abdominal region
MRI	Magnetic resonance imaging
MUAC	Mid upper arm circumference
PA	Physical activity
NZ	New Zealand
SAD	Sagittal abdominal diameter
SAT	Subcutaneous adipose tissue
SCD	Sagittal chest diameter

SD	Standard deviation
SE	Standard error
SEE	Standard error of estimate
SH/H	Sitting height/Height
STM	Soft tissue mass
TBF	Total body fat
TBW	Total body water
TC	Total cholesterol
TF	Thigh fat
TG	Total triglycerides
VAT	Visceral adipose tissue
WC	Waist circumference
WHO	World Health Organization
WHR	Waist to hip ratio

GLOSSARY

There are a number of ethnic categories used in this thesis as well as other studies/reports discussed. To avoid any confusion, this glossary section is for clarifying ethnic categories used in the results section of this thesis and in major reports from the New Zealand health sectors. The ethnic categories used in other referenced studies and reports will be explained in the content.

Asian: An ethnic category for people with origins in the Asian continent from Afghanistan in the west to Japan in the east, and from China in the north to Indonesia in the South. Asian is divided into three subgroups in Asian health Chart Book 2006: Chinese, Indian and Other Asian. The other Asian group includes Koreans, Japanese, Vietnamese, Filipinos, Bangladeshis, Pakistanis and Afghanis.

Asian Indian: An ethnic category for people with origins in the Indian subcontinent. It includes Sri Lankan and Fijian Indian.

Maori: A tribal people of Polynesian origin indigenous to New Zealand.

Pacific People: People of Polynesian origin but not Maori.

New Zealand Chinese: An ethnic category for people normally living in New Zealand with origins in China.

South Asian: An ethnic category that includes people with origins in India, Sri Lankan, Bangladesh and Pakistan. Fijian Indians are included in this category as their country of ancestral origin is India.

CHAPTER 1: INTRODUCTION

The statement of the problem, complexities of measurement of body fat and a current literature review are presented in this chapter. A discussion of the associations among ethnicity, lifestyle, environmental influences, body composition and health outcomes is presented. Known ethnic differences in body composition, especially on bone mineral density (BMD) and the relationship between percentage body fat (%BF) and body mass index (BMI), will be discussed. Finally, the demography and health outcomes of New Zealand (NZ) Chinese will be reviewed.

1.1 The problem

The ethnic diversity in New Zealand is increasing and so is the burden of chronic diseases associated with obesity to the health system. Definition of obesity is not clearly defined and is further complicated by the difficulty of accurately measuring fatness of an individual.

1.1.1 Ethnic diversity

New Zealand is a multi-ethnic country and in 2001 was comprised of mainly European (79%), Maori (15%), Pacific people (7%), and Asian (7%) (Statistics New Zealand, 2008b). The ethnic diversity in New Zealand has been estimated to increase in the future with the proportion of European dropping to 70%, Maori increasing to 17%, Pacific people to 9% and Asian to 15% in 2021 (Statistics New Zealand, 2008b). In addition, the 65+ year age group has been projected to increase from 12% in 2006 to 25% of the whole population by the late 2040s. Cancer, cardiovascular disease (CVD) and diabetes are the leading causes of deaths in New Zealand (New Zealand Health Information Service, 2006). Ethnic inequalities in mortality exist in New Zealand. For example, in 2003, the age-standardised mortality rate from diabetes mellitus for Maori was six and a half times higher than non –Maori (58.2 for Maori versus 9.0 for non-Maori). The age-standardised rate of death from all causes of death for Maori was 1.93 times higher than for non-Maori. The reported causes of such health disparities include access to health care, education, socioeconomic status, social marginalization, discrimination, stress, tobacco consumption and diet (University of Otago & Ministry of Health, 2003). More recently, the Asian Health Chart Book 2006 has reported marked differences in health outcomes between two main Asian subgroups. Asian Indians have significantly more cardiovascular disease hospitalization and higher CVD mortality rates than New Zealand (NZ) Chinese (Ministry of Health, 2006). The body composition (fat, muscle and bone) is strongly linked to an individual's health (Snijder et al., 2006). Therefore the ethnic differences of body composition may give additional explanations for the occurrence of health disparities in New Zealand.

One of the body composition components, body fat, has been studied extensively ever since people have accumulated more of it due to lifestyle change. Excessive body fat and abdominal fatness are linked to many medical conditions such as type 2 diabetes and cardiovascular disease. Excessive body fat also has a negative impact on one's physical function and quality of life. Such excess of body fat is defined as obesity. As body fat is difficult to measure, for convenience, BMI is the most widely used measurement to define cut-offs for obesity. Waist circumference (WC) is commonly used as measures of abdominal fat. The World Health Organisation (WHO) BMI classifications of overweight (25 $kg.m^{-2}$) and obesity (30 $kg.m^{-2}$) are intended as a threshold for reflecting risk for type 2 diabetes and cardiovascular disease and therefore are used as a basis for informing and triggering the health policy action (WHO expert consultation, 2004). However, there is an ethnic difference in the relationship between %BF and BMI (%BF/BMI), and the relationship between disease and BMI (ibid). Therefore, ethnic-specific BMI has been applied in New Zealand people, with 26 and 32 $kg.m^{-2}$ correlating to overweight and obesity, respectively in both Maori and Pacific people (Ministry of Health, 2003d). Recently, a proposed ethnic-specific BMI cut-off was applied to the Asian population in New Zealand, with 23 and 25 $kg.m^{-2}$ for overweight and obesity respectively. However, the Ministry of Health claimed that there is limited data supporting this proposed BMI cut-off for Asians (Ministry of Health, 2006). Therefore, there is a need for scientific data on %BF/BMI relationship and association of BMI and diseases for Asian ethnic groups. The %BF/BMI relationship of Asian Indian has been studied and findings show that, for the same BMI, Asian Indian men (17-30y) have more body fat than European men (Rush et al., 2004), Asian Indian women (18-60y) have more total body fat and central fat mass than European women (Rush et al., 2007a). However, we are unaware of any research that examines the %BF/BMI relationship in NZ Chinese or any analysis of the whole body composition and regional composition for NZ Chinese using the Dual-energy X-ray Absorptiometry (DEXA). NZ Chinese started to settle in New Zealand in 1860s, and is one of fastest growing ethnic minorities in NZ with recent immigration (Ip, 2003b). However, knowledge about health risks for NZ Chinese is very limited.

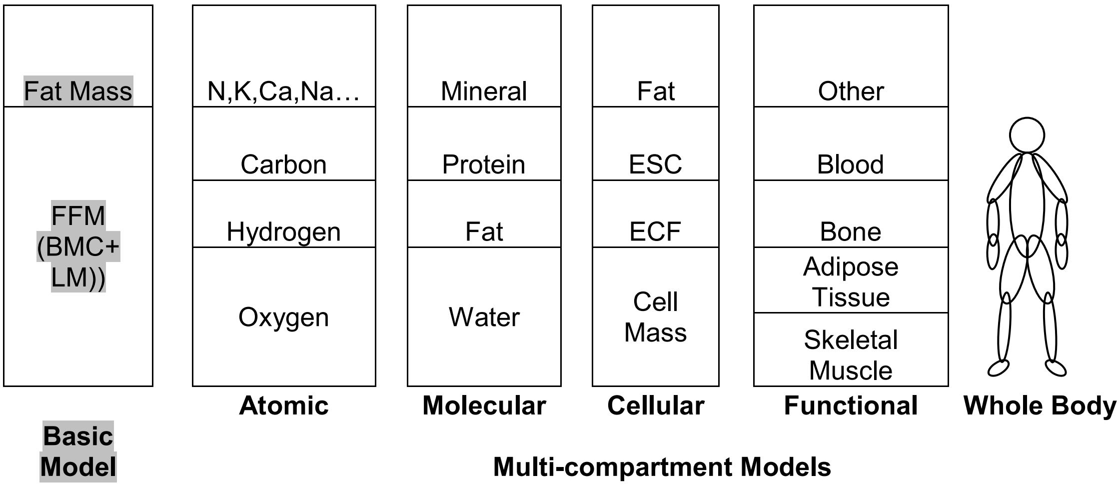
In addition to the body fat, which is linked to type 2 diabetes and CVD diseases, another component of the body, the bone mineral mass, is linked to osteoporosis. Osteoporosis is not defined as a disease like type 2 diabetes, but it can lead to bone fractures, particularly at the hip, spine and wrist, which result in a decreased quality of life. It is estimated that the cost of osteoporosis is over $1.15 billion per year in NZ (Brown et al., 2007). Osteoporosis mainly affects people over 50 years of age. Therefore, osteoporosis is a serious health issue in an aging population. BMD is used as a measure of bone strength and to define osteoporosis. A regional DEXA scan is a recommended diagnosis method to measure BMD. So, the diagnosis of osteoporosis is expensive, and the condition is not as visible as the obesity until the fracture occurs. In New Zealand, the hip fracture rates for women over 50 years are 70% higher than that of men. In addition, Europeans over 50 years have approximately 30% higher hip fractures rates than Maori, Pacific and Asian people (Brown et al., 2007). The ethnic comparison of BMD among major ethnic groups may help understand such difference in hip fracture rates.

In general, components of body composition, particularly body fat, regional body fat and bone mineral mass, are linked to health conditions such as obesity and osteoporosis. The body composition differences may help to explain and understand the difference of health outcome and health status in different ethnic groups, and provide further intervention points for policy to cut down the heavy burden of obesity and osteoporosis on the public health sector in New Zealand. To review studies on ethnic difference in body fat, it is necessary to outline the methods used to measure body fat first.

1.1.2 Measurement of body fat

The composition of the human body is multilevel, dynamic and complex. It has been expressed and studied using different models, two of which include the basic two-compartment model and multi-compartment model (Wang et al., 1992; Snijder et al., 2006). These models are illustrated in Figure 1.1. The main three tissue components of body composition: adipose tissue, skeletal muscle and bone are linked to function, fitness and well being. In the scope of this thesis, the term body fat is frequently used for adipose tissue.

Figure 1.1: Basic model and multi-compartment models for expressing human body composition



Adapted from Ellis (2000); FFM, fat free mass; BMC, bone mineral content; LM, lean tissue mass; ESC, extracellular solids; ECF, extracellular fluid.

Body component of interest can be directly and indirectly measured at different levels. For the purpose of this study, the whole body is divided into fat mass (FM) and fat free mass (FFM). FFM is further divided into bone mineral content (BMC) and lean tissue mass (LM). The body fat mass is the major interest of this study. Because the direct measurement of body fat of healthy human beings is impractical and unethical, it is not discussed here. Indirect methods, which measure other characteristics of the body that are influenced by fat distribution, are widely used for humans (Snijder et al., 2006). Indirect methods are based on certain assumptions about relationships between body components. These assumptions about relationships may be obtained from direct methods, theoretical considerations, or statistical analysis. The various methods currently used for assessment of body fat are summarized in the Table 1.1.

Table 1.1: Comparison of techniques for assessment of body fat

Capability to estimate body fat and fat distribution	Anthropometry (BMI, WC, SAD, WHR, Skin fold thickness)	Single frequency BIA	DEXA	Deuterium oxide dilution	Underwater weighing /Air displacement	CT/MRI
Accuracy in estimating body fat	Low	Low	High	High	Low	High
Equipment/material cost	Inexpensive	Inexpensive	Expensive	Expensive	Moderately expensive	Very expensive
Portability	Portable	Portable	Not portable	Portable	Not portable	Not portable
Training requirement for operator of the equipment	Low	Moderate	High	High	High	High
Special requirement for the subject	No	No	No	Yes	Yes	No
Provide fat distribution	Yes	No	Yes	No	No	Yes
The ability to discriminate visceral fat from subcutaneous fat	No	No	No	No	No	Yes
Suitable for ethnic comparison	No	No	Yes	Yes	Yes	Yes

BMI, body mass index; WC, waist circumference; SAD, sagittal abdominal diameter; WHR, waist to hip ratio; BIA, bioelectrical impedance analysis; DEXA, Dual-energy X-ray absorptiometry; CT, computer assisted tomography; MRI, magnetic resonance imaging.

For convenience and large surveys, BMI is the most widely used measurement for body fat and obesity. WC and Waist to hip ratio (WHR) are commonly used as measures of abdominal fat. WC was recognized as a measure of central obesity by the IDF epidemiology Task Force Consensus Group (International Diabetes Federation, 2005). Anthropometry is easy to conduct and is used at a population level for predicting body fat. Estimation of body fat is based on the statistical relationship between the easy measurable parameters (BMI, WC) and body fat obtained from reference measurement methods, such as DEXA. However, these relationships may be age, gender and ethnic – specific (Snijder et al., 2006).

Single frequency (50Hz) bioelectrical impedance analysis (BIA) measures electrical properties of a human body based on the fact that fat tissue conducts electricity more poorly than fat free tissues. The human body is assumed as a cylindrical conductor. BIA can estimate the FFM and total body water (TBW) in healthy subjects with a validated BIA equation, which should be age, sex and ethnic specific (Kyle et al., 2004).

DEXA is an indirect method based on attenuation of X-rays projected through the supine human body, the intensity of the beam of the X-rays on the dorsal side of the body is related to the thickness, density and chemical composition of the body (Ellis, 2000). High energy (70 keV) and low energy (40 keV) X-rays are simultaneously applied but the radiation dose is much lower than that used in CT. The relative absorption (R values) of fat, lean and bone tissue are assumed based on theoretical and experimental studies. Therefore, DEXA not only provides an image of the anatomical position of the bone in the body, but also estimates three body composition values: FM, BMC and LM. Total body weight is determined by the sum of FM, BMC and LM. FFM is the sum of BMC and LM, and the soft tissue mass (STM) is the sum of FM and LM. All the soft tissue in the same DEXA scan area is assumed to have the same fat-to-lean ratio. The depth of soft tissue and bone are considered constant (ibid).

Deuterium oxide is used as an indicator to measure body water by the principle of indicator dilution. The body is assumed to have a fixed hydration constant, i.e. the ratio of hydration of FFM (TBW/FFM) is constant. Fat mass is calculated by the difference between body weight and FFM (Ellis, 2000; Deurenberg-Yap & Deurenberg, 2002). This method cannot provide information about fat distribution. In addition, the hydration ratio may vary in individuals (Ellis, 2000). Deuterium oxide dilution is administered orally. The advantage of the method is its portability.

Underwater weighing and air displacement are densitometry based on the same fact: fat tissue is less dense than fat free tissue. The fat tissue density and fat free tissue density are assumed fixed, they do however vary among individuals and change with age and health conditions. Therefore, the densitometry alone can not measure body fat content very accurately. In fact, it is often used in combination of other methods, such as dilution, to obtain accurate body fat information (Deurenberg & Deurenberg-Yap, 2003). This method also cannot provide information about fat distribution.

Both computer assisted tomography (CT) and magnetic resonance imaging (MRI) scanning provide a cross-sectional anatomical image of the body region scanned. CT is based on X-rays and requires a relatively high dose. Multiple CT and MRI images can provide fat distribution information and discriminate subcutaneous adipose tissue (SAT) and visceral adipose tissue (VAT). CT and MRI machines are expensive and not portable (Ellis, 2000).

For ethnic total body fat comparison, the later four methods are better choices than others. However, only DEXA and CT/MRI can provide information on fat distribution in regions of interest of the body. Compared to CT and MRI, DEXA is less expensive but can not monitor changes in SAT and VAT.

Some of six measurement techniques described above can be combined to accurately estimate body fat values based on multi-compartment models. For example, body fat mass can be estimated by a four-compartment model: body weight = fat mass + TBW + BMC + protein. TBW can be measured by deuterium oxide dilution; body density can be determined by air displacement; and BMC can be obtained by DEXA (Deurenberg-Yap et al., 2002).

1.2 Literature review

1.2.1 Human body composition and health

In the context of this section, body composition and its relationship to health, body fat, bone, muscle and skeletal proportions are each discussed in turn with references to differences related to sex and ethnicity.

1.2.1.1 Body fat, obesity and related health problems

Obesity is a condition of excessive body fat. Excess body fat shortens life expectancy through increasing a person's risk of type 2 diabetes, metabolic syndrome, CVD, cancer, joint pain and degeneration, kidney stones and gallstones (Ministry of Health, 2003a). The WHO estimated that around 300 million people in the world were obese in 2000 (WHO, 2003a). The CVD accounts for one third of the all deaths worldwide (WHO, 2007). Furthermore, apart from overall obesity, the fat distribution can affect the specificity of determining the risk of diseases (Snijder et al., 2006). Fat stored in the central region of the body is related to metabolic profile.

A small study on older Michigan adults (23M and 31F) over 60 years of age found that abdominal fat (measured by DEXA) and WC were significantly inversely related to insulin sensitivity (Lee et al., 2005). Furthermore, the association was found independent of sex. WHR was found not associated with insulin sensitivity in these older adults.

Meanwhile, the negative association between hip circumference (HC) or leg fat and metabolic profile was found not only in white population over 50s (Snijder et al., 2004a), but also in other non-white population over 20s (such as Micronesians, Melanesians, Indians and Creoles) (Snijder et al., 2004b).

A sectional study conducted in Taiwan shows that in healthy Chinese males and females aged 17-81 years, a relative excess of fat in the central region of the body, assessed by DEXA, is related to higher blood pressure, greater fasting and oral glucose tolerance test 2-h plasma glucose, greater glycosylated haemoglobin, higher serum concentrations of cholesterol, triglyceride and low density lipoprotein (LDL) cholesterol, and lower high density lipoprotein (HDL) cholesterol level (Wu et al., 1998). Furthermore, glucose tolerance status of these Chinese can be differentiated by using the pattern of body fat distribution assessed by DEXA (Chang et al., 1999).

A Japanese study of 128 overweight and obese Japanese females, aged 34-66 years, shows that truncal fat, measured by DEXA, and VAT, measured by CT, are positively correlated with number of CVD risk factors at base line and after weight reduction (Okura et al., 2004). Leg fat is negatively associated with a number of CVD risk factors at base line and after weight reduction. In addition, lean mass of the trunk and leg has a negative relationship with CVD risk factors. CVD risk factors measured in the study include systolic blood pressure and diastolic blood pressure, serum total cholesterol, triglycerides, serum HDL, LDL, and fasting plasma glucose.

Therefore, increased abdominal fat is associated with metabolic disturbances in different ethnic groups including European, Indian and Chinese. The accumulation of VAT in the abdomen results in such metabolic disturbances (Bergman et al., 2007). VAT is considered to have a more damaging effect on a person's health than SAT (Bergman et al., 2006; Snijder et al., 2006).

The prevalence of obesity for adults in New Zealand in 1989 was 11% and in 1997 was 17% (Russell et al., 1999). The latest 2002/03 healthy survey reported that the prevalence had increased to 21% in 2002 (Ministry of Health, 2003d). High BMI was estimated to contribute to 11% of all deaths in New Zealand in 1997 (Ministry of Health, 2003c). The annual direct cost of obesity to the New Zealand health sector was estimated around $135 million per year in 1991 (Swinburn et al., 1997). The mentioned cost did not include the costs to individuals of weight-loss programs and costs in lost of productivity due to obesity related diseases and premature deaths. Therefore, the increasing prevalence of obesity in New Zealand has and will have a significant adverse impact on the wellbeing of many New Zealanders.

1.2.1.2 Bone, skeletal muscle and health

In an individual's lifespan, bone mass reaches its peak during the early 20s. Females start to lose their bone mass from around age of 35 years and males from around age of 60 years. The bone loss reaches a point that bones are subject to fractures, which is called osteoporosis. BMD is used to define osteoporosis and can be measured by the

DEXA scan (Brown et al., 2007). Bone fractures significantly decrease the quality of an individual's life (Saladin, 2001a) and increase the risk of mortality. Since females have less peak bone mass, smaller bone size and lose bone mass earlier than males, they are at a higher risk of osteoporosis than males (Seeman, 2001; Tuck et al., 2005). Females have a three times higher osteoporosis incidence than males (WHO, 2003b). In 1995, the estimated national direct pharmacotherapy expenditures for osteoporosis in New Zealand was $3,385,590 per year (Lane, 1996). In 2007, the 80000 bone breakage occurred in New Zealanders were attributed to osteoporosis and about 75% of them were females (Brown et al., 2007). These fractures require hospitalization and nursing home care, and decrease an individual's quality of life. The total cost of osteoporosis is over $1.15 billion per year in NZ. Of course, the increasing aging population in NZ will increase the osteoporosis prevalence and fracture incidences if nothing is done for prevention. It is estimated that the health care expenditure in NZ for care associated with osteoporosis in 2020 is nearly $1.6 billion (Brown et al., 2007).

The function of muscle is to produce movement of individual body parts and to produce 85% of body heat (Saladin, 2001b). The loss of skeletal muscle mass is common in older people and can easily contribute to a fall and to reliance on others for routine tasks, such as shopping and bathing. In New Zealand, the prevalence of musculoskeletal disease is high in adults over 45 years: 30% of NZ adults over 45 years have arthritis and 33% of adults over 45 years have back problems. Therefore, muscle, especially skeletal muscle mass, contributes significantly to a person's physical activity and fitness, which is important for long-term well-being and health. However, compared with body fat and bone, skeletal muscle has received less attention in research despite the importance of its contribution to daily functional capacity and long-term health.

1.2.1.3 Height, leg length and health

An epidemiological study conducted in England and Scotland in the 1990s, which was the follow up of the Boyd Orr cohort involving 2990 subjects from 1134 families, had shown that childhood leg length, as measured from the ground to the summit of the iliac crest, is positively associated with cancer mortality rates and negatively related to the death from coronary heat disease (Gunnell et al., 1998a; Gunnell et al., 1998b).

A longitudinal study of a British national birth cohort (N=2879) found that parental height, birth weight, and weight at 4 years are positively influence adult leg and trunk length at 43 years(Wadsworth et al., 2002). Breastfeeding and energy intake at 4 years are positively associated with leg length at 43 years. Further cross-sectional analyses of the same cohort found that adult height and leg length are strongly and negatively related to systolic blood pressure and pulse pressure measured at the age of 36, 43 and 53 (Langenberg et al., 2003; Langenberg et al., 2005).

Studies from US communities found that both Black and White adults (aged 44-65 years) leg length, as calculated by standing height minus sitting height, is inversely associated with intimal-medial thickness, measured by β-mode ultrasound. This was a huge sample size cohort study with 12,254 participants. Confounding factors included parental and adult cardiovascular disease risk factors and adult socio demographic factors (Tilling et al., 2006).

Similarly, a large cross-sectional study, consisting of 21,021 Americans aged from 2-90 years and including three different ethnic groups: non-Hispanic white, African-American black and Mexican-American, found that relative leg length is negatively associated with body fat, assessed by skinfold thickness (Frisancho, 2007). Relatively short legs indicate a slowed growth trajectory during childhood and/or adolescence in the presence of negative environmental factors, such as poverty.

Recently, a cross-sectional study of 2860 Hong Kong Chinese aged 25-74 years found that central obesity, measured by WC, is positively associated with height. This association is most pronounced in males (Schooling et al., 2007). Schooling et al. explained that the recent rapid industrialization in Hong Kong has been associated with increased pubertal growth and therefore increased height due to a relatively longer trunk. Such growth patterns have a more prominent effect on males than females, as females grow less during the pubertal period.

In summary, longitudinal and cross-sectional studies have shown that relative leg length in the adult may serve as an index of the developmental history and therefore health of individuals and populations.

1.2.2 Factors that influence body composition

In a simple model of body composition, there are three main elements: body fat, bone and lean. A large proportion of the lean mass is skeletal muscle. A variety of factors, including genetics, age, lifestyle, social-economic and environmental factors, determine an adult's body composition, current and future health (Ben-Shlomo & Kuh, 2002). These factors are divided into pre-existing factors and modifiable factors in the following discussion. Pre-existing factors including genes and age are not modifiable and are discussed below.

1.2.2.1 Pre-existing factors that influence adult body composition

Genes influence body fat, bone and muscle. One obvious genetic difference is sex. Sex differences in adult body composition are obvious across all ethnic groups, with males being taller and heavier than females. Females have a greater average percentage body fat and less muscle mass. On average, healthy females have 20-30 %BF, while males have 10-15 %BF (Wells, 2007). In addition, females deposit fat differently to males. Females store more fat in the thigh area and males tend to accumulate the fat at the abdominal area (Lawlor et al., 2004). Furthermore, females have more SAT and males have more VAT for a fixed WC (Kuk et al., 2005). Males have greater BMD and a larger skeletal size than females (Tuck et al., 2005). These sex differences in fat distribution, bone size and BMD are partly responsible for the fact that males have a greater risk of CVD than females (New Zealand Guidelines Group, 2003), and females are at a higher risk of osteoporosis than males (Seeman, 2001).

Gesta and his co-workers conducted experimental studies in mice and in European subjects to explore the genetic basis in differences in body fat distribution and development of adipocyte cell mass (Gesta et al., 2006). They found that several developmental genes are strongly related to BMI and WHR. The gene expression in VAT has the highest and most significant association with WHR and BMI. In addition, twin studies show that total body fat and fat distribution (measured by DEXA) are influenced by genetic factors (Malis et al., 2005).

Ethnicity includes multiple environmental and genetic influences that have some relationships with the geographic origins of ancestors (Collins, 2004). In addition, ethnicity can provide information about culture, diet, education, access to social services and socioeconomic status. Frequently, ethnicity is used as a convenient proxy for genetic factors influencing body composition.

Foetal nutrition and maternal smoking influence an adult's body composition. Birth weight is a convenient proxy for studying foetal nutrition and maternal smoking. In general infants who have a low birth weight have been shown to have higher body fat in later life and more central obesity than those who are heavier at birth (McMillen & Robinson, 2005). Furthermore, Barker and his colleagues published a series of retrospective epidemiological studies conducted in England and Wales in the late 1980s and early 1990s. They found that low birth weight is linked to increased levels of CVD and its associated risk factors in adult life. These have led to the foetal origins hypothesis or the Barker hypothesis (Barker & Martyn, 1992). Babies born small are fatter in adult life compared to babies born large. The principle of the hypothesis is that nutritional, hormonal and metabolic environments in-utero permanently programmes the body's composition, physiology and metabolism. Therefore, Barker emphasizes that a woman's diet and body composition in pregnancy plays a role in her subsequent generation's health (Barker, 2003). The association between low birth weight and adult cardiovascular and metabolic disease has been found not only in European populations residing in Europe and North America but also in Indians living in India (Barker, 2007).

Age is an important aspect in adult body composition: after the age of 30 years, bone and muscle mass generally decrease while fat mass increases with increasing age (Saladin, 2001a). This pattern is reported in NZ European, Maori and Samoan people (Jovanovic, 2001). Females reach their peak bone mass between the ages of 20-25 years. After that, bones gradually lose their mass (Borer, 2005).

1.2.2.2 Lifestyle and environmental factors that influence body composition

Modifiable lifestyle factors include diet, physical activity, smoking and alcohol consumption. They are influenced by both individual choice and also the environment that the individual inhabits. Interactions of these factors have different effects on the three main body compartments dependent on life stage.

Energy Intake

When energy intake from food and drinks exceeds energy expenditure (energy required for resting metabolism, conversion of food to nutrients available for cellular processes and physical activity), the surplus energy is deposited as body fat (Peters et al., 2000). Both environmental and societal changes contribute to changes in dietary intakes and physical activity patterns. Increasing consumption of sugary drinks and high fat food can result in increasing energy intakes. Declining physical activity results in a decrease in total energy expenditure. Increasing energy intakes and declining physical activity due to mechanisation, motorisation and computerization are major factors that contribute to the increase of body fat mass and obesity incidence throughout the world (Silventoinen et al., 2004; World Cancer Research Fund/American Institute for Cancer Research, 2007).

Bone Health

In addition to hormones, adequate energy intake, sufficient absorption of calcium, adequate Vitamin D availability and interactions with physical activity and weight bearing are crucial determinants for the growth of bones in length, width and mass (Borer, 2005). Furthermore, these factors are also important in regulating the maintenance of bone structure throughout the lifespan (WHO, 2003b; Borer, 2005). Physical activity, especially weight-bearing resistance activity, can help accumulate peak bone mass during childhood, adolescence and youth. Inactivity, particularly lack of weight-bearing resistance activity, accelerates bone mass loss during adulthood and in later life. For example, healthy males lost 2-3% of the proximal tibia BMD after 5 weeks of bed rest (Berg et al., 2007).

Age and body weight are the two main factors influencing BMD (Reid, 2002). In addition, fruit and vegetable consumption is found to be positively associated with high BMD in the elderly (Tucker et al., 1999; Tucker et al., 2002). Alcohol intake is positively associated with femoral BMD in premenopausal and postmenopausal females (Felson et al., 1995). However, such association is not found in males (Ruffing et al., 2006). In contrast, excessive alcohol is linked to low BMD in males (Olszynski et al., 2004) and smoking tobacco reduces BMD (WHO, 2003b).

Muscle and physical strength

Muscle mass and strength reach their peak when an individual is in their 20s. Both the aging process and decreased use of muscles cause the shrinkage of muscle and loss of muscle strength (Saladin, 2001d). Physical activity, particularly resistance exercise, can stimulate muscle growth and strengthen muscles (Saladin, 2001c). In adults, exercised muscles grow through the enlargement of pre-existing cells.

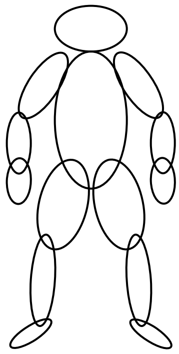
Cohort studies found that within the same BMI groups, adults with lower mortality risk have higher levels of fitness or reported physical activity than those with higher mortality risk (LaMonte & Blair, 2006). Therefore there is also metabolic fitness to be considered and this is not measured by an anatomical measurement of muscle mass.

Hormones affect fat, muscle and bone mass significantly throughout the whole human lifetime (Solomon & Bouloux, 2006; Veldhuis et al., 2005). For example, for females, oestrogen deficiency during menopause results in significant bone lose (WHO, 2003b). Hormone levels may be modifiable. It was beyond the scope of this study to address the influence of hormone on body composition. There is also some evidence that the size of organs e.g. liver, heart, kidney and brain, which are mainly made up of lean mass, differs between ethnicity (Gallagher et al., 2006). Such ethnic differences of organ size will not be discussed in this thesis.

In general, the body components yield information about sex, genes, hormonal factors, foetal nutrition, and physical activity (Figure 1.2). Body fat and bone measurements are directly associated with CVD and osteoporosis directly as previously discussed. Thus, body composition data can be useful in understanding factors that may predispose to chronic disease. Furthermore ethnic differences in body fat quantity and distribution, BMD and leg length may contribute to the understanding of ethnic health disparities in the world and in multi-ethnic nations, such as New Zealand.

Figure 1.2: Factors influencing body composition

Pre-existing factors	*Modifiable factors*
Genes	Hormones
Sex	Geographic and social environment
Age	Diet
Geographic origins	Physical activity
Foetal nutrition	Tobacco consumption
Maternal smoking	Alcohol consumption



1.2.3 Cut-off points for obesity and the association of BMI with body fat

The proposed cut-off points for obesity for females and males correspond to %BF of 35% and 25%, respectively (WHO, 1995). However, precise quantification of body fat is very expensive and not easy to perform at population level. Therefore, BMI is often used as the indication of excessive body fat in studies on the association of body fat and associated disease risks. Based on morbidity and mortality data of the European population studies, BMI cut-off for obesity is 30 $kg.m^{-2}$ and overweight 25 $kg.m^{-2}$ (WHO expert consultation, 2004). However, the association of BMI and morbidity and mortality may be not static within the population over time due to environmental changes and nutritional transitions. Therefore, the BMI cut-off for obesity is only a convenient proxy for obesity and may possibly change over time. Recently, ethnic differences in the association of %BF/BMI were studied intensively among white, black and Asians in different countries (Rush et al., 2007a). The following will review the studies between Chinese and other ethnic groups.

In 1990s, Deurenberg et al. compared the %BF/BMI relationship between 205 Beijing Chinese and 189 Dutch aged 18-67 years, using underwater weighing for body fat measurements at two different sites. The measured body fatness was not different between the studied groups. In addition, the body fat predicted from BMI, age and sex was close to the measured body fatness (by underwater weighing) (Deurenberg et al., 1997). The authors concluded that there is no difference in association of %BF/BMI between Beijing Chinese and Dutch European.

Deurenberg et al. also investigated the effect of body build on the relationship of %BF and BMI in three young healthy adult groups (in their 20s): Beijing Chinese (26F,14M), Wageningen Dutch European (26F,14M) and Singapore Chinese (26F,14M) (Deurenberg et al., 1999). %BF was estimated by underwater weighing for Beijing Chinese and Dutch European, %BF was calculated by using deuterium oxide dilution and air displacement for Singapore Chinese. The three different ethnic groups were measured in the different three study sites. The authors found that Singapore Chinese had the smallest wrist widths and greatest slenderness index (height/sum of wrist and knee width), which indicated that Singapore Chinese had smallest body frame among the three groups. Beijing Chinese had the greatest relative sitting height and Dutch European the lowest. Measured %BF was significantly greater in Singapore Chinese compared to Dutch European for the same BMI, which was explained by the smaller body frame of Singapore Chinese. Therefore, the authors claimed, body frame (measured in skeleton width and slenderness index) has a significant effect on the relationship of %BF/BMI. Relative sitting height was shown to have an impact on the %BF/BMI relationship in males: males with longer relative sitting height or shorter relative leg length has greater %BF at the same level of BMI. The authors cautioned that different methodologies used in the study in different sites might be responsible for the differences in the relationship of %BF/BMI among the three groups. However, Beijing Chinese might be more active than other groups since mechanisation and motorisation level in Beijing in the 1990s was lower than that of both Singapore and Wageningen. Such differences of physical activity among the three groups resulting from different economic environments could have accounted for the differences of %BF/BMI reported in the study.

A study investigating a representative population sample of Chinese (N=108), Malays (N=76), and Indians (N=107), aged 18-75 years, living in Singapore found that for the same age and sex, Chinese have a significantly lower %BF than Indian at the same BMI (Deurenberg-Yap et al., 2000). %BF was calculated by a four-compartment model using combination of densitometry, deuterium oxide dilution and DEXA techniques. Furthermore, using Dutch Europeans %BF prediction equation from BMI, %BF was underestimated for Chinese, Malays and Indians, which indicates that Dutch Europeans have less %BF than Singaporeans at the same BMI. The BMI value that corresponds to the same %BF in Dutch Europeans with a BMI of 30 $kg.m^{-2}$ is about 27 $kg.m^{-2}$ for

Chinese and Malays, and 26 kg.m^{-2} for Indians. The authors indicated that slenderness (calculated as height/sum of wrist and knee widths) and relative sitting height (calculated as sitting height/standing height) partly contribute to the ethnic differences in the %BF/BMI relationship. However, Singapore Indians, who have a higher %BF at the same BMI than Singapore Chinese, were found to have a significantly less relative sitting height (in other words, longer relative legs) than Singapore Chinese. These ethnic differences of leg lengths and association of %BF/BMI between Singapore Chinese and Indians do not support the hypothesis of shorter legs having higher %BF at the same BMI (Deurenberg et al., 2002).

A cross sectional study of healthy 298 males and 771 females (96.7% of them were Chinese), aged 30-70 years, in Singapore, analysed the relationship of %BF/BMI and the CVD risk factors in different %BF groups (Goh et al., 2004b). %BF was derived from DEXA. CVD risk factors included total cholesterol (TC) level, total triglycerides (TG) level, LDL cholesterol level, HDL cholesterol level, fasting glucose (GLU) level and fasting insulin (INS) level. Corresponding to 25% BF for male and 35% BF for female, the BMIs are 27 and 25 kgm^{-2}, respectively. Meanwhile, corresponding to 20% BF for male and 30% for female, the BMIs are 25 and 23 kg.m^{-2}, respectively. The higher levels of TC, LDL, TC/HDL, GLU, and INS and lower level of HDL are in higher %BF groups. The BMI cut-off of 27 and 25 kg.m^{-2} for Singapore Chinese males and females, respectively, are reported to adequately identify groups with high TC, LDL, TC/HDL, TG and INS levels. Furthermore, the authors concluded that the gender differences in BMI cut-offs for obesity should be taken into account for the Asian population. The above recommended gender-specific BMI cut-offs based on %BF is a better proxy than WC, W/H and HC for classifying obesity in the study subjects.

A population based study in 330 healthy Hong Kong Chinese (190F, 140M) aged 20-80y using DEXA for body fat measurement reported that corresponding to the same body fatness at BMI of 25 and 30 kg.m^{-2} in Dutch European, BMIs are 23 and 25 kg.m^{-2} in Hong Kong Chinese (He et al., 2001). %BF of Dutch European was derived from the BMI using prediction formula developed in a Dutch population. Furthermore, corresponding to 35%BF for female and 25%BF for male, BMIs are 22.6 kg.m^{-2} and 24.6 kg.m^{-2} in Hong Kong Chinese female and male, respectively.

A recent study of 1,122 Hong Kong Chinese females aged 41-63 years using two different DEXA machines found that corresponding to %BF of 30% and 35%, BMIs are 19.5 kg.m^{-2} and 23.3 kg.m^{-2} for these middle aged females using the regression equation after adjustment for age (Chen et al., 2006). The exclusive criterion of the study was women with known medical conditions to affect bone health. Therefore, the effect of conditions influencing body fat and fat distribution, such as using anabolic steroids, was unknown. The authors also cautioned that the results are age and gender specific.

A study of 1,079 Taiwan Chinese aged 20+ years, using DEXA for %BF measurement, found that Taiwan Chinese also have a higher %BF than Europeans at the same BMI (Chang et al., 2003). In addition, correspond to BMI of 23.0 and 25.0 kg.m^{-2}, %BF derived from DEXA are 35 and 38% for female Taiwan Chinese, and 23 and 25% for males, respectively.

The Chinese obesity cut offs determined from the above studies are summarised in the Table 1.2.

Table 1.2: Comparison of BMIs derived from regression models between DEXA %BF and BMI in Chinese from different countries

Author	Location	Number of subjects	Age	BMI ($kg.m^{-2}$) equivalent to body fat for overweight		BMI ($kg.m^{-2}$) equivalent to body fat for obesity	
				30%BF for female	20%BF for male	35%BF for female	25%BF for male
Goh[1]	Singapore	771 F 298 M	30-70y	23	25	25	27
He[2]	Hong Kong	190 F 140 M	20-80y	NA	NA	22.6	24.6
Chen[3]	Hong Kong	1122 F	41-63y	19.5	NA	23.3	NA
Chang[4]	Taiwan	570 F 509 M	≥ 20y	20.0	21.1	23.0	25.0

BMI, body mass index; NA, not available; F, female; M, male; [1]reference value obtained from Goh, Tain et al. (2004); [2] reference value obtained from He et al. (2001); [3]reference value calculated from the inverse regression equation after adjustment for age obtained from Chen et al. (2006); [4]reference value obtained from DEXA regression models in Chang et al. (2003).

As shown in Table 1.2, the BMIs of Hong Kong Chinese and Taiwan Chinese equivalent to body fat for obesity are very close. Singapore Chinese have greater BMIs than Hong Kong and Taiwan Chinese at the same body fatness levels. Manufacturer differences of DEXA technology and software used in the studies in the different countries might be responsible for the differences (Plank, 2005). In addition, it might reflect the true differences of %BF/BMI relationship among Chinese living in different countries.

As BMI cut-offs for obesity are often used to identify people with health risks, especially cardiovascular risks (WHO expert consultation, 2004), to establish new BMI cut-offs is not only based on the relationship of %BF/BMI, but also supported by studies on the relationship of BMI and cardiovascular risk factors or association of BMI and co-morbidities.

A cross-sectional study with a national representative sample of 15,239 Mainland Chinese male and female, aged 35-74 years, reported that the BMI cut-off of 24 $kg.m^{-2}$

is sensitive and specific for identifying Mainland Chinese with high risks of cardiovascular disease (Wildman et al., 2004). Risk factors measured in the study included blood pressure, TC, LDL-cholesterol, TG, glucose values and HDL-cholesterol levels.

Similarly, a cross-sectional study of 2,319 Singaporean Chinese (1211F + 1108M), aged to 18-69 years, found that there are hierarchical changes of CVD risk factors along with increments of BMI ranges. Females with a BMI between 22.6-25 kg.m^{-2} and males with a BMI between 23.5-25.6 kg.m^{-2} are already having notable increased CVD risk factors (Deurenberg-Yap et al., 1999). A more recent report on 14,919 Hong Kong healthy Chinese males and females, aged 18-93 years, found that, BMI cut-offs for predicting CVD risk factors are between 23- 25 kg.m^{-2} (Ko & Tang, 2007).

Therefore, large cross-sectional studies of Chinese in China, Singapore and Hong Kong on the relationship between CVD risk factors and BMI supported that BMI cut-offs between 23-25 kg.m^{-2} may be appropriate for screening obesity in Chinese. In New Zealand, to identify overweight and obese people and develop intervention strategies, there is a need for published data on the relationship of BMI and %BF in Asian ethnic groups (Duncan et al., 2004).

A paper in preparation examines the body composition of 933 healthy volunteers (454 male and 479 female), aged 17-80 years, of the four different ethnic groups (European, Maori, Pacific and Asian Indian) (personal communication with Professor Elaine Rush). For example, a European woman with a BMI of 25 kg.m^{-2}, had a %BF of 35.1%, but in Asian Indian woman BMI was 19.9 kg.m^{-2} for the %BF (see Table 1.3). The gap in this data is that NZ Chinese is not included.

Table 1.3: BMIs corresponding to %BF in NZ ethnic groups aged 17-80 years

SEX	%BF	BMI equivalents (kg.m^{-2})				
		European	Asian Indian	Maori	Pacific	NZ Chinese
Women	35.1%	25	19.9	27.6	26.5	?
Women	43.3%	30	25	35.8	35.6	?
Men	20.2%	25	19.1	25.5	27.1	?
Men	29.6%	30	24.6	31.4	34.4	?

Unpublished data

1.2.4 Ethnic differences in fat distribution

An abdominal fat comparison of 200 healthy NZ premenopausal females, aged 18-51 years found that Indian females have much greater abdominal fat percentage (around the lumbar spine) than European, Chinese and Polynesian females at a fixed BMI (Orr-Walker et al., 2005). The difference is greatest in the youngest age group (aged 18-26 y). The abdominal fat percentage was assessed by antero-posterior scans of the lumbar spine using DEXA.

In the USA, a cross-sectional study of 1796 healthy adults, aged 18-96 years, including 4 ethnic groups: Caucasian, African-American, Hispanic-American and Asian, found that truncal fat is influenced by age, sex, ethnicity and total body fat (Wu et al., 2007). Body fat and truncal fat were assessed by DEXA. Asian is Eastern Asian origin (mainly Japanese, Chinese and Korean). After adjustment for age, height and weight, females have significantly higher %BF than males in all 4 ethnic groups. In addition, Asian have significantly higher %BF than Caucasian for males and females. At the mean age of 44.1 years, the differences in truncal fat (kg) between Asian and Caucasian are not statistically significant. However, at a fixed total body fat (16.6kg for male and 26.9kg for female), the increased amount of truncal fat associated with aging is significantly greater in Asian females than Caucasian females.

A recent study compared ethnic differences of abdominal fat, SAT and VAT among 195 aboriginal, 219 Chinese, 201 European and 207 South Asian people aged 30-65 years in Canada (Lear et al., 2007). SAT and VAT was assessed by CT, total body fat by DEXA. The authors found that: at given BMIs of 25 and 30 $kg.m^{-2}$, European has more body fat mass than Chinese and less body fat mass than South Asian; Chinese and European have no difference in abdominal fat, measured by CT; South Asian people have more abdominal fat than European and Chinese. At the same total body fat mass, Chinese and South Asian have greater amounts of VAT and SAT than Europeans. For example, at 20 kg of total body fat mass, Chinese and South Asian have 11.6% and 22.6% more VAT mass, respectively, than European. The comparison was adjusted for sex, education, humerus breadth, smoking status and physical activity.

In general, Chinese people may have more body fat than Europeans and less than Indians at a given BMI. In addition, Chinese people may have more truncal and abdominal fat and VAT than Europeans and less than Indians. The BMI cut-offs for obesity for Chinese is between 23-25 $kg.m^{-2}$.

1.2.5 Ethnic differences in bone mineral density

Most of the studies of ethnic differences in BMD are conducted in females as osteoporosis is more a concern in females particularly after menopause. DEXA is commonly used as a technique to measure BMD, which is expressed as the BMC per square centimetre of the projected area. The review below will focus on NZ studies and studies that have investigated Chinese, European and Indian groups in other countries.

An ethnic comparison of BMD at the lumbar spine, femoral neck, Ward's triangle and the trochanter, measured by a single DEXA, was conducted in 200 NZ females, aged 18-51 years (Cundy et al., 1995). The study found that when unadjusted, Polynesian have significantly greater BMD values at all 4 sites compared with the other three ethnic groups, and European have a significantly greater BMD than Chinese and Indian. After adjustment for size of the scanned area and BMI, Polynesian females remain the highest BMD among the 4 ethnic groups; there is no difference in BMD at almost 4 sites among European, Chinese, Indian females. The high BMD in Polynesian (Pacific people and Maori) females can help explain their lower hip fracture incidence (Brown et al., 2007). The female hip fracture incidence in NZ is summarized in Table 1.4. However, that Asian woman has such a lower hip fracture incidence than European woman can not be explained by the differences of BMDs between European and Asian (Chinese + Indian) reported above.

Table 1.4: Annual NZ female hip fracture incidence (per 10,000) between 2003 and 2005

Age	European	Maori	Pacific	Asian
>50 years	849.98	510.35	387.2	591.27

Values are calculated from Brown et al. (2007).

A Singapore study of 1222 Chinese, 122 Malays and 231 Indian females, aged 20-59 years, found that in all age groups (20-29, 30-39, 40-49, and 50-59 years), there is no significant difference in unadjusted lumbar spine BMD, measured by DEXA (Goh et al., 2004a). In the age group of 20-29 years, there is no significant difference in unadjusted femoral neck BMD among the three ethnic groups. However, in the other 3 older age groups, Chinese females have a significantly lower unadjusted femoral neck BMD than Indian females (0.928 ± 0.105 g/cm^2 vs. 0.975 ± 0.125 g/cm^2, $P < 0.05$). In addition, Chinese have significantly longer hip axis length than other 2 ethnic groups after adjustment for height (9.87 ± 0.52 cm vs. 9.69 ± 0.55 cm, $P<0.05$).

In contrast, an American study found that there are few significant differences in BMD between 103 Europeans and 103 Asians (most born in American) youth, aged 9-26 years (Bachrach et al., 1999). The authors explained that the similar diet and activity patterns in the 2 groups appeared to eliminate the ethnic differences in BMD, measured by DEXA. In this study, the Asian is not further characterized by ethnicity or geographical origin.

A comparison study among American community-based samples of European (N=1,550), African-American (N=935), Japanese (N=281), Chinese (N=250), and Hispanic (N=286) females, aged 42-52 years, found that Chinese females living in USA have lower BMD measured by DEXA at the lumbar spine and femoral neck than European females (Finkelstein et al., 2002). Furthermore, after adjustment for body weight and other covariates, BMD at lumbar spine are similar between them. However, in females weighing less than 70kg, most of Chinese females are in this category, Chinese has higher adjusted BMD at femoral neck than European, aged 42-52 years. These authors concluded the results may explain the higher fracture rates in European females than that in Chinese females. The covariates in the study included body weight, age at menarche, number of pregnancies, smoking, education level, physical activity, alcohol intake and calcium intake.

A Chinese-American study found that Chinese females (from mainland and Hong Kong) who had lived in the USA for less than 10 years had a lower BMD than those who had lived in the USA. for more than 20 years (Babbar et al., 2006). The mean age arrival in the USA was 45.3 years. The authors explained that living in the USA may have resulted in a calcium-rich diet and increased leisure-time physical activity in Chinese women, which can decrease the bone loss. When adjusted for body weight, Chinese women are not different from European in BMD. Furthermore, over half of the studied 359 Chinese women (with average age 63.0 ± 8.2) living in New York had osteoporosis, which is concerning.

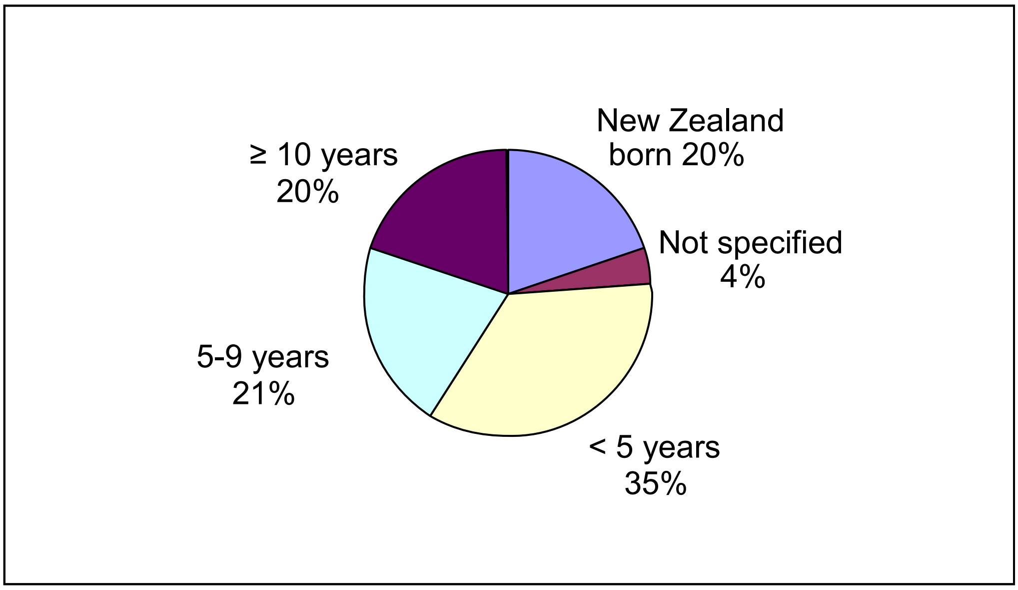
Differences in the confounding factors used across the studies make it difficult to compare results and draw definitive conclusions regarding the difference of BMD among Chinese, European and Indian. However, it is clear that BMD is affected by environment and body size and proportions.

1.2.6 New Zealand Chinese and the need for ethnic specific information

Chinese started to settle in New Zealand in the mid 1860s, about 140 years ago (Ip, 2003a). The NZ Chinese population reached 147,570 in 2006, accounting for 3.7% of the whole population in NZ (Statistics New Zealand, 2007). NZ Chinese is the largest Asian group in New Zealand. In fact, it has been referred as the New Zealand's largest non-European and non-Polynesian ethnic group (Ip, 2003a).

Two major periods of Chinese immigration occurred during the last 140 years: early settlement and recent arrivals. The early settlers arrived between 1865 and 1920, and the recent arrivals after 1987 (Ip, 2003b). New Zealand immigration policy had some critical changes in 1986 and again thereafter. Consequently the education status, language ability and financial status influenced the demographic characteristics of recently arrived Chinese migrants. In general from 1987, the new immigrants are better educated and skilled, and have much more investment capital than early settlers. Besides, early settlers came from rural south China, while most of new recent arrivals came from urban areas of Hong Kong, Taiwan, China. There are some features that the newly arrived Chinese and the third or fourth generation of the early settlers share. One is the physical appearance: yellow skin and black hair and eyes, which indicate that the two Chinese groups have close genetic connections. Other features include the enjoyment of oriental foods and a focus on education and family. The proportion of the recent arrivals after 1987 is more than half of the whole NZ Chinese, as shown in the Figure 1.2 below. In addition, as a result of immigration policies in NZ, NZ Chinese and other Asian ethnic groups have much more youthful population structures than the total population (Table 1.4), with the greatest percentage being aged 25-44 years, followed by the 15-24 years category for Chinese group.

Figure 1.2: Distribution of duration of residence in New Zealand for Chinese



Adapted from Ministry of Health (2006)

Table 1.5: Age and sex distribution of Asian groups, percent

Age group (years)	Chinese		Indian		Other Asian		New Zealand total	
	Male	Female	Male	Female	Male	Female	Male	Female
0-4	6.9	6.1	8.3	8.0	7.9	6.6	7.6	6.9
5-14	14.3	12.3	16.9	16.5	19.7	15.1	16.2	14.7
15-24	26.0	22.3	16.4	17.5	23.7	20.4	13.9	13.1
25-44	28.1	33.2	36.4	37.0	32.4	40.7	29.2	30.2
45-64	18.8	20.2	18.5	17.1	14.0	14.6	22.3	21.8
65+	6.0	5.8	3.5	3.8	2.3	2.6	10.8	13.3

Adapted from Abbott et al. (2006)

Despite the long history of Chinese in NZ, only in the recent decade, health status and specific health issues for NZ Chinese have started to be noted. Using WHO BMI cut-off points, BMI >30kg.m^{-2}(obese) and 25.0-29.9 kg.m^{-2} (overweight), Asian as an all encompassing group have lower rates of overweight and obesity than European (20% vs.36% and 5% vs. 20%, respectively) (Scragg & Maitra, 2005). Scragg and Maitra also reported that NZ Chinese has the lowest rates of overweight and obesity after dividing the Asian group into Chinese, South Asian (Indian and Sri Lankan), Korean, and South-East Asian (Japanese, Indonesian, and other Asian). If using ethnic-specific BMI cut-off points, BMI >25kg.m^{-2}(obese) and 23.0-24.9 kg.m^{-2} (overweight) for Asian, European have lower obesity rates than Indian and higher than NZ Chinese; and Chinese have significantly lower obesity rates than Asian Indian (20.1% vs.34.2% for male and 10.5% vs.52.9% for female) (Ministry of Health, 2006). There are 3 subgroups used in the Asian Health Chart Book 2006: Chinese, Indian and other Asian. A major finding reported in this book is that Asian Indians have significantly more cardiovascular disease hospitalization, higher CVD mortality rates and higher prevalence of self-reported doctor-diagnosed diabetes than NZ Chinese. The prevalence of self-reported diabetes in Indian is 3 times higher than the NZ population, and the high CVD mortality rates in Indian would be associated with the high prevalence of diabetes in Indian. Consistent with the foetal origins of adult diseases hypothesis, that small babies have more CVD risks, the risk of low birth weight is about 70% more in Indian than the whole NZ population. NZ Chinese show significantly less prevalence of low birth weight than the whole population (ibid).

Despite the ethnic difference, the Asian health Chart Book 2006 also illustrated the migration effect on health. For example, age-standardised cardiovascular disease mortality among NZ Chinese significantly increases with duration of residence in NZ in a dose-response manner. Similarly, age-standardised cancer death rates among Chinese living in NZ less than 5 years is lower than those living in NZ>5 years. In addition, the duration of years in NZ is significantly correlated to the likelihood of self-reported high blood cholesterol, high blood pressure and being obese. Furthermore, a cross-sectional study report that the most recent Chinese migrant (< 5 years), aged 15-85 years, have better self-rated health than those with residency of more than 5 years (Abbott et al., 2000). In general, recent migrants are healthier than the long-standing migrants and NZ-born. Such a healthy immigration effect has been recognized internationally (McDonald & Kennedy, 2004). Acculturation into a higher energy dense diet and less physically active lifestyle may be partly responsible for the less healthy condition in longer standing migrants than recent arrivals. For example, a much higher intake of dairy products with lower consumption of cereal are found in both mainland Chinese women (20-45 years) and older mainland Chinese (>60 years) living in Auckland than Chinese living in urban areas of China (Tan, 2001; Xie, 2003), which may indicate the adoption of a typical westernized diet that contains a lot of saturated fat and calcium.

It is anticipated that the health problems of the Asian population may increase with the decreasing proportion of recent arrivals among Asian in NZ. Coupled with the aging population in NZ, such increasing health problems in Asian and, of course, in other ethnic migrants, there could be a huge impact on our already heavily burdened health sectors. It is not surprising that the health requirement for immigration to NZ has been tightened. After 28th November 2005, applicants with any conditions considered dangerous to public health (infectious diseases, such as HIV infection and pulmonary tuberculosis), and with conditions which may impose significant cost or demands on the NZ health services or special education services can not be approved for residence in NZ (New Zealand Immigration Services, 2005). One example of such costly conditions is cardiac disease including ischaemic heart disease, cardiomyopathy and valve disease requiring surgical and/or other procedural intervention. No doubt, this health selection change in immigration policy may result in a remarkably healthy immigration effect on the health of migrants who arrived in NZ after 2006.

However, to improve the health of all New Zealanders, it is not enough just to change the health requirement of immigration. The New Zealand healthy eating – healthy action (HEHA) strategy and implementation plan were developed by Ministry of Health to guide concerted efforts to improve nutrition, increase physical activity and reduce obesity in New Zealand at a population level (Ministry of Health, 2003b, 2004). Key population health messages of HEHA are listed in the following (Ministry of Health, 2003b):

- Eat a variety of nutritious foods.
- Eat less fatty, salty, sugary foods.
- Eat more vegetables and fruits.
- Fully breastfeed infants for at least six months.
- Be active every day for at least 30 minutes in as many ways as possible.
- Add some vigorous exercise for extra benefit and fitness
- Aim to maintain a healthy weight throughout life.
- Promote and foster the development of environments that support healthy lifestyles.

In addition, the 5+ A Day promotion program was introduced in New Zealand in 1994, mainly in preschool and primary schools (5+ A Day, 2007). This is to encourage increase of consumption of vegetables and fruits in New Zealand by increasing nutritional knowledge and positive attitudes to vegetables and fruits. Recently, a survey in preschool children and school children's families found that the positive attitude to fruits and vegetables and intake of fruits and vegetables are greater in NZ Europeans than non-Europeans, and less in NZ Asians than non-Asians (Ashfield-Watt, 2006).

It is unknown whether or not these health messages of HEHA and 5+ A Day have influenced NZ Chinese. It is difficult to engage with the Chinese communities as indicated in recent reports and research. NZ Chinese have low levels of healthcare service utilisation, especially in clinical preventive services (Ministry of Health, 2006). Language is the main barrier of the access issue of health and other public social services in NZ Chinese (DeSouza & Garrett, 2005).

The latest national survey shows that the prevalence of adults who eat at least three servings of vegetables and two servings of fruit is lower in NZ Chinese than European (25.9% vs.32.1% for males and 39.8% vs. 52.7% for females) (Ministry of Health, 2003d, 2006). NZ Chinese are significantly less physically active than Europeans and the total population. In addition, Tan reported that most mainland Chinese females in the study (residence less than 5 years in NZ) reported decreased physical activity and increase of their body weight after immigration (Tan, 2001). Therefore, NZ Chinese need to respond to the health message to increase their fruit and vegetable consumption and physical activity as well as other ethnic groups do. On the other hand, NZ Chinese have a better profile of behavioural risk factors than European. For example, the self-reported hazardous drinking and tobacco consumption are much lower in NZ Chinese than in European and the total population (Ministry of Health, 2006).

The Asian Health Chart Book 2006 is a starting point to provide evidence for differences in health outcomes and factors influencing health between NZ Chinese and Indian. In general, there is lack of health research relevant to NZ Chinese. To the best of my knowledge after an extensive literature search, there is no research that has been conducted using DEXA to measure the whole body to analyse total body composition, body fat and fat distribution in NZ Chinese.

1.3 Aims

The primary aims of this study were to:

- Collect and describe body composition data for NZ Chinese aged 30-39 years.
- Compare the relationships of BMI and body fatness of Maori, Pacific people, Asian Indian and European people with NZ Chinese aged 30-39 years.
- Compare NZ Chinese body composition data with other NZ ethnicities, especially Europeans and Asian Indian, aged 30-39 years.

The secondary aims of this study were to:

- Evaluate the association of %BF/fat distribution with birth weight, as well as the link between CVD risk factors (e.g., blood pressure, fasting blood glucose level) and birth weight. These results may test the foetal origins of adult diseases hypothesis in these participants.
- Investigate lifestyle factors (e.g., fruit & vegetable consumption, physical activity), CVD risk factors and awareness of the nutrition messages promoted by HEHA and 5+ A Day in this study group. This information may help design future intervention strategies in reducing obesity for Chinese.

1.4 Hypotheses

It was hypothesised that:

- NZ Chinese, for the same height and weight, have more body fat (measured by DEXA) than Europeans but less than Asian Indians.
- BMI cut-off for obesity for NZ Chinese is between 23-25 $kg.m^{-2}$. The proposed BMI cut –off used in the Asian health chart book, 23 $kg.m^{-2}$ for overweight and $\geq$ 25 $kg.m^{-2}$ for obesity (Ministry of Health, 2006) is more appropriate for NZ Chinese than in Asian Indian.
- NZ Chinese, for the same height and weight, have more abdominal fat than Europeans but less than Asian Indians. NZ Chinese have greater abdominal to thigh fat ratio and central to appendicular fat ratio than Europeans but less than Asian Indians.
- NZ Chinese, for the same weight, have the similar whole body BMD to Europeans and Asian Indians.

- Those born with a lower birth weight have more body fat (measured by DEXA) at adulthood than those born with a higher birth weight (foetal origins of adult diseases hypothesis).
- Increased body fatness is associated with low physical activity levels.

1.5 Significance

This study should provide essential data on the relationships between body composition, body fat and body size in NZ Chinese aged 30-39 years relative to other main ethnic groups in NZ. This need has been identified by the Ministry of Health and the WHO to help understand the higher risk of disease at a lower BMI. In addition, the study includes the association of birth weight and body composition in later life, which links with the foetal/developmental origins of adult disease hypothesis in the NZ Chinese ethnic population.

Furthermore, the results from this study may help participants as well as the NZ Chinese ethnic group as a whole become more aware of their unique body composition. Findings from the thesis may help in the future design of intervention strategies which focus on supporting the Chinese ethnic population to maintain healthy behaviours throughout their lives.

CHAPTER 2: DESIGN AND METHODS

This chapter describes how and what was done to meet the purposes of the thesis. Firstly the design and then the methods of measurement and data analysis are explained.

2.1 Design

2.1.1 Brief overview

Ethics approval (number 06/172) was gained from the Auckland University of Technology Ethics Committee on the 17th November 2006 for a period of three years (Appendix 1). The information sheets and consent forms were written in both English and Chinese (Appendices 2, 3, 4 and 5 respectively). The translation to Chinese was carried out by the researcher.

This study was a stratified (male and female) convenience study with participants aged 30-39 years selected by BMI to cover a range of body fatness, height and weight. One hour visit to the body composition unit in the Department of Surgery (University of Auckland, 3rd floor, Auckland City Hospital Support Building, Park Road, Auckland) was required from each participant. Each visit was arranged in the mornings and the participants were asked not to eat or drink anything except water for at least 8 hours prior to the tests. They were also asked to empty their bladder before any measurements were made. Each participant was assigned a unique identification number and proceeded through the required measurements in a set pattern which was recorded on a protocol sheet (Appendix 7). At the end of the measurements, each participant was provided with a \$20 petrol voucher to cover the travel expenses of the visit. The data was collected from 8th December 2006 to the end of March 2007.

All participants underwent measurement of anthropometry, whole body fat, lean mass and BMC by DEXA, and screening tests for blood pressure, fasting glucose and lipids. Each participant completed a questionnaire focusing on general diet, physical activity, birth history, health knowledge and socio-demographic data. Confounding variables (e.g. smoking, alcohol consumption) were also collected by questionnaire.

Comparative analysis of the body composition by DEXA of European, Maori, Pacific people (measured previously) with NZ Chinese (measured in this study) would be analysed separately by sex. The comparison data would be matched by age to the NZ Chinese data.

2.1.2 Participants

2.1.2.1 Determination of sample size

Previous research investigating differences in body composition has shown that between Asian Indian and European males of the same height and weight, there is an average difference of 7.6% body fat with a standard error of 1.4% (Rush et al., 2004). Power calculations indicated that if 20 NZ Chinese males of a range of body fatness were measured and were on average 3% more fat than Europeans of the same age range (already measured) the likelihood of not finding a true difference would be less than 1 in 100. Therefore, the sample size for this study was determined as minimum of 40 participants: 20 female NZ Chinese and 20 male NZ Chinese.

2.1.2.2 Determination of sample characteristics exclusion and inclusion criteria

A NZ Chinese individual is considered to be any person whose family originates from mainland China (including Taiwan Chinese, Singapore Chinese, Malaysian Chinese and Mainland Chinese, etc.) who is now living in New Zealand. All four grandparents must be self-identified as Chinese. In line with other ethnic data Chinese participant needed to have been a resident in New Zealand for at least 3 years to allow adaptation to the local environment (including food supply and physical activity patterns).

It was decided to study NZ Chinese aged 30-39 years for two reasons. Firstly, it was relatively easier to recruit healthy participants from younger age groups than older age groups, and secondly, to reduce the variability of the confounding variable of age. As the study used a DEXA scan involving a small amount of X-ray, those women who were pregnant or planning to be pregnant were excluded. In addition, body composition and fat distribution are affected by breastfeeding, lifting weights, the presence of illness and using anabolic steroids (Butte & Hopkinson, 1998; Solomon & Bouloux, 2006). Thus, exclusion criteria were: breastfeeding women, pregnant or planning to be pregnant women, those individuals who lifted weights more than once a week, had major health conditions, were unwell at the time of the measurements, or used anabolic steroids or other drugs that may alter body composition.

2.1.2.3 Participant recruitment

For the purposes of ethnic comparison across a range of body fatness, participants with a range of BMI values as a surrogate for body fatness were recruited. Potential participants were recruited from Auckland by advertisements in Chinese communities (Appendix 6) and personal contacts. Those who were interested in volunteering were sent the information sheets and consent forms written both in English and Chinese, along with a detailed map of Auckland City Hospital. A follow up telephone call was made to the potential participant to discuss the project and an appointment was made for the participant's visit to Auckland City Hospital.

2.2 Measurements

The researcher undertook specific training in techniques of all measurements before commencing the data collection. The measurements, including the DEXA scan and health screening, were all conducted by the researcher under the supervision of Professor Elaine Rush and Associate Professor Lindsay Plank.

2.2.1 Anthropometry

Repeat measurements of height to within ±0.5 cm, body weight to within ±0.1 kg and circumferences to within ±0.5 cm were made and the average of the measurements within the required precision used in data analysis.

Standing heights, sitting heights and weights were measured using a set of scales made in England by Avery, Birmingham (Type: 3306 ABV, Number: S-813020). This set of scales was a standard mechanical weighing scale and not easy to move i.e. very stable. It was always placed in the same room next to the DEXA scan laboratory and calibrated regularly. The body heights and weights were measured to the nearest 0.1 cm and 0.1 kilogram, respectively.

The participants' arm, waist and hip were measured using non-stretch tape (Figure finder tape measure, Novel products line, Rockton, IL, USA) with a device to ensure that constant tension was applied to within 0.5 cm. When measurements were taken, the measurer's eye was at the same level as the scale, tape and ruler to avoid any error of parallax. All anthropometry measurements were made with participants wearing light clothing and without shoes and are described in more detail below.

2.2.1.1 Standing height

The participants were asked to stand on the centre of the platform of the scale with their back, shoulder blades, buttocks and heels against the measuring rail of the scale. If there was any extra hair (e.g. a pony tail) or accessories on the top of the head the participant was asked to remove them. The head was positioned in the Frankfort plane and the participant asked to take a breath in and draw themselves to their full height. A horizontal plate on the same scale was placed over the participant's head firmly without exerting extreme pressure.

2.2.1.2 Sitting height

The participants were asked to sit on a stool with their back and shoulder blades against the measuring rail of the scale. A horizontal plate on the same scale was placed over the participant's head firmly without exerting extreme pressure. The stool's height was subtracted from the recorded height.

2.2.1.3 Body weight

The participants were asked to stand still on the platform of the scale with weight evenly distributed between the two feet. Participants' clothing items were recorded and their estimated weight was subtracted later from the recorded body weight.

2.2.1.4 Mid upper arm circumference

The participants were asked to hang their right arm in a relaxed position by the side of their body. The midpoint of the right upper arm was marked after measuring the distance from the lateral acromion process to the anterior cubital fossa at the front. A second point was identified as midway from the lateral acromion process to the tip of the olecranon process. The girth was measured with the non-stretch tape aligned with these two points.

2.2.1.5 Waist circumference

The unclothed WC was measured at the midpoint between the lower costal (rib) border and the iliac crest. The midpoint was marked at the right side of the waist. The participants held the zero end of the non-stretched tape at the marked midpoint and the measurer walked around the participant with another end of the tape to avoid any unnecessary embarrassment. The participants were then asked to stand straight with their abdomen relaxed, arms at their sides and their feet together while the measurment was recorded.

2.2.1.6 Hip circumference

The hip circumference was measured over the participants' tight shorts or trousers with their feet together and with their gluteal muscles relaxed. The participants were asked to assist in dropping down of the non-stretched tape to the hip area after measurement of the WC. The measurer stood at the right side of the participant to ensure the tape was held in a horizontal plane at the greatest posterior (gluteal) protuberance of the buttocks when the measurement was taken.

2.2.2 Sagittal diameter

Supine sagittal body thicknesses were measured using two rulers (TAURUS 300F5c & 400F5c, NZ) to the nearest 0.1 cm. The supine sagittal body thickness at the chest (nipple line) and the highest point of the abdomen were measured before the DEXA scan when the participants wearing light clothing were supine on the bed. Two rulers (one perpendicular and the other horizontal) were used to obtain the thickness.

2.2.3 Body composition and fat distribution measurements

2.2.3.1 DEXA Scan

Each participant had a whole-body DEXA scan by a single DEXA machine (model DPX+ with software version 3.6y, Lunar Radiation Corp., Madison, WI) from head to toe to obtain the whole and regional fat, lean and BMD. This DEXA machine used two X-ray wavelengths: 38 keV and 70 keV. R-value is the ratio of 38 KeV attenuation to 70 keV attenuation (Lunar Radiation Corporation, 1992b). The manufacturer's software algorithm converts the R values for each measurement point to lean, fat and bone mineral proportions. The manufacturer-programmed quality assurance checks were carried out on the DEXA machine every 24 hours.

The participants were instructed to lie face-up on the bed with bare feet, hands next to the body, palms down and legs slightly apart (Appendix 8). Only the body part being scanned needed to be kept still at any one time. This involved lying with light clothing on the table for between 20 to 40 minutes dependent on the body size, length and thickness of the participant. See the instruction for operation of the DEXA scanner and software in Appendix 9. The result printouts could be obtained at the end of the analysis program (Appendix 10) and one copy was given after explanation to the participant.

2.2.3.2 Total body scan analysis

Each total body scan file was digitally adjusted by the researcher to obtain the best interpretation and set standard areas using anatomical landmarks. Firstly, the researcher adjusted the grey scale of the image values to make the soft tissue boundaries clear on the screen. Then, the extended research mode was selected to analyze total body scans (Lunar Radiation Corporation, 1992a). In this mode, the total body was divided by digital lines into four main regions: head, trunk, arms and legs. The trunk was further divided into three regions: ribs, spine and pelvis. The spine was subdivided into the thoracic and lumbar regions. The locations of cut regions of each total body scan image were adjusted according to the following sequence and position in Table 2.1:

Table 2.1: The locations of cut regions of total body scan image

Sequence	Name of the cut	Anatomical position of the cut
1	Neck	Below the jaw bone with clear shoulder
2	Right arm	Through the right humeral head without touching the ribs, pelvis or greater trochanter
3	Right rib	Close to but not touching the right side of the spine
4	Centre	Through the centre of the body
5	Left rib	Close to but not touching the left side of the spine
6	Left arm	Through the left humeral head without touching the ribs pelvis or greater trochanter
7	Dorsal	At the site of the first rib or below the T12
8	Pelvis	One pixel above the pelvis
9	Lumbar	A square surrounding the last vertebra above the pelvis and the part of the spine in the pelvis region
10	Pelvis tip	At the site where the two angled lines pass through the femoral necks.

Finally, the LUNAR software calculated BMD, mass of fat tissue, mass of lean tissue, and the percentage fat mass for the total body and anatomical sub regions. The analysis results were printed out for later entry into the database for analysis.

2.2.3.3 Bone length determination

Bone lengths were determined using the right side of the DEXA image. Humeral length, radial length, femoral length, tibial length, and total subject skeletal length were calculated from the x and y co-ordinates on the digitized image of proximal to distal points on the bones.

Specifically, humeral length was measured from the top of the humeral head to the distal point on the trochlea of the humerus. Radial length was measured from the top of the head of radius to the distal point of the styloid process of radius. Femoral length was measured from the proximal point of the femoral head to the middle of the patellar surface. Tibial length was measured from the proximal point of the intercondylar eminence to the distal point of the medial malleolus. Total skeletal length was measured from the apex of the cranium to the plantar surface of the calcaneus bone.

The equation used to derive length from proximal (P_x, P_y) and distal (D_x, D_y) co-ordinates of each of bone landmarks was:

$$\text{Bone length} = \sqrt{((Dy - Py) * 0.98)^2 * + ((Dx - Px) * 0.48)^2} \text{ (cm)}$$

The equation was developed from calibration scans made by the researcher using trigonometric principles. Dimensions were measured in pixels and then converted to centimetres (cm) from a calibration scan of an aluminium ruler on the DEXA. One pixel on the y axis was equal to 0.98cm and on the x axis 0.48 cm. The calibration scan of an aluminium ruler was a whole-body DEXA scan of a ∏ shape aluminium ruler with 6 phantoms, which represented soft tissues of head, trunk, left and right arms and left and right legs.

2.2.3.4 Regional fat distribution analysis

Abdominal and thigh regional fat information was obtained by region of interest analysis using the whole-body DEXA scan (Lunar Radiation Corporation, 1992c). The region of abdominal fat was determined to be the maximum abdominal tissue area between the upper horizontal border (about parallel with the junction of the T12 and L1 vertebrae) and the lower border (on top of the iliac crest). The region of thigh fat was positioned just below the ischial tuberosities with the side of the region following the shape of the thighs and was set at the same height as the abdominal region (Appendix 11).

2.2.4 Resting blood pressure and pulse

Systolic and diastolic blood pressures were measured on the left arm using a digital blood pressure monitor (OMRON T5 Blood Pressure Monitor with Fuzzy Logic. Model: T5 HEM-762-C1, Rating: DC 6V 4W, Serial No.: 2902712L, Japan). The measurements were made after the DEXA scanning to ensure optimal relaxation of the participant. The participants were asked to keep lying face-up on the bed and place their left arms aside their body with palms facing upwards. The digital blood pressure monitor automatically read the systolic and diastolic blood pressures and the pulse. The measurement was repeated until both systolic and diastolic were within 10 mmHg of each other and the heart rate readings were within 10 beat per minute.

2.2.5 Point of care testing

To ensure a good circulation to the fingers, the participants were asked to wash their hands with soap and warm water and then dry their hands thoroughly. To further improve the circulation to the fingertips, the participants were asked to open and close their hands a few times and to hang their arms down. Three drops of capillary blood were sampled from the side of the left finger using a disposable lancet in a retractable spring loaded device (Accu-CHEK softclix Pro). The blood droplets were immediately placed on specific strips for analysing the blood glucose, cholesterol and triglyceride concentrations. Blood glucose was measured by the Accu-CHEK Advantage metre Blood Glucose System (made in USA). Accu-Chek advantage II Glucose strips code: 398 Lot 449398, expire June 2007. Total cholesterol and triglycerides levels were measured by Accutrend GCT metre (made in Mannheim, Germany). Accutrend Cholesterol strips code: 041, Lot 24804121 expire June 2007. Accutrend Triglycerides strips code: 675 Lot 24767521 expire October 2007. The participants were instructed to refrain from eating and drinking any food or beverage aside from water for at least eight hours before the blood testing.

2.2.6 Questionnaire

This was administered verbally to the participants while they were being measured by the DEXA scan. The questionnaires were written in both English (Appendix 12) and Chinese (Appendix 13). Participants could choose either version of the questionnaire to be administered.

Most of the questions in the questionnaire were adopted from the following sources:

- Qualitative Food Frequency Questionnaire, National Nutrition Survey 1996 (Quigley & Watts, 1997).
- Physical activity and Nutrition in New Zealand Questionnaire (Sport & Recreation New Zealand & Cancer Society, 2005).
- New Zealand Health Survey Questionnaire 2003 (Thompson et al., 2005).
- General nutrition knowledge questionnaire for adults (Parmenter & Wardle, 1999).

The questionnaire had 4 components:

1. Vegetable, fruit, tobacco and alcohol consumption patterns, and physical activity levels.
2. Birth weight, maternal smoking and birth history data.

3. Knowledge/Awareness of the HEHA key messages in the group.
4. Socio-demographic data.

2.3 Data processing

All data on the protocol sheet and DEXA results were reviewed by the investigator at the end of each visit and data was entered to the Excel™ sheet as soon as possible. To minimise error, an AUT Master's student (Purvi Chhichhia or Sunnie Xin) checked the data entry.

2.4 Statistical analysis

SPSS, version 14.0 (SPSS Inc, Chicago, IL) was used for the statistical analysis. The 5% level was chosen for statistical significance.

Continuous variables were examined whether they had normal distributions and for all the presented data distributions were normal (Peat & Barton, 2005). The continuous variables were expressed as mean ± standard deviation (SD) and range. Two tailed independent t-test was used to compare the continuous variables for male and female groups in NZ Chinese. Categorical variables were reported as frequency and percentage (%).

Bivariate correlations were used to investigate relationships between variables: birth weight, anthropometry, body fat by DEXA, fasting blood biochemical and physical activity parameters using the Pearson's product-moment correlation coefficient (r), and 95% confidence intervals (CI) for the value calculated using an Excel spreadsheet provided by Professor Will Hopkins.

As there is a curvilinear relationship between %BF and BMI, BMI was transformed to the logarithm before linear regression analysis. Similarity of regression slopes among the ethnic groups was verified by examining the significance of the interaction between the covariate(s) and the group variable. The regression equations for predicting %BF from logBMI for the ethnic groups were examined for the significance of the elevations. When a significant difference of elevation was found, the ethnic groups then were recoded to provide common slope regression equations for these groups. The process will be illustrated in more detail in results section regarding the association of %BF and BMI. Both the standard error of the estimate (SEE) and the coefficient of determination (R^2) are reported to provide a measure of the accuracy of the prediction.

2.5 Feedback to participants

A copy of the body composition result was available to each participant immediately after the completion of the DEXA measurements. An explanation of the DEXA and health screening results was made to each participant by the researcher. In addition, at the end of the study, copies of a summary of overall results were sent to the participants who had requested (Appendix 15).

CHAPTER 3: RESULTS

The results chapter has been divided into three sections. Section A comprises data concerning demographic, anthropometric, birth history, DEXA and metabolic screening measurements conducted on 20 male and 23 female NZ Chinese aged 30-39y. Section B details the comparison of DEXA measures of NZ Chinese with previously collected DEXA measures on European, Maori, Pacific people and Asian Indian in the same age range. Section C presents the body composition data of NZ Chinese in the context of health behaviours of the NZ Chinese participants.

3.1 Section A: Main data collected

3.1.1 Demographic details

Table 3.1 below presents the mean age of participants and length of their NZ residence. The mean age of all participants was 36 years ranging from 30- 39 years and their average stay in NZ was 85 months. No participants were born in NZ. All except one of the participants were tertiary educated, 25 (58.1%) were in full time employment and 26 (60.5%) had an annual income greater than NZ$45000 (Table 3.2).

Table 3.1: Mean age of the NZ Chinese participants and length of residence in New Zealand

Variable	Females (N=23)	Males (N=20)	Total (N=43)
Age	36 ± 2	36 ± 2	36 ± 2
	(31-39)	(30-39)	(30-39)
Months in NZ	90 ± 50	78 ± 45	85 ± 48
	(37-204)	(36-192)	(36-204)

Values are mean ± SD; Range in parentheses; NZ, New Zealand.

Table 3.2: Socioeconomic indicators of the NZ Chinese participants

Socio economic indicators	Females (N=23)	Males (N=20)	Total (N=43)
Highest qualification			
Secondary school qualification	0	1 (5.0%)	1 (2.3%)
Bachelors degree	8 (34.8%)	11 (55.0%)	19 (44.2%)
Masters degree	6 (26.1%)	5 (25.0%)	11 (25.6%)
PhD	1 (4.3%)	0	1 (2.3%)
Diploma (not Post Graduate)	5 (21.7%)	1 (5.0%)	6 (14.0%)
Diploma – Post Graduate	2 (8.7%)	0	2 (4.7%)
Trade or technical certificate	0	2 (10.0%)	2 (4.7%)
Professional qualifications	1 (4.3%)	0	1 (2.3%)
Employment			
Working full-time	14 (60.9%)	11 (55.0%)	25 (58.1%)
Working part-time	2 (8.7%)	2 (10.0%)	4 (9.3%)
Unemployed	1 (4.3%)	1 (5.0%)	2 (4.7%)
At home	4 (17.4%)	0	4 (9.3%)
Student	2 (8.7%)	3 (15.0%)	5 (11.6%)
Personal investor	0	3 (15.0%)	3 (7.0%)
Annual income			
Less than $14999	3 (13.0%)	1 (5.0%)	4 (9.3%)
Between $20000-$29999	1 (4.3%)	1 (5.0%)	2 (4.7%)
Between $30000-$44999	3 (13.0%)	8 (40.0%)	11 (25.6%)
Between $45000-$59999	7 (30.4%)	3 (15.0%)	10 (23.3%)
More than $60000	9 (39.1%)	7 (35.0%)	16 (37.2%)

Values are number (%); PhD, the degree of Doctor of Philosophy.

3.1.2 Anthropometric measurements

In order to investigate any differences in body composition between males and females, the data are presented separately for males and females.

3.1.2.1 Height, weight and sitting weight

Table 3.3 presents physical characteristics of NZ Chinese. On average, Chinese males were 11.0 cm taller and 16.0 kg heavier than Chinese females ($p<0.001$). Mean BMI of Chinese males was 2.8 $kg.m^{-2}$ greater than Chinese females ($p=0.002$). Chinese males had 5.7 cm higher sitting height than females ($P<0.001$), however, had the same mean sitting height to height ratio (SH/H) as Chinese females.

Table 3.3: Physical characteristics of the NZ Chinese participants

Physical characteristics	Females (N=23)	Males (N=20)	P value
Height (cm)	160.0 ± 5.3 (150.8-169.6)	171.0 ± 4.3 (162.7-177.2)	<0.001
Weight (kg)	54.5 ± 6.7 (44.4-67.5)	70.5 ± 11.2 (46.6-95.8)	<0.001
BMI ($kg.m^{-2}$)	21.2 ± 2.1 (18.1-26.6)	24.0 ± 3.5 (17.5-32.4)	0.002
Sitting height (cm)	85.3 ± 3.0 (80.4-92.0)	91.0 ± 3.2 (84.0-96.2)	<0.001
SH/H	0.53 ± 0.01 (0.51-0.55)	0.53 ± 0.01 (0.51-0.55)	0.714

Values are mean ± SD; Range in parentheses; BMI, body mass index: SH/H ratio, sitting height to height ratio; P value calculated using two-tailed independent t-test.

Table 3.4 illustrates the distribution of BMI of the participants with WHO recommendation. Using the WHO BMI standard (WHO, 2003a), 5% of the males were obese and 30% of males were overweight. Only 4.3% of females were overweight and none were obese.

Table 3.4: Distribution of BMI of the NZ Chinese participants with WHO recommendation

BMI ($kg.m^{-2}$)	<18.5 Underweight	18.5-24.99 Normal	25-29.99 Overweight	>=30 Obese
Females (N=23)	2 (8.7%)	20 (87.0%)	1 (4.3%)	0
Males (N=20)	2 (10.0%)	11 (55.0%)	6 (30.0%)	1 (5.0%)

Values are number (%); BMI, body mass index; WHO, world health organization.

3.1.2.2 Girths, mid upper arm circumference and sagittal diameter

The unadjusted measurements for fat distribution and results are presented in Table 3.5. Males displayed greater measurements than females for all instances. On average, Chinese male had a 10.2 cm greater WC (P<0.001), a 4.8 cm greater HC (P=0.009), and a 3.6 cm more mid upper arm circumference (MUAC) (P<0.001) than Chinese female. WHR of males was 0.06 higher than females (P<0.001).

Table 3.5: Fat distribution by anthropometry of the NZ Chinese participants

Variables	**Females (N=23)**	**Males (N=20)**	**P value**
Waist circumference (cm)	75.6 ± 6.6	85.8 ± 9.9	<0.001
	(65.2-89.5)	(64.0-106.0)	
Hip circumference (cm)	93.3 ± 4.2	98.1 ± 7.0	0.009
	(84.5-100.9)	(81.3-113.0)	
WHR	0.81 ± 0.05	0.87 ± 0.05	<0.001
	(0.69-0.94)	(0.76-0.94)	
Mid upper arm circumference (cm)	26.5 ± 2.6	31.1 ± 3.7	<0.001
	(22.1-32.1)	(24.4-41.0)	
Sagittal chest diameter (cm)	18.2 ± 1.4	20.6 ± 2.1	<0.001
	(15.8-20.2)	(16.3-24.4)	
Sagittal abdominal diameter (cm)	16.4 ± 1.5	18.6 ± 2.4	0.001
	(14.3-19.5)	(14.3-24.4)	

Values are mean ± SD; Range in parentheses; P value calculated using two-tailed t-test; WHR, waist to hip ratio; P value calculated using two-tailed independent t-test.

The distribution of WC data is presented in Table 3.6. According to the ethnic-specific WC cut-offs (International Diabetes Federation, 2005), 5 females and 8 males were classified as centrally obese.

Table 3.6: Distribution of waist circumference of the NZ Chinese participants

	Females (N=23)		**Males (N=20)**	
Waist circumference	<80 cm	≥80 cm	<90cm	≥90cm
	18 (78.3%)	5 (21.7%)	12 (60.0%)	8 (40.0%)

Values are number (%); Waist circumference cut-off value obtained from International Diabetes Federation (2005); WHR, waist to hip ratio.

The between sex difference in WC adjusted for weight was not significant (Table 3.7), but there was a significant difference (~4cm) in adjusted HC (P<0.001) when adjusted for weight. Height was not a significant covariate (P=0.363 for WC, P=0.146 for HC) and was not included in this analysis.

Table 3.7: Girths adjusted for weight

Dependent variables	Female		Male		P Value
	Mean	SE	Mean	SE	
Waist circumference (cm))	81.5	1.0	79.0	1.1	0.136
Hip circumference (cm)	97.6	0.5	93.1	0.6	<0.001
Sagittal chest diameter (cm)	19.4	0.2	19.1	0.2	0.505

SE, standard error; P value calculated using two-tailed independent t-test.

Unadjusted mean sagittal chest diameter (SCD) of Chinese males was 2.4 cm thicker than females (P<0.001) and unadjusted sagittal abdominal diameter (SAD) was 2.2 cm thicker (P=0.001). After adjustment for weight (61.9kg), the SCD difference was not significant (P=0.505). Again, the height was not a significant (P=0.413) covariate and was not included in this analysis. Both height and weight were significant, positive covariates for MUAC and SAD in men and women. After adjustment for weight (61.9kg) and height (165.1 cm), the sex difference in MUAC or SAD was not statistically different (Table 3.8).

Table 3.8: Arm circumference and abdominal diameter adjusted for weight and height

Dependent variables	Female		Male		P Value
	Mean	SE	Mean	SE	
Mid upper arm circumference (cm)	28.3	0.3	29.1	0.4	0.184
Sagittal abdominal diameter (cm)	17.5	0.2	17.4	0.2	0.718

SE, standard error

In general, Chinese males, relative to body weight, had smaller hips than females but other proportions relative to body weight and height were not different.

3.1.3 Body Composition by DEXA

Unadjusted total body composition measurements by DEXA are summarised in Table 3.9. On average, Chinese males had more FFM, more BMC, higher BMD and more appendicular skeleton muscle mass (ApSM) than Chinese females (P<0.001). Absolute mean body fat mass was not different between males and females.

Chinese females had significantly more %BF, truncal fat (%) (P=0.024), abdominal fat (%), and thigh fat (%) than Chinese males (P<0.001). However, C/Ap fat ratio and A/T fat ratio of females were smaller than those of males (P<0.001). Figure 3.1 illustrates that there was an inverse relationship between %BF and %ApSM, and Figures 3.2 and 3.3 graphically demonstrate that females were more like a pear-shape (gynoid); in contrast, males were more like an apple-shape (android). Chinese females proportionately deposited more fat in the thigh area than the abdominal area. This is in agreement with the findings of larger WHR of males (Table 3.5).

Table 3.9: Body composition by DEXA of the NZ Chinese participants

Body composition by DEXA	Females (N=23)	Males (N=20)	P value
Total body			
Fat free mass (kg)	37.51 ± 3.15	54.27 ± 6.08	<0.001
	(32.45-42.19)	(41.25-64.74)	
Total body fat (kg)	16.38 ± 4.53	16.03 ± 7.08	0.847
	(7.93-24.95)	(4.57-32.24)	
%BF	29.9 ± 5.5	21.9 ± 7.2	<0.001
	(17.7-37.4)	(9.7-35.1)	
Bone mineral content (kg)	2.21 ± 0.21	2.85 ± 0.35	<0.001
	(1.84-2.72)	(2.08-3.48)	
Bone mineral density (g cm^{-2})	1.14 ± 0.06	1.23 ± 0.09	<0.001
	(1.04-1.29)	(1.02-1.37)	
Regional measurements			
Truncal fat mass(kg)	9.47 ± 3.01	10.33 ± 4.69	0.470
	(3.78-15.4)	(2.55-21.4`)	
Truncal fat (%)	17.2 ± 3.9	14.1 ± 4.9	0.024
	(8.4-24.1)	(5.5-22.5)	
Appendicular skeletal muscle mass (kg)	13.99 ± 1.34	22.07 ± 2.83	<0.001
	(12.07-15.96)	(16.47-28.16)	
Appendicular skeletal muscle mass (%)	26.1 ± 2.0	31.7 ± 3.1	<0.001
	(23.2-30.3)	(25.5-36.2)	
Central-to-appendicular fat ratio	1.36 ± 0.27	1.81 ± 0.40	<0.001
	(0.91-2.02)	(1.10-2.56)	
Abdominal fat (kg)	1.40 ± 0.46	1.58 ± 0.78	0.359
	(0.46-2.13)	(0.31-3.27)	
Abdominal fat (%)	8.4 ± 1.1	9.5 ± 1.3	0.003
	(5.8-10.7)	(6.3-11.2)	
Thigh fat (kg)	1.69 ± 0.37	1.32 ± 0.51	0.011
	(1.02-2.33)	(0.49-2.39)	
Thigh fat (%)	10.6 ± 1.7	8.6 ± 1.6	<0.001
	(6.8-14.9)	(6.4-13.4)	
Abdominal-to-thigh fat ratio	0.83 ± 0.23	1.15 ± 0.30	<0.001
	(0.39-1.59)	(0.47-1.73)	

Values are mean ± SD; Range in parentheses; P value calculated using two-tailed t-test.

Figure 3.1: %BF and %ApSM of the NZ Chinese participants (Mean ± SE)

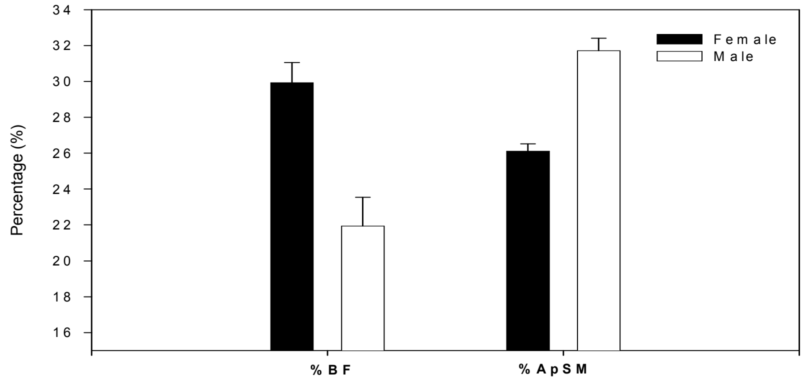


Figure 3.2: Abdominal and thigh fat proportions of the NZ Chinese participants (Mean ± SE)

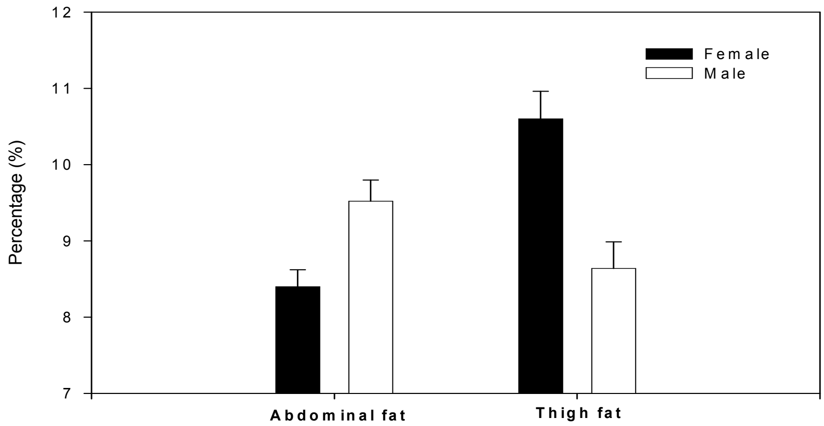
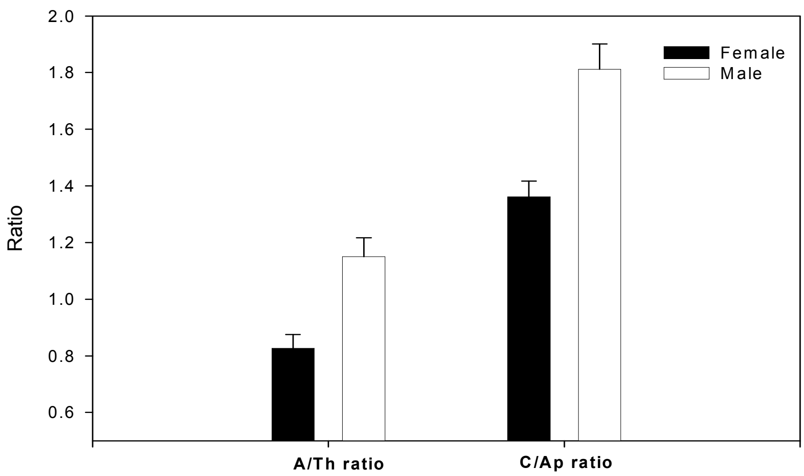


Figure 3.3: Abdominal-to-thigh fat ratio and central-to-appendicular- fat ratio (kg/kg) of the NZ Chinese participants (Mean ± SE)



After adjustment for height and weight, Chinese females had 8.04kg more body fat (P<0.001), had 3.90kg more truncal fat mass (P=0.000005), and 0.51kg more abdominal fat (P=0.001) than Chinese males. After adjustment for height and weight, Chinese female had 8.38kg less fat free mass (P<0.001), and 4.47kg less ApSM (P<0.001) than males (Table 3.10). Adjusted for weight, Chinese females had 1.01kg (P<0.001) more thigh fat than males. Height was not a significant (P=0.275) covariate and was not included in the thigh fat comparison (Table 3.11).

Table 3.12 displays data on bone lengths measured by DEXA. On average, the arm and leg bones of the Chinese males were 4.52 cm and 5.81 cm longer than those of the female respectively (P<0.001). However, adjusted for height, the sex differences in arm length and leg length were decreased to 0.74 cm and 0.44 cm respectively and were not significant (Table 3.13).

Table 3.10: Total and regional fat mass adjusted for weight and height

Dependent variables	**Female (N=23)**		**Male (N=20)**		**P Value**
	Mean	SE	Mean	SE	
Total body fat (kg)	19.96	0.66	11.92	0.73	<0.001
Truncal fat (kg)	11.68	0.41	7.78	0.45	<0.001
Abdominal fat (kg)	1.72	0.08	1.21	0.09	0.001
Fat free mass (kg)	41.41	0.69	49.79	0.76	<0.001
Appendicular skeletal muscle mass (kg)	15.67	0.36	20.14	0.40	<0.001

SE, standard error; P value calculated using two-tailed t-test.

Table 3.11: Thigh fat adjusted for weight

Dependent variables	**Female (N=23)**		**Male (N=20)**		**P Value**
	Mean	SE	Mean	SE	
Thigh fat (kg)	1.99	0.06	0.98	0.07	<0.001

SE, standard error; P value calculated using two-tailed t-test.

Table 3.12: Bone length determined by DEXA for the NZ Chinese participants

Bone length by DEXA	Females (N=23)	Males (N=20)	P value
Humerus length (cm)	27.48 ± 1.67	29.72 ± 1.65	<0.001
	(24.88-30.69)	(27.19-33.24)	
Radius length (cm)	21.60 ± 1.62	23.89 ± 1.76	<0.001
	(18.72-23.70)	(20.07-26.57)	
Arm length (cm)	49.09 ± 2.79	53.61 ± 2.62	<0.001
	(43.78-53.31)	(49.37-59.70)	
Femur length (cm)	39.62 ± 1.87	42.52 ± 1.95	<0.001
	(36.71-43.57)	(38.30-45.39)	
Tibia length (cm)	34.28 ± 2.02	37.19 ± 1.41	<0.001
	(30.84-40.25)	(34.86-40.59)	
Leg length (cm)	73.90 ± 3.37	79.71 ± 2.87	<0.001
	(69.23-83.82)	(74.56-85.98)	

Values are mean ± SD; Range in parentheses; P value calculated using two-tailed t-test.

Table 3.13: Arm and leg lengths adjusted for height

Dependent variables	Female (N=23)		Male (N=20)		P Value
	Mean	SE	Mean	SE	
Arm length (cm)	50.85	0.57	51.59	0.63	0.459
Leg length (cm)	76.40	0.55	76.84	0.61	0.650

SE, standard error; P value calculated using two-tailed t-test.

3.1.4 Health screening results

3.1.4.1 Blood pressure and pulse

Blood pressure and pulse measures are presented in Tables 3.14 and 3.15. On average, males had a significantly higher systolic blood pressure than females (P=0.011). All females had normal blood pressure. While 2 out of 20 males (10%) had raised blood pressure and were classified as hypertensive (Carretero & Oparil, 2000).

Table 3.14: Blood pressure and pulse of the NZ Chinese participants

Functional measurements	Females (N=23)	Males (N=20)	P value
Systolic blood pressure (mmHg)	103 ± 9 (90-124)	112 ± 12 (96-146)	0.011
Diastolic blood pressure (mmHg)	69 ± 6 (61-81)	72 ± 9 (62-95)	0.271
Pulse (beat/minute)	66 ± 8 (52-83)	63 ± 8 (47-78)	0.294

Values are mean ± SD; Range in parentheses; P value calculated using two-tailed t-test.

Table 3.15: Distribution of the NZ Chinese participants in different blood pressure categories

Categories*	Females (N=23)	Males (N=20)	Total (N=43)
Systolic blood pressure (SBP) (mmHg)			
Normal SBP< 130	23 (100.0%)	19 (95.0%)	42 (97.7%)
Borderline 130≤SBP <140	0	0	0
Hypertension SBP≥140	0	1 (5.0%)	1 (2.3%)
Diastolic blood pressure (DBP) (mmHg)			
Normal DBP< 85	23 (100.0%)	18 (90.0%)	41 (95.3%)
Borderline 85≤DBP <90	0	0	0
Hypertension DBP≥90	0	2 (10.0%)	2 (4.7%)

Values are number (%); * Classification values obtained from International Diabetes Federation (2005) and Carretero et al. (2000).

3.1.4.2 Fasting blood glucose and lipid profile

Fasting blood glucose and lipid profile measures are presented in Tables 3.16 and 3.17. On average, fasting glucose in males was 0.4 mmol/L higher than females (P=0.013). Two males had fasting blood glucose levels above the normal range and all females were within the normal range.

Table 3.16: Fasting blood glucose level of the NZ Chinese participants

Blood measurements	Females (N=23)	Males (N=20)	P value
Fasting glucose (mmol/L)	4.8 ± 0.5 (4.0-5.6)	5.2 ± 0.5 (4.2-6.4)	0.013

Values are mean ± SD; Range in parentheses; P value calculated using two-tailed t-test.

Table 3.17: Distribution of the NZ Chinese participants in different fasting blood glucose categories

Fasting blood glucose	Females (N=23)	Males (N=20)	Total (N=43)
Normal range 3.5 ~ 5.6 (mmol/L)	23 (100.0%)	18 (80.0%)	41 (95.3%)
Borderline 5.6 ~ 6.0 (mmol/L)	0	1 (5.0%)	1 (2.3%)
>6.0 (mmol/L)	0	1 (5.0%)	1 (2.3%)

Values are number (%); Classification values were obtained from International Diabetes Federation (2005).

The fasting lipid profile distribution is presented in Table 3.18. Nine females and six males had total cholesterol too low to detect for the instrument. In addition, 2 females and 2 males had total triglycerides below the detection levels of the instrument. Therefore, the mean cholesterol and triglyceride level were not calculated. Two females and 2 males had raised total cholesterol levels and 11 females and 10 males had raised total triglyceride level.

Table 3.18: Distribution of the NZ Chinese participants in different fasting lipid profile

Categories	Females (N=23)	Males (N=20)	Total (N=43)
Cholesterol <5 mmol/L	21 (91.3%)	14 (70.0%)	35 (81.4%)
Cholesterol >5 mmol/L	2 (8.7%)	6 (30.0%)	8 (18.6%)
Triglycerides ≤1.7 mmol/L	12 (52.2%)	10 (50.0%)	22 (51.2%)
Triglycerides >1.7 mmol/L	11 (47.8%)	10 (50.0%)	21 (48.8%)

Values are number (%); Cholesterol classification value was obtained from Diagnostic Medlab Ltd; Triglyceride classification value were obtained from International Diabetes Federation (2005).

3.1.4.3 CVD risk factors and body composition

Table 3.19 presents the distribution of participants within risk factors for CVD. Taking into account the four risk factors measured (raised blood pressure, fasting glucose, fasting cholesterol and fasting triglyceride), 26 (60.5%) participants had at least one risk factor, 7 (16.3%) participants had 2 risk factors and only 1 (2.3%) had 3 risk factors.

Table 3.19: Distribution of the NZ Chinese participants with risk factor for CVD

Risk factor	Females (N=23)	Males (N=20)	Total (N=43)
None	10 (43.5%)	7 (35.0%)	17 (39.5%)
One risk factor	12 (52.5%)	6 (30.0%)	18 (41.9%)
Two risk factors	1 (4.3%)	6 (30.0%)	7 (16.3%)
Three risk factors	0	1 (5.0%)	1 (2.3%)

Values are number (%).

Comparison of WC, WHR, leg/height, %BF and truncal fat (%) between those with risk factors and those without demonstrates that the mean WC of males with at least one risk factor was 10.3 cm (P=0.022) greater than those with no risk factors (Table 3.20). Furthermore, the WHR difference in males of the two groups was significant (P=0.022) too. However, the mean WC difference of the two groups in females was only 2.1 cm and not significant (P=0.486). The mean WHR difference between the two groups in females was nearly significant (P=0.056). There were no difference in leg/height ratio, measured by DEXA, in the two groups for both male and female. The mean %BF, % Truncal fat and abdominal fat mass of males with at least one risk factor were significantly greater (P=0.013, P=0.020 and P=0.011 respectively) than those with no risk factors. However, these differences were not found in females.

Table 3.20: Waist circumference, WHR, leg/height, body fat (%) and truncal fat (%) comparison in different groups divided by CVD risk factors

Variables	Sex	No risk factors group	At least one risk factor group	P value
WC (cm)	F	74.4 ± 5.3	76.5 ± 7.6	0.486
	M	79.1 ± 8.2	89.4 ± 9.0	0.022
WHR	F	0.78 ± 0.04	0.83 ± 0.06	0.056
	M	0.84 ± 0.04	0.89 ± 0.05	0.022
Leg/height	F	0.47 ± 0.01	0.47 ± 0.01	0.296
	M	0.47 ± 0.01	0.48 ± 0.02	0.398
Body fat (%)	F	31.2 ± 4.9	28.9 ± 5.9	0.332
	M	16.7 ± 3.3	24.7 ± 7.3	0.013
Truncal fat (%)	F	17.9 ± 3.6	16.7 ± 4.2	0.504
	M	10.8 ± 2.8	15.9 ± 4.9	0.020
Abdominal fat	F	8.3 ± 0.9	8.5 ± 1.2	0.751
(%)	M	8.8 ± 1.3	9.9 ± 1.1	0.052
Abdominal fat	F	1.46 ± 0.47	1.35 ± 0.46	0.575
(kg)	M	1.00 ± 0.38	1.89 ± 0.78	0.011

Values are mean ± SD; WC, waist circumference; WHR, waist to hip ratio; P value calculated using two-tailed t-test.

3.1.5 Geographical origin

According to their self-reported biological grandparents' origin, the participants were classified into northern or southern Chinese. If 3 or 4 of their grandparents were northern, then he or she was classified as northern Chinese. If 2 of their grandparents were northern and the other 2 were southern, then the participant was classified to northern/southern. There were 2 females and one male classified to northern/southern, 17 participants from northern, and 23 from southern of China (Table 3.21). Northern males were 1.4 cm taller and 3.3kg lighter than southern males, but northern females were only 0.1 cm taller and 2.0kg heavier than southern females. These differences were not statistically significant (Table 3.22).

Table 3.21: NZ Chinese participants' geographical origin in China

Origin	Females (N=23)	Males (N=20)	Total (N=43)
Northern	7 (34.8%)	10 (50.0%)	17 (39.5%)
Southern	14 (60.9%)	9 (45.0%)	23 (53.5%)
Northern/Southern	2 (8.7%)	1 (5.0%)	3 (7.0%)

Values are number (%)

Table 3.22: Body size and body composition comparison in different origin groups

Variable	Northern	Southern	P value
Height (cm)			
Females (N=20)	160.2 ± 5.1	160.1 ± 5.1	0.967
Males (N=19)	171.6 ± 4.6	170.2 ± 4.6	0.508
Weight (kg)			
Females (N=20)	55.0 ± 4.1	53.0 ± 7.3	0.504
Males (N=19)	69.4 ± 9.7	72.9 ± 13.2	0.512
BMI ($kg.m^{-2}$)			
Females (N=20)	21.4 ± 1.2	20.6 ± 1.9	0.310
Males (N=19)	23.5 ± 2.6	25.1 ± 4.3	0.323
%BF			
Females (N=20)	31.6 ± 2.9	28.2 ± 6.0	0.160
Males (N=19)	20.3 ± 6.0	24.5 ± 8.2	0.217
BMD ($g\ cm^{-2}$)			
Females (N=20)	1.16 ± 0.07	1.13 ± 0.06	0.268
Males (N=19)	1.20 ± 0.11	1.25 ± 0.06	0.204
FFM (kg)			
Females (N=20)	37.26 ± 3.29	37.31 ± 3.27	0.973
Males (N=19)	54.74 ± 6.05	54.15 ± 6.69	0.845
Leg length (cm)			
Females (N=20)	73.8 ± 3.1	74.2 ± 3.6	0.822
Males (N=19)	79.6 ± 3.3	79.8 ± 2.7	0.877

Values are mean ± SD; BMI, body mass index; %BF, percentage body fat; BMD, bone mineral density; FFM, fat free mass; P value calculated using two-tailed t-test

3.1.6 Birth weight

Thirty nine participants reported their birth weight (Table 3.23). Chinese males were significantly 0.3 kg heavier than Chinese females when they were born (P=0.036).

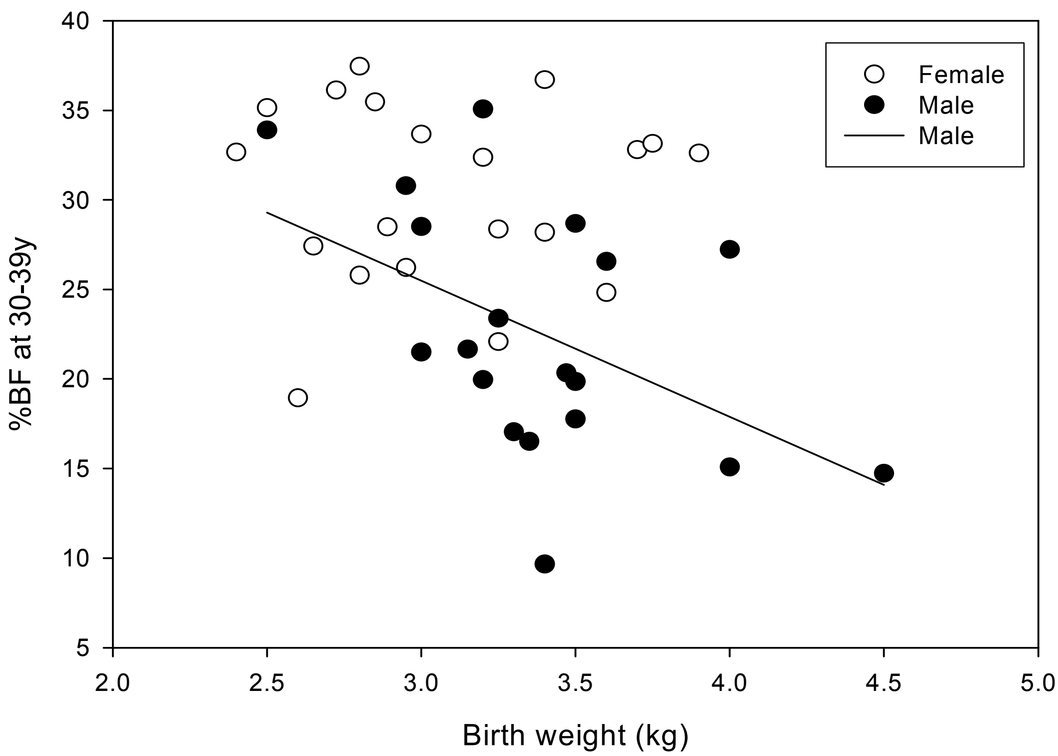
Table 3.23: Birth weight of 19 males and 20 females NZ Chinese participants

Birth weight	Females (N=20)	Males (N=19)	P value
Self reported birth weight	3.1 ± 0.4 (2.4-3.9)	3.4 ± 0.4 (2.5-4.5)	0.036

Values are mean ± SD; Range in parentheses; *p value calculated using two-tailed t-test.

The relationship between birth weight and %BF at 30-39 years are shown in figure 3.4. Males' birth weights were significantly negatively correlated to the %BF measured at age 30-39 years (r=0.49, 95% CI= (0.05-0.77), P=0.035). But the females were not correlated to their middle aged %BF (r=0.03, 95%CI= (-0.42-0.47), P=0.901).

Figure 3.4: Birth weight and %BF at 30-39 years in NZ Chinese participants



The CVD risk factors measured in this study were blood pressure, fasting blood glucose, fasting triglyceride and fasting cholesterol. The study group were separated to two groups according to their risk factors: those who had all parameters within the normal range and those who had at least one parameter in the abnormal range. The mean birth weight of the group with at least one abnormal risk factor was lighter than that of the group with normal risk factors, but the differences were not statistically significant (Table 3.24).

Table 3.24: Birth weight comparison in different groups

Groups	Birth weight of those with normal risk factors (kg)	Birth weight of those with at least one abnormal risk factor (kg)	P value
Females (N=20)	3.1 ± 0.5	3.0 ± 0.4	0.500
Males (N=19)	3.5 ± 0.5	3.3 ± 0.4	0.372

Values are mean ± SD; P value calculated using two-tailed t-test.

3.1.7 Maternal smoking

Data on smoking environment and birth weight comparison in different environment are displayed in Tables 3.25 and 3.26. Mothers of all participants were reported to be not smoking during their pregnancies. Twelve of 34 participants, who knew their maternal situation, were in a second hand smoking environment (any one in the house smoking). Fifteen out of 42, who knew their childhood situation, were in a second hand smoking environment. The birth weight differences between the yes and no second hand maternal smoking were not significant.

Table 3.25: Smoking environment

Variable	Females (N=23)	Males (N=20)	Total (N=43)
Mother smoking during pregnancy	0	0 (1 NK)	0 (1 NK)
Second hand smoking during pregnancy	7 (3 NK)	5 (6 NK)	12 (9 NK)
Smoking environment in childhood	9	6 (1 NK)	15 (1 NK)

Values are number; NK, did not know.

Table 3.26: Birth weight comparison in different smoking environment

Sex	Second hand maternal smoking	Number	Birth weight (kg)	P value between yes and no groups
Females	Yes	6	3.3 ± 0.6	0.380
	No	12	3.1 ± 0.3	
	Did not know	2	2.5 ± 0.1	
Males	Yes	5	3.3 ± 0.3	0.501
	No	8	3.5 ± 0.6	
	Did not know	6	3.4 ± 0.4	

Values are mean ± SD; P value calculated using two-tailed t-test

3.2 Section B: Comparison to other ethnic groups

Over the last 15 years Professor Elaine Rush and Associate Professor Lindsay Plank's team have scanned, on the same DEXA machine, healthy males and females with a wide range of body composition and age from the Maori, Pacific, European and Asian Indian ethnic groups (Swinburn et al., 1999; Rush et al., 2004; Rush et al., 2007a; Rush et al., 2007b). The anthropometrics and DEXA measurement characteristics of the 247 males and females aged 30-39 years from this data set are presented in Tables 3.27 and 3.28. Females and males are analysed separately in this part due to obvious differences in body composition between them, which has been discussed in the literature review and shown in Section A for NZ Chinese.

Section B focuses on the differences for NZ Chinese in particular in comparison with Asian Indian and European ethnic groups. Since European is the major reference population in NZ, and at present Asian are often included as one homogeneous group in NZ statistics, the data was analysed to assess differences between NZ Chinese and Asian Indian compared with European. For a complete set of results from univariate analysis of covariance and pairwise comparisons for all ethnic groups, see appendix 14.

Table 3.27: Comparisons of body composition of females of five ethnic groups (n=131)

Variables	**European N=37**	**Maori N=23**	**Pacific N=23**	**Asian Indian N=25**	***NZ Chinese N=23***	**P value**
Age (y)	34 ± 3 (30-39)	34 ± 2 (30-38)	34 ± 3 (30-39)	35 ± 3 (30-39)	*36 ± 2 (31-39)*	0.142
Weight (kg)	66.5 ± 13.6 (49.1-102.0)*	79.1 ± 16.5 (52.2-108.3)*	89.1 ± 19.0 (60.2-136.9)*	67.3 ± 11.3 (47.1-91.9)*	*54.5 ± 6.7 (44.4-67.5)*	<0.001
Height (cm)	164.9 ± 5.9 (151.5-176.5)*	161.9 ± 5.4 (150.5-173.0)	162.7 ± 5.8 (153.5-172.5)	158.7 ± 5.3 (142.5-166.4)	*160.0 ± 5.3 (150.8-169.6)*	<0.001
BMI (kg.m^{-2})	24.5 ± 5.2 (18.6-39.4)	30.1 ± 5.9 (20.9-40.5)*	33.6 ± 6.7 (22.6-46.0)*	26.9 ± 5.3 (17.7-38.1)*	*21.2 ± 2.1 (18.1-26.6)*	<0.001
Waist (cm)	ND	94.1 ± 13.6 (72.0-116.0)*	95.1 ± 13.8 (73.0-124.0)*	84.3 ± 9.4 (65.2-103.9)*	*75.6 ± 6.7 (65.3-89.6)*	<0.001
Hip (cm)	ND	111.7 ± 11.5 (93.0-135.0)*	114.6 ± 13.1 (97.0-144.0)*	105.8 ± 9.9 (91.1-124.5)*	*93.3 ± 4.2 (84.5-100.9)*	<0.001
WHR	ND	0.84 ± 0.07 (0.69-1.00)	0.83 ± 0.06 (0.72-0.90)	0.80 ± 0.07 (0.68-0.93)	*0.81 ± 0.05 (0.69-0.94)*	0.088
Humerus (cm)	29.10 ± 2.38 (21.93-32.48)*	27.88 ± 1.82 (24.31-30.62)	28.69 ± 2.07 (25.51-32.19)	27.55 ± 1.95 (24.14-32.97)	*27.48 ± 1.67 (24.88-30.69)*	0.008
Radius (cm)	23.40 ± 1.92 (20.17-28.80)*	23.52 ± 1.55 (20.84-26.20)*	24.68 ± 2.00 (20.97-28.86)*	24.96 ± 2.19 (20.18-27.94)*	*21.60 ± 1.62 (18.72-23.70)*	<0.001
Arm (cm)	52.51 ± 2.98 (46.90-58.04)*	51.40 ± 2.73 (47.43-56.82)	53.37 ± 2.93 (46.99-57.90)*	52.51 ± 2.84 (45.73-58.90)*	*49.09 ± 2.79 (43.78-53.31)*	<0.001
Femur (cm)	41.63 ± 2.20 (37.01-44.82)*	40.23 ± 2.40 (35.21-43.65)	41.36 ± 2.75 (35.53-48.96)	39.81 ± 2.07 (34.56-43.20)	*39.62 ± 1.87 (36.71-43.57)*	0.002
Tibia (cm)	35.61 ± 2.64 (30.07-43.20)	34.14 ± 2.68 (29.78-40.37)	36.21 ± 2.03 (32.70-40.32)	35.70 ± 2.24 (29.78-40.33)	*34.28 ± 2.02 (30.84-40.25)*	0.008
Leg (cm)	77.24 ± 4.45 (67.79-87.73)*	74.38 ± 4.44 (66.64-82.88)	77.57 ± 3.97 (68.23-85.45)*	75.51 ± 3.82 (64.34-82.57)	*73.90 ± 3.37 (69.23-83.82)*	0.003
L/H (cm)	0.475 ± 0.015 (0.446-0.504)	0.468 ± 0.016 (0.442-0.495)	0.481 ± 0.020 (0.437-0.533)*	0.481 ± 0.010 (0.455-0.499)*	*0.469 ± 0.012 (0.451-0.503)*	0.003
FFM (kg)	44.38 ± 4.70 (35.20-58.54)*	46.82 ± 5.91 (37.90-57.83)*	52.26 ± 8.69 (34.38- 72.64)*	37.26 ± 3.44 (31.66-43.12)	*37.51 ± 3.15 (32.45-42.19)*	<0.001
FMI (kg.m^{-2})	16.3 ± 1.6 (13.2-21.1)*	17.8 ± 1.9 (14.4-21.5)*	19.7 ± 2.5 (14.6-24.5)*	14.8 ± 1.6 (11.9-18.5)	*14.6 ± 1.0 (13.3-16.9)*	<0.001
TBF (kg)	22.16 ± 10.88 (9.21-49.13)	32.45 ± 11.83 (14.70-53.99)	36.74 ± 12.61 (16.74-62.89)	29.86 ± 9.71 (11.95-50.72)	*16.38 ± 4.53 (7.93-24.95)*	<0.001
% BF	31.7 ± 9.4 (16.6-50.4)	39.8 ± 7.2 (27.7-53.9)*	40.3 ± 7.4 (27.1-53.4)*	43.4 ± 7.7 (25.7-56.7)*	*29.9 ± 5.5 (17.7-37.4)*	<0.001
BMC (kg)	2.58 ± 0.32 (1.97-3.23)*	2.62 ± 0.31 (2.13-3.21)*	2.88 ± 0.40 (2.02-3.78)*	2.23 ± 0.26 (1.69-2.63)	*2.21 ± 0.21 (1.84-2.72)*	<0.001
BMD (g cm^{-2})	1.16 ± 0.08 (1.05-1.33)	1.19 ± 0.08 (1.05-1.37)	1.28 ± 0.09 (1.04-1.41)*	1.15 ± 0.08 (1.00-1.28)	*1.14 ± 0.06 (1.04-1.29)*	<0.001
ApSM (kg)	17.43 ± 2.42 (12.91-24.77)*	18.27 ± 2.77 (13.86-23.61)*	20.48 ± 3.40 (13.58-26.83)*	14.61 ± 1.70 (11.30-17.29)	*13.99 ± 1.34 (12.07-15.96)*	<0.001
ApSM (%)	26.7 ± 4.0 (19.5-34.1)	23.4 ± 2.7 (17.7-27.0)*	23.4 ± 3.1 (17.8-30.2)*	22.2 ± 3.4 (15.9-28.0)*	*26.1 ± 2.0 (23.2-30.3)*	<0.001
C/Ap ratio	0.95 ± 0.23 (0.51-1.60)*	1.20 ± 0.20 (0.87-1.61)	1.18 ± 0.16 (0.94-1.47)	1.06 ± 0.21 (0.77-1.59)*	*1.36 ± 0.27 (0.91-2.02)*	<0.001
AF (kg)	1.54 ± 1.11 (0.33-4.19)	2.80 ± 1.29 (1.08 –5.46)*	3.04 ± 1.27 (1.15-6.20)*	2.57 ± 1.04 (0.58-4.83)*	*1.40 ± 0.46 (0.46-2.13)*	<0.001
AF (% of TBF)	6.3 ± 1.8 (3.5-9.5)*	8.4 ± 1.2 (5.8-10.2)	8.1 ± 1.1 (5.9-11.4)	8.4 ± 1.5 (4.8-10.7)	*8.4 ± 1.1 (5.8-10.7)*	<0.001
AF (% of MAR)	29.6 ± 12.4 (9.0-53.2)	42.8 ± 8.3 (26.7-55.9)*	42.5 ± 8.2 (26.8-57.1)*	45.6 ± 8.8 (19.8-57.6)*	*33.8 ± 8.1 (15.3-44.6)*	<0.001
TF (kg)	2.39 ± 0.97 (1.15-5.09)*	3.19 ± 0.97 (1.72-4.97)*	3.39 ± 1.04 (1.71-5.29)*	3.22 ± 1.02 (1.77-6.01)*	*1.69 ± 0.37 (1.02-2.33)*	<0.001
TF (% of TBF)	11.4 ± 1.8 (7.8-15.0)	10.1 ± 1.4 (8.2-12.5)	9.4 ± 0.9 (8.1-11.4)	10.9 ± 1.5 (8.4-14.8)	*10.6 ± 1.7 (6.8-14.9)*	<0.001
A/T ratio	0.59 ± 0.25 (0.24-1.20)*	0.86 ± 0.22 (0.47-1.20)	0.88 ± 0.18 (0.58-1.40)	0.80 ± 0.23 (0.33-1.27)	*0.83 ± 0.23 (0.39-1.59)*	<0.001

Values are mean ± SD. Range in parentheses. *Significantly different to NZ Chinese. Abbreviations: BMI, body mass index; ND, not determined; WHR, waist to hip ration; L/H, leg length to height ratio; FFM, fat free mass; FM, fat mass; FMI, fat mass index; TBF, total body fat; %BF, percentage body fat; BMC, bone mineral content; BMD, bone mineral density; ApSM, appendicular skeletal muscle; C/Ap ratio, central- to-appendicular fat ratio; AF, abdominal fat; MAR, mass of abdominal region; TF, thigh fat; A/T ratio, abdominal-to-thigh fat ratio.

Table 3.28: Comparisons of body composition of males of five ethnic groups (n=116)

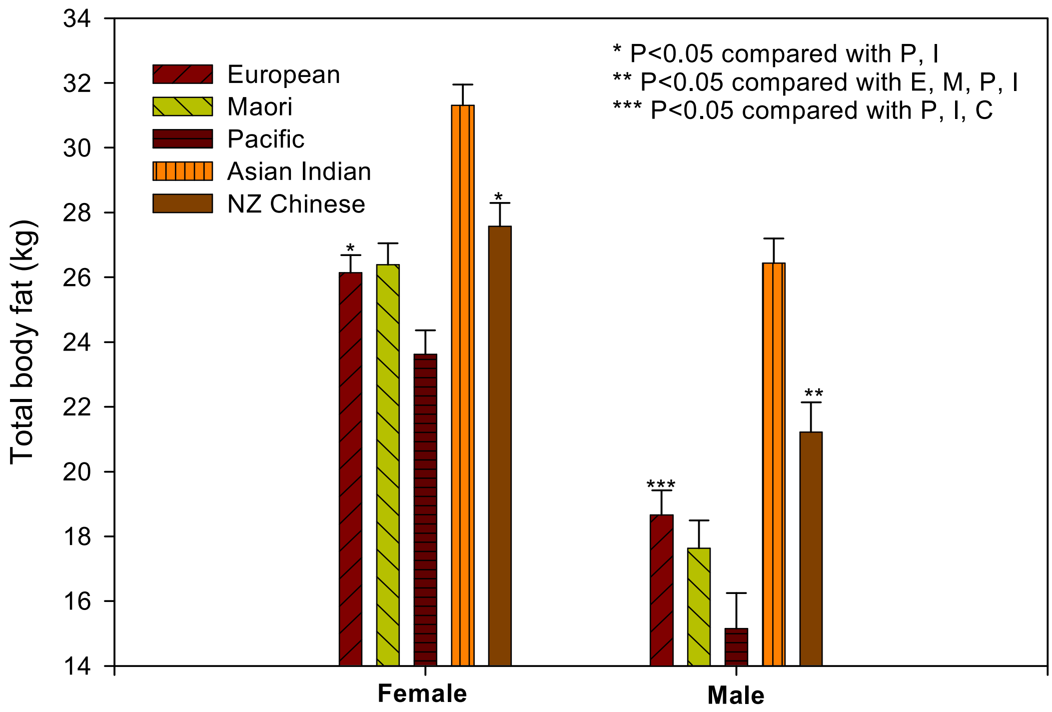
Variables	European N=29	Maori N=23	Pacific N=15	Asian Indian N=29	*NZ Chinese N=20*	P value
Age (y)	34 ± 2 (30-38)*	33 ± 3 (30-39)*	34 ± 2 (31-38)	35 ± 3 (30-39)	*36 ± 2 (30-39)*	0.017
Weight (kg)	79.8 ± 7.8 (64.0-97.4)*	88.2 ± 14.0 (62.0-114.8)*	92.1 ± 9.1 (81.5-108.0)*	72.6 ± 12.6 (48.5-106.4)	*70.5 ± 11.3 (46.6-95.8)*	<0.001
Height (cm)	176.5 ± 6.5 (166.0-191.0)*	174.3 ± 6.8 (156.0-185.0)	171.3 ± 6.7 (154.0-179.0)	169.1 ± 7.7 (151.4-181.5)	*171.0 ± 4.4 (162.7-177.2)*	0.001
BMI ($kg.m^{-2}$)	25.6 ± 2.1 (21.4-30.9)	29.1 ± 4.5 (18.9-37.7)*	31.5 ± 4.1 (26.0-42.2)*	25.4 ± 4.4 (18.7-39.6)	*24.1 ± 3.5 (17.5-32.4)*	<0.001
Waist (cm)	ND	97.5 ± 10.9 (81.0-124.0)*	100.3 ± 11.6 (81.0-120.0)*	90.7 ± 12.1 (65.4-130.0)	*85.8 ± 9.9 (64.0-106.0)*	0.001
Hip (cm)	ND	106.4 ± 8.1 (94.0-121.0)*	106.7 ± 5.3 (98.0-117.0)*	98.3 ± 6.8 (90.2-116.6)	*98.1 ± 7.0 (81.3-113.0)*	<0.001
WHR	ND	0.92 ± 0.05 (0.83-1.02)	0.94 ± 0.08 (0.83-1.10)*	0.92 ± 0.08 (0.71-1.17)	*0.87 ± 0.05 (0.76-0.94)*	0.035
Humerus (cm)	30.38 ± 2.09 (26.28-35.12)	31.53 ± 2.54 (27.22-37.06)	29.66 ± 2.07 (26.26-33.64)	29.31 ± 2.92 (24.27-36.45)	*29.72 ± 1.65 (27.19-33.24)*	0.014
Radius (cm)	26.45 ± 1.43 (24.08-29.76)*	26.19 ± 2.08 (21.39-29.76)*	27.12 ± 1.72 (24.02-30.72)*	27.28 ± 2.30 (21.32-31.86)*	*23.89 ± 1.76 (20.07-26.57)*	<0.001
Arm (cm)	56.83 ± 2.72 (51.53-62.00)*	57.72 ± 3.44 (49.56-63.92)*	56.78 ± 3.14 (51.18-61.58)*	56.59± 4.12 (48.52-66.30)*	*53.61 ± 2.62 (49.37-59.70)*	0.002
Femur (cm)	44.56 ± 2.07 (40.60-48.47)*	44.10 ± 2.65 (36.49-48.09)	43.49 ± 2.34 (38.43-47.66)	42.77 ± 2.64 (37.55-48.02)	*42.52 ± 1.95 (38.30-45.39)*	0.012
Tibia (cm)	38.58 ± 2.25 (33.63-43.80)	37.45 ± 2.88 (30.72-42.26)	37.79 ± 3.09 (32.92-45.12)	38.53 ± 2.15 (34.56-43.24)	*37.19 ± 1.41 (34.86-40.59)*	0.152
Leg (cm)	83.14 ± 3.91 (75.91-89.97)*	81.55 ± 4.86 (68.26-90.29)	81.28 ± 4.92 (72.15-90.45)	81.30 ± 4.02 (74.06-88.42)	*79.71 ± 2.87 (74.56-85.98)*	0.086
L/H (cm)	0.48 ± 0.01 (0.45-0.50)	0.48 ± 0.01 (0.45-0.50)	0.49 ± 0.01 (0.47-0.51)*	0.49 ± 0.02 (0.46-0.51)*	*0.47 ± 0.01 (0.44-0.50)*	0.013
FFM (kg)	63.23 ± 6.69 (51.74-83.22)*	66.47 ± 8.03 (52.36-82.31)*	68.81 ± 3.86 (59.87-74.17)*	49.35 ± 7.96 (30.58-64.68)	*54.28 ± 6.08 (41.25-64.74)*	<0.001
FMI ($kg.m^{-2}$)	20.3 ± 2.0 (17.1-26.4)*	21.8 ± 2.0 (16.9-25.8)*	23.5 ± 2.0 (20.5-29.4)*	17.2 ± 2.0 (13.3-22.2)	*18.5 ± 1.6 (15.6-21.3)*	<0.001
TBF (kg)	17.12 ± 6.82 (4.82-26.47)	22.38 ± 8.93 (7.15-39.30)	23.66 ± 7.33 (11.39-37.48)*	23.39 ± 8.58 (7.87-48.09)*	*16.03 ± 7.08 (4.57-32.24)*	0.001
% BF	21.0 ± 7.6 (6.3-33.2)	24.5 ± 7.0 (11.4-34.9)	25.2 ± 5.6 (13.6-35.3)	31.6 ± 7.7 (14.0-50.5)*	*21.9 ± 7.2 (9.7-35.1)*	<0.001
BMC (kg)	3.35 ± 0.43 (2.65-4.38)*	3.47 ± 0.37 (2.60-4.18)*	3.44 ± 0.39 (2.60-4.03)*	2.60 ± 0.39 (1.93-3.58)	*2.85 ± 0.35 (2.08-3.48)*	<0.001
BMD ($g\ cm^{-2}$)	1.26 ± 0.08 (1.10-1.44)	1.31 ± 0.08 (1.06-1.41)*	1.33 ± 0.05 (1.25-1.40)*	1.16 ± 0.09 (1.04-1.38)*	*1.23 ± 0.09 (1.02-1.37)*	<0.001
ApSM (kg)	26.76 ± 3.25 (20.48-37.68)*	28.48 ± 4.21 (21.42-36.81)*	29.86 ± 2.34 (24.21-33.64)*	21.30 ± 3.68 (12.61-29.97)	*22.07 ± 2.83 (16.47-28.16)*	<0.001
ApSM (%)	33.4 ± 3.3 (26.5-38.6)	32.3 ± 3.3 (26.9-40.0)	32.5 ± 3.0 (27.3-37.9)	29.5 ± 3.8 (20.3-36.7)	*31.7 ± 3.1 (25.5-36.2)*	0.001
C/Ap ratio	1.33 ± 0.21 (0.97-1.74)*	1.55 ± 0.29 (0.96-2.14)*	1.38 ± 0.19 (0.95-1.65)*	1.45 ± 0.27 (0.86-1.98)*	*1.81 ± 0.40 (1.10-2.56)*	<0.001
AF (kg)	1.38 ± 0.67 (0.30-2.60)	2.03 ± 0.95 (0.40-4.16)	2.10 ± 0.83 (0.65-3.44)	2.28 ± 0.94 (0.69-5.35)*	*1.58 ± 0.78 (0.31-3.27)*	0.001
AF (% of TBF)	7.8 ± 1.2 (4.8-9.9)*	8.8 ± 1.4 (5.6-11.7)	8.7 ± 1.5 (5.6-11.4)	9.7 ± 1.2 (6.5-11.5)	*9.5 ± 1.3 (6.3-11.2)*	<0.001
AF(% of MAR)	24.5 ± 10.0 (5.7-41.9)	31.2 ± 9.2 (10.7-46.2)	30.0 ± 7.0 (13.1-40.5)	39.1 ± 7.9 (16.7-53.4)*	*29.6 ± 9.9 (10.9-46.7)*	<0.001
TF (kg)	1.51 ± 0.56 (0.47-2.48)	1.90 ± 0.68 (0.78-3.22)*	2.03 ± 0.54 (1.07-2.99)*	2.00 ± 0.76 (0.71-3.99)*	*1.32 ± 0.51 (0.49-2.39)*	<0.001
TF (% of TBF)	9.0 ± 1.0 (6.6-11.4)	8.7 ± 0.9 (7.2-10.9)	8.7 ± 0.9 (7.4-10.9)	8.6 ± 1.3 (6.7-12.5)	*8.6 ± 1.6 (6.4-13.4)*	<0.001
A/T ratio	0.88 ± 0.21 (0.42-1.39)*	1.03 ± 0.22 (0.52-1.43)	1.01 ± 0.25 (0.52-1.54)	1.16 ± 0.27 (0.52-1.62)	*1.15 ± 0.30 (0.47-1.73)*	<0.001

Values are mean ± SD. Range in parentheses. *Significantly different to NZ Chinese; Abbreviations: BMI, body mass index; ND, not determined; WHR, waist to hip ration; L/H, leg length to height ratio; FFM, fat free mass; FM, fat mass; FMI, fat mass index; TBF, total body fat; %BF, percentage body fat; BMC, bone mineral content; BMD, bone mineral density; ApSM, appendicular skeletal muscle; C/Ap ratio, central-to-appendicular fat ratio; AF, abdominal fat; MAR, mass of abdominal region; TF, thigh fat; A/T ratio, abdominal-to-thigh fat ratio.

3.2.1 Total body fat

Figure 3.5 illustrates total body fat mass when adjusted for height and weight. After adjustment for height and weight, Asian Indian had the most total body fat mass and NZ Chinese the second most among the 5 ethnic groups. On average, a NZ Chinese female had 3.74kg less fat mass than an Asian Indian female (P<0.001), and 1.43kg more fat mass than a European female (P=0.105). For males, NZ Chinese had 5.21kg less fat mass than Asian Indian (P<0.001), and 2.56kg more fat mass than European (P=0.033).

Figure 3.5: Ethnic comparison of total body fat adjusted for weight and height (Mean ± SE)



3.2.2 BMI and body fatness

The relationships between %BF and logarithm of BMI for each ethnic group were separately analysed by sex and illustrated in figures 3.5a and 3.5b. BMI was log-transformed as the relationship between BMI and %BF is curvilinear. The slopes of the regression of %BF on the logarithm of BMI for the five ethnic groups were compared.

Figure 3.5a: Association of % body fat and BMI for females in 5 ethnic groups

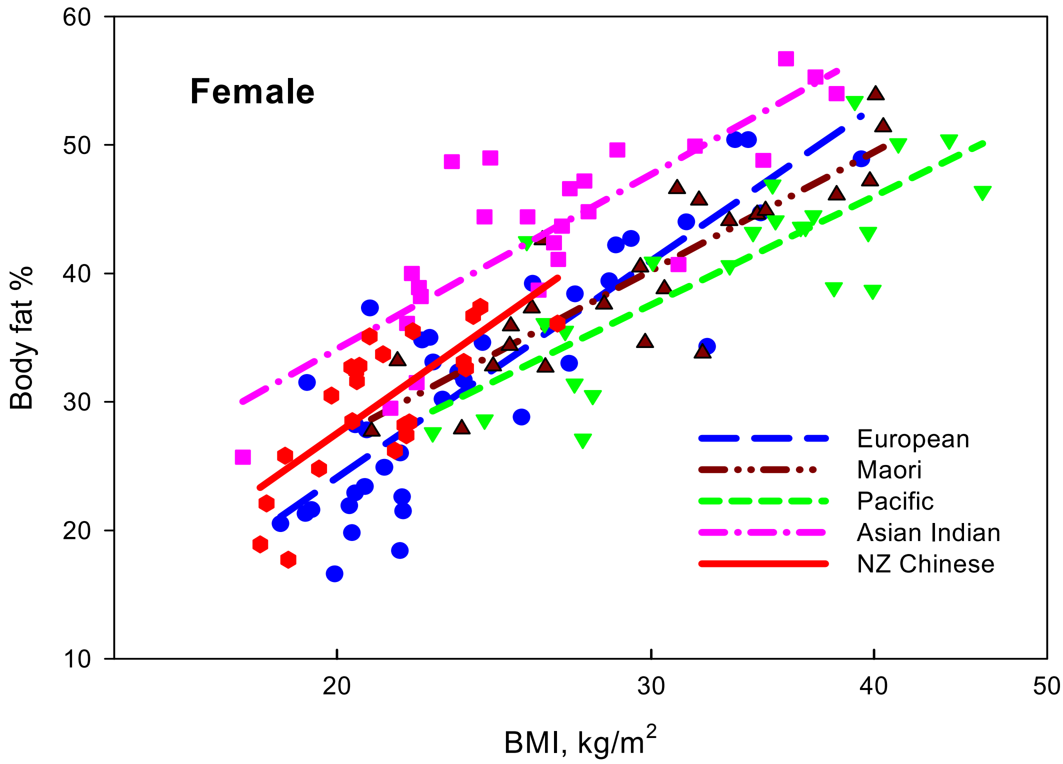
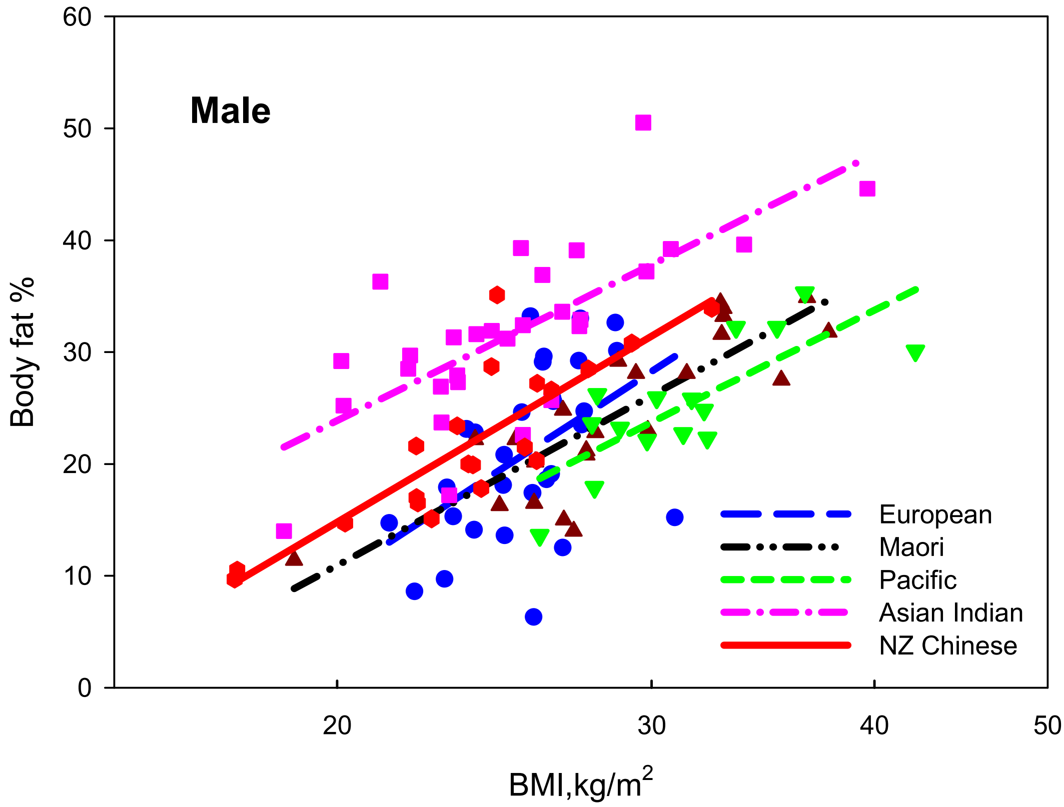


Figure 3.5b: Association of % body fat and BMI for males in 5 ethnic groups



For females, the slope of the regression of %BF on the logarithm of BMI for Pacific was different from the slope for European (P=0.037). The slope for the European females was steeper than for Pacific females. The regression equation for Pacific females alone was:

$\%BF = 67.6 \log_{10}(BMI) - 62.29$

(Standard error of estimate (SEE) = 4.53%, $R^2 = 0.65$)

For females, no significant differences were found among the slopes for European, Maori, Asian Indian and NZ Chinese. The covariance analysis showed that there was no significant difference between European and Maori in the elevations of the regression lines (P=0.794). Therefore, to develop the regression equation, European and Maori were given the same code, Pacific was excluded and the other 2 ethnic groups were recoded as showing in the Table 3.29.

Table 3.29: Recoding for regression for females

	European	Maori	Asian Indian	NZ Chinese
Group 1	0	0	1	0
Group 2	0	0	0	1

The common regression equation for predicting %BF from BMI for the European, Maori, Asian Indian and NZ Chinese females aged 30-39 years was:

Females $\%BF = 86.00 \log_{10}(BMI) - 86.89 + 8.06\ group1 + 2.84\ group2$

(SEE = 4.25%, $R^2 = 0.81$)

According to the two equations developed above, for the same %BF of 33.3%, BMI of 25 $kg.m^{-2}$, compared with European, BMI in NZ Chinese females and Asian Indian females was 1.8 and 4.9 $kg.m^{-2}$ lower respectively (Table 3.29). Furthermore, at %BF of 40.1% (equivalent to a BMI of 30 $kg.m^{-2}$ in Europeans), the BMI in NZ Chinese females and Asian Indian females was 2.2 and 5.8 $kg.m^{-2}$ lower than European females, respectively.

Table 3.30: Comparison of European females BMI and corresponding percent body fat with estimated BMI equivalents for other four ethnic groups derived from regression equations for predicting percent body fat from BMI

European		Maori	Pacific	Asian Indian	NZ Chinese
BMI (kgm^{-2})	Body fat (%)	Approx.BMI (kgm^{-2})	Approx.BMI (kgm^{-2})	Approx.BMI (kgm^{-2})	Approx.BMI (kgm^{-2})
20	25.0	20.0	19.6	16.1	18.5
25	33.3	25.0	26.0	20.1	23.2
30	40.1	30.0	32.8	24.2	27.8
35	45.9	35.0	39.9	28.2	32.4
40	50.9	40.0	47.2	32.2	37.1
45	55.3	45.0	54.9	36.3	41.7
50	59.2	50.0	62.7	40.3	46.3

BMI, body mass index.

For males, there were no significant differences in the slopes of the regression of %BF on the logarithm of BMI for the five ethnic groups. However, the covariance analysis showed that the elevation of the regression line for Maori males was not different to European males. Therefore, to obtain the regression equation for male, Maori males were recoded as the same to European males 0, and the other ethnic groups were recoded according to the Table 3.31:

Table 3.31: Recoding for regression for males

	European	Maori	Pacific	Asian Indian	NZ Chinese
Group 1	0	0	1	0	0
Group 2	0	0	0	1	0
Group 3	0	0	0	0	1

The common regression equations for predicting %BF from BMI for the five ethnic groups aged 30-39 years were:

Males %BF = 84.97 $\log_{10}$(BMI) – 98.97 – 2.92 group1 + 11.70 group2 + 3.91 group3 (SEE = 5.08%, R^2 = 0.63)

After the recoding, as presented in Table 3.31, the differences in the elevations of the regression lines between Pacific males and European males did not reach statistical significance (P=0.066). This might be due to the apparent small number of Pacific males, 15, less than 20. For this reason, the analysis did not further recode the Pacific males as to the same as European.

Thus, %BF was 19.8% in European males with a BMI of 25.0 kg.m^{-2}; for the same %BF, BMI in NZ Chinese males was 2.5 kg.m^{-2} lower and in Asian Indian males was 6.8 kg.m^{-2} lower. At a %BF equivalent to a BMI of 30 kg.m^{-2} in Europeans males, the BMIs for NZ Chinese and Asian Indian males were 3.0 and 8.2 units lower, respectively (Table 3.32).

Table 3.32: Comparison of European males BMI and corresponding percent body fat with estimated BMI equivalents for other four ethnic groups derived from regression equations for predicting percent body fat from BMI

European		Maori	Pacific	Asian Indian	NZ Chinese
BMI (kgm^{-2})	Body fat (%)	Approx.BMI (kgm^{-2})	Approx.BMI (kgm^{-2})	Approx.BMI (kgm^{-2})	Approx.BMI (kgm^{-2})
20	11.6	20.0	21.6	14.6	18.0
25	19.8	25.0	27.1	18.2	22.5
30	26.5	30.0	32.5	21.8	27.0
35	32.2	35.0	37.9	25.5	31.5
40	37.2	40.0	43.3	29.1	36.0
45	41.5	45.0	48.7	32.8	40.5
50	45.4	50.0	54.1	36.4	45.0

BMI, body mass index.

From the regression equations derived from the data analysed, the BMIs of NZ Chinese aged 30-39y corresponding to a body fat of 35% for females and 25% for males were 24.2 and 25.9 kg.m^{-2}, respectively. BMIs corresponding to a body fat of 30% for female and 20% for male were 21.2 and 22.6 kg.m^{-2}, respectively (Table 3.33).

Table 3.33: BMIs corresponding to %BF using the regression equations

Sex	%BF	BMI equivalents (kg.m^{-2})				
		European	Maori	Pacific	Asian Indian	NZ Chinese
Female	30.0%	22.9	22.9	23.2	18.4	21.2
Female	35.0%	26.1	26.1	27.5	21.1	24.2
Male	20.0%	25.1	25.1	27.2	18.3	22.6
Male	25.0%	28.8	28.8	31.1	21.0	25.9

BMI, body mass index; %BF: percentage body fat.

3.2.3 Fat distribution

3.2.3.1 Appendicular fat mass and C/Ap fat ratio

Figure 3.6 illustrates the ethnic comparison of appendicular fat mass adjusted for height and weight. Asian Indian females and males had higher appendicular fat mass than European, Asian Indian and NZ Chinese ethnic groups. The differences of appendicular fat mass between European and NZ Chinese females and males were not significant.

NZ Chinese males had the significantly highest C/Ap fat ratio among the five ethnic groups ($P<0.001$), whilst NZ Chinese females had significantly higher C/Ap fat ratio than European and Asian Indian females ($P<0.001$) (Figure 3.7).

Figure 3.6: Ethnic comparison of appendicular fat mass adjusted for weight and height (Mean ± SE)

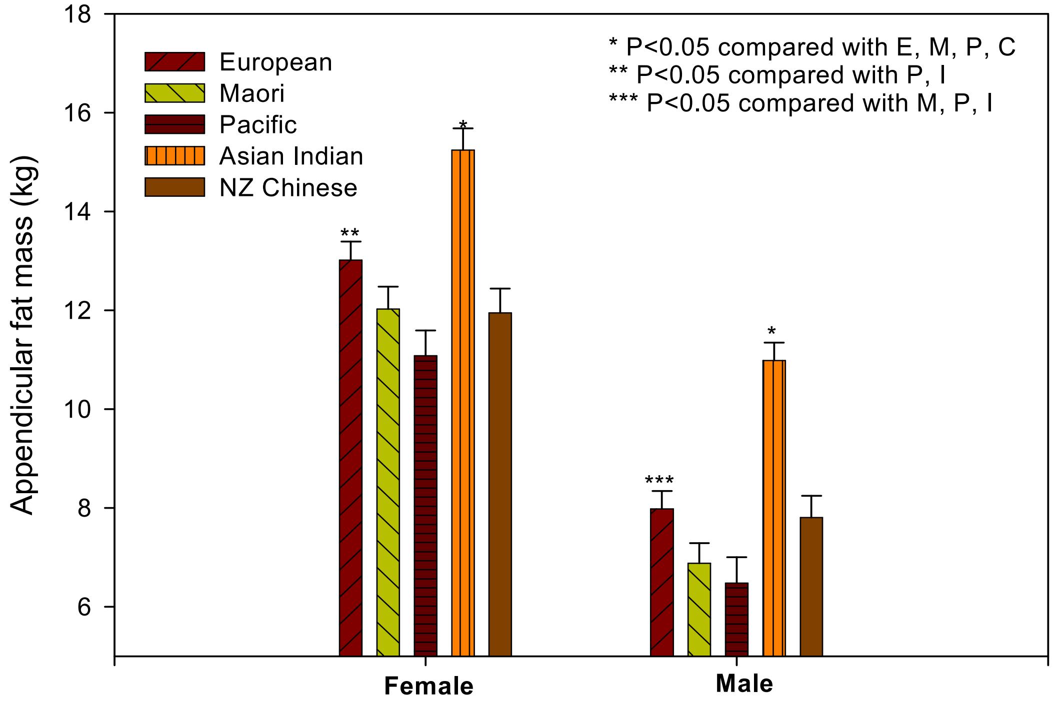
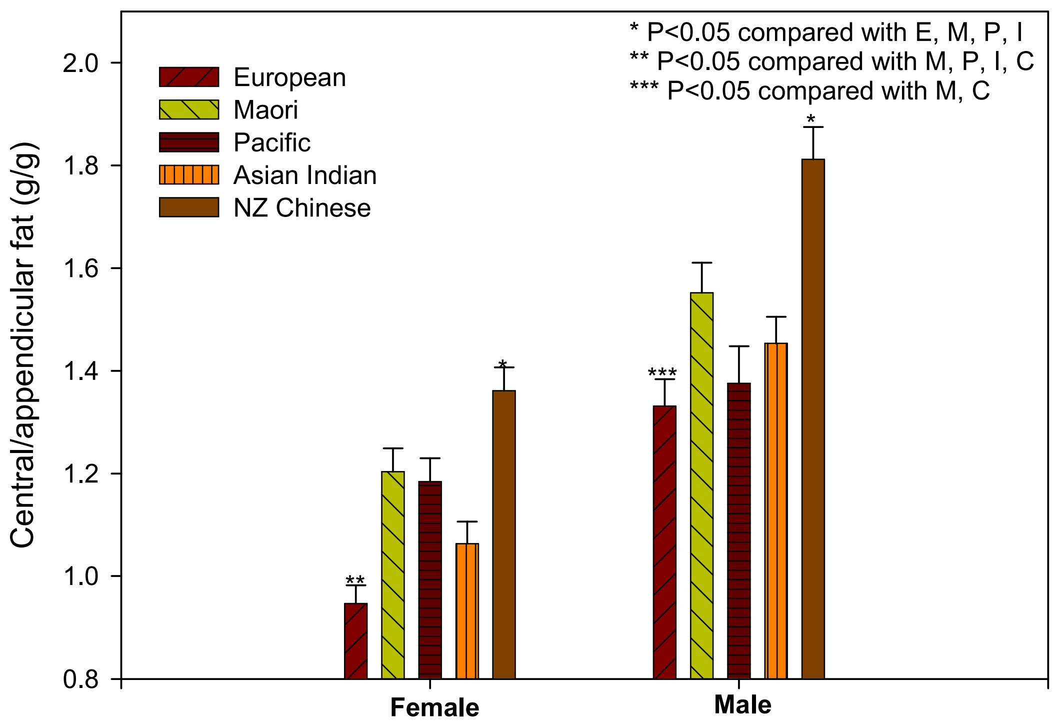


Figure 3.7: Ethnic comparison of central-to-appendicular fat ratio (Mean ± SE)



3.2.3.2 Abdominal fat and thigh fat

After adjustment for height and weight, Asian Indians had the greatest abdominal fat in the 5 ethnic groups; NZ Chinese was the second greatest and Pacific was the least for both males and females (Figure 3.8). NZ Chinese had 445g and 507g more abdominal fat than European for females and males respectively (P<0.001).

In addition, the abdominal fat (g) measured by DEXA was positively associated with WC in Maori (P<0.001), Pacific (P<0.001), Asian Indian (P<0.001) and NZ Chinese (P<0.001) for both males and females (Table 3.34).

Table3.34: Correlation of waist circumference and abdominal fat (g)

Sex	Ethnicity	Pearson's correlation coefficient (95% CI)	P value
Female	Maori (n=22)	0.93 (0.84-0.97)	<0.001
	Pacific (n=22)	0.91 (0.79-0.96)	<0.001
	Asian Indian (n=25)	0.86 (0.70-0.94)	<0.001
	NZ Chinese (n=23)	0.75 (0.49-0.89)	<0.001
Male	Maori (n=20)	0.94 (0.85-0.98)	<0.001
	Pacific (n=12)	0.97 (0.89-0.99)	<0.001
	Asian Indian (n=29)	0.90 (0.80-0.95)	<0.001
	NZ Chinese (n=20)	0.92 (0.81-0.97)	<0.001

Pearson's correlation co-effecient calculated using bivariate correlation; correlations signficant at P<0.05; CI, confidence intervals.

Again, after adjustment of height and weight Asian Indian had the greatest thigh fat for both males and females in these five ethnic groups (P<0.001). NZ Chinese, European and Maori had similar thigh fat for both males and females (Figure 3.9). Asian Indian had on average 734g and 516g more thigh fat than NZ Chinese for females and males respectively (P<0.001).

Figure 3.8: Ethnic comparison of abdominal fat adjusted for weight and height (Mean ± SE)

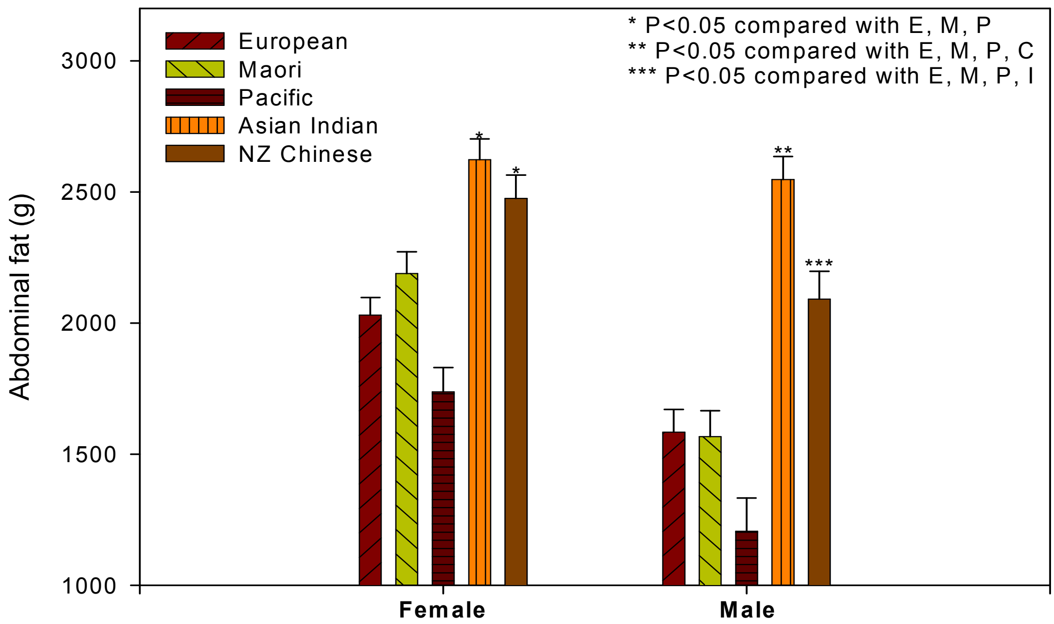
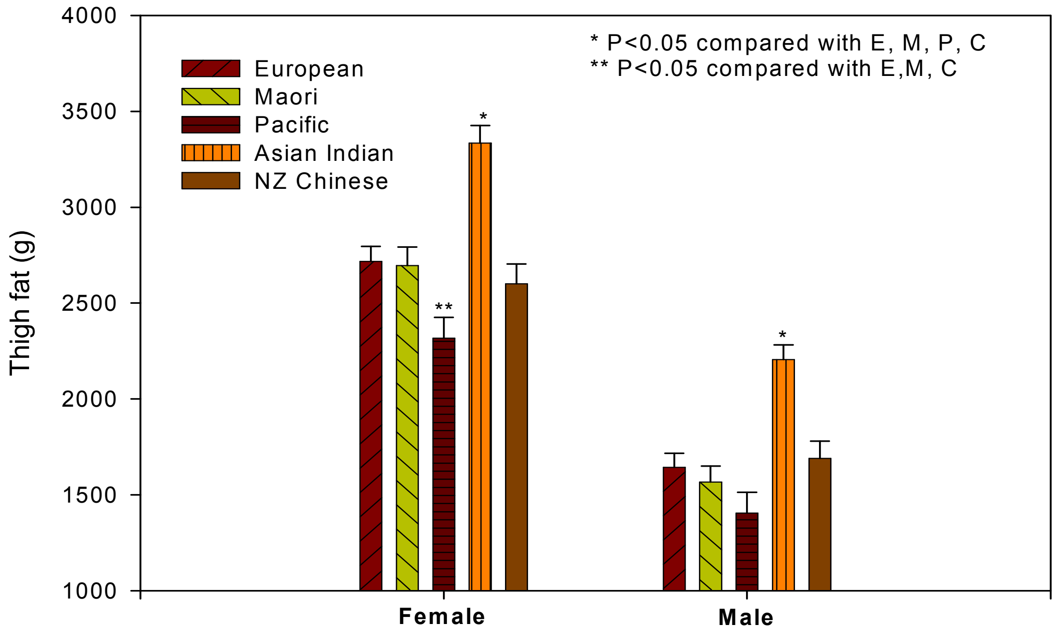
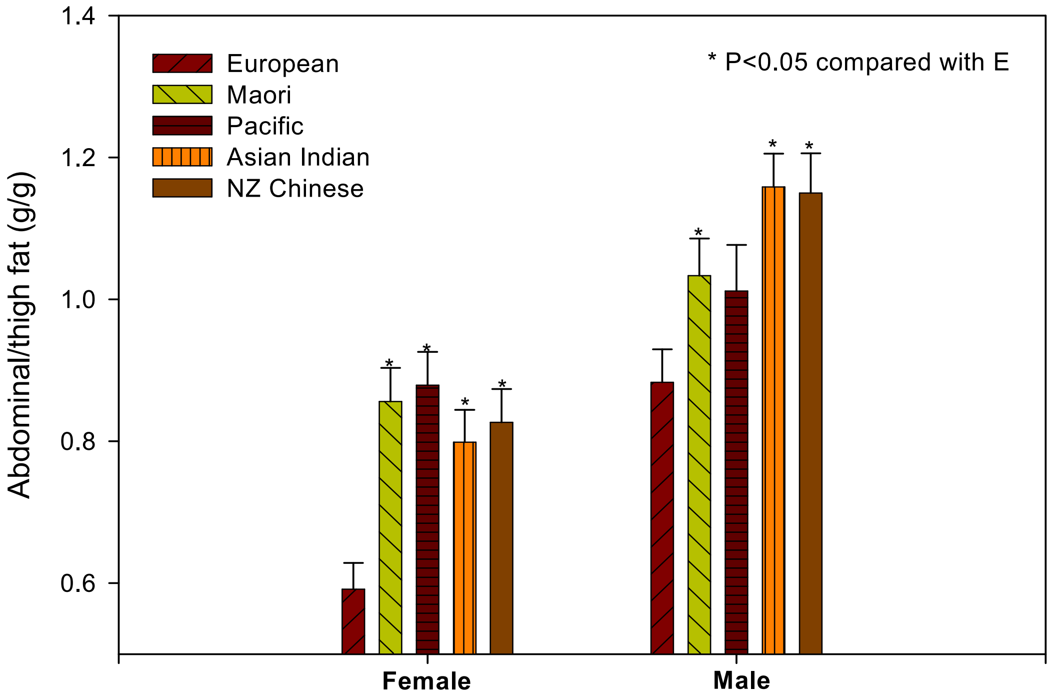


Figure 3.9: Ethnic comparison of thigh fat adjusted for weight and height (Mean ± SE)



European females had the significantly lowest ratio of A/T fat ratio in the five ethnic female groups (P<0.05) (Figure 3.10). European males had significantly lower ratio of A/T fat ratio than Maori, Asian Indian and NZ Chinese (P<0.05). NZ Chinese females and males had significantly higher A/T fat ratio than Europeans (P<0.001). The differences among Maori, Pacific, Asian Indian and NZ Chinese in the A/T fat ratio were not significant.

Figure 3.10: Ethnic comparison of abdominal to thigh fat ratio (Mean ± SE)



3.2.4 Fat free mass and appendicular skeletal muscle mass

Figures 3.11 and 3.12 illustrate FFM and ApSM adjusted for weight and height. Asian Indians had significant least FFM among these five ethnic female and male groups (Figure 3.11). NZ Chinese was the second least. NZ Chinese had 2.09 kg less FFM than European for females (P=0.021), and 3.16kg less for males (P=0.011). After adjustment of weight and height, Pacific females had the significant most ApSM among these five ethnic female groups. Pacific males had the significant highest of ApSM compared to European, Asian Indian and NZ Chinese males (Figure 3.12). NZ Chinese had significantly less ApSM compared to European, Maori and Pacific females and males. The ApSM differences between Asian Indian and NZ Chinese were not significant.

Figure 3.11: Ethnic comparison of fat free mass adjusted for weight and height (Mean ± SE)

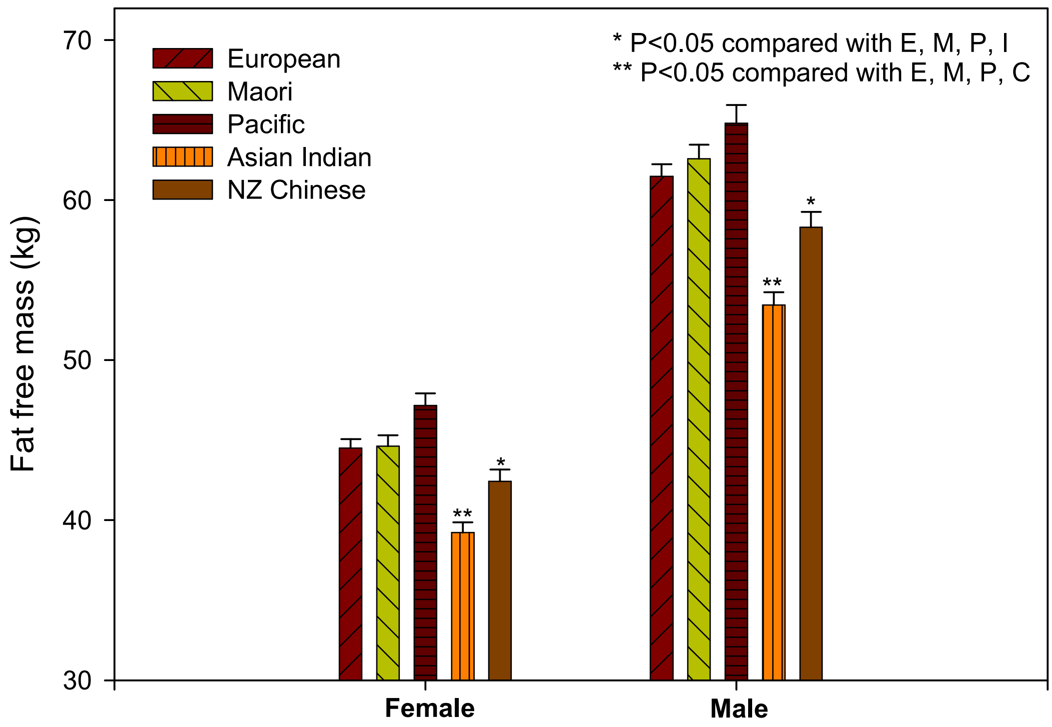
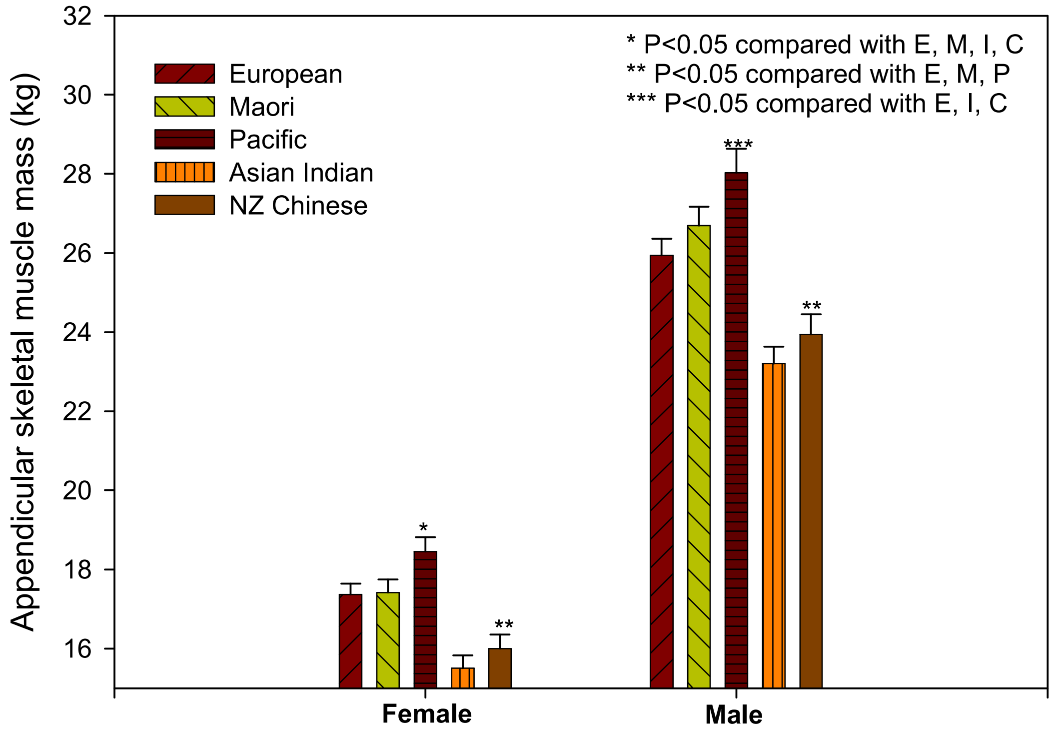


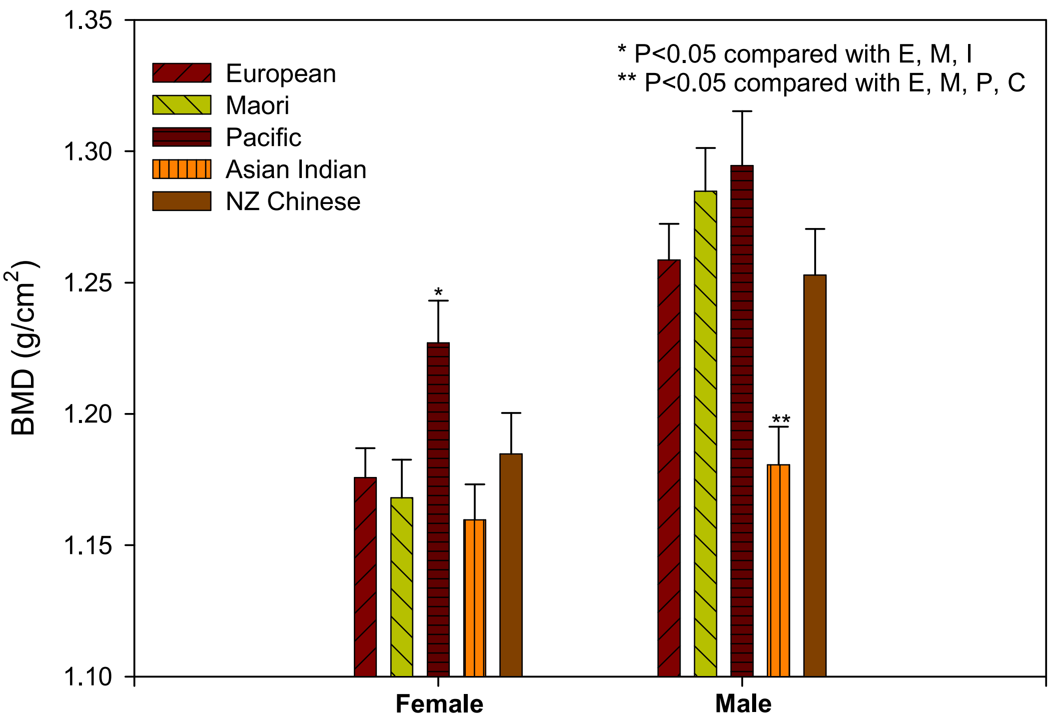
Figure 3.12: Ethnic comparison of appendicular skeletal muscle mass adjusted for weight and height (Mean ± SE)



3.2.5 Bone mineral density

Pacific females had the highest BMD adjusted for weight compared to European, Maori and Asian Indian females (P<0.05) (Figure 3.13). The BMD difference between Pacific and NZ Chinese females was not significant (P=0.091). Asian Indian males had the lowest BMD after adjustment for weight compared to the other four ethnic groups (P=0.001). The BMDs of NZ Chinese females and males were very similar to that of Europeans after adjustment for body weight. In addition, the NZ Chinese females reported that they had at least one menstrual cycle in the last month before the DEXA scan.

Figure 3.13: Ethnic comparison of bone mineral density adjusted for weight (Mean ± SE)



3.2.6 Bone length

Figures 3.14a, 3.14b, 3.15a, and 3.15b illustrate leg bone length and arm bone length after adjustment for measured height and DEXA height. Leg bone length was defined as the sum of femur and tibia bone lengths. After adjustment for measured height, Asian Indian had the longest leg bone length in these five ethnic groups. European, Maori and

NZ Chinese had significantly shorter leg bones than Pacific and Asian Indian for females, had significant shorter leg bones than Asian Indian for males. Adjusted for measured height, NZ Chinese leg bones were 2.4 cm shorter than Asian Indian for female (P<0.001), and 2.5 cm shorter for male (P=0.001). After adjustment for DEXA height, NZ Chinese leg bone lengths were still the shortest. For female, NZ Chinese leg length was 1.52 cm shorter than European (P=0.016) and 2.94 cm shorter than Asian Indian (P<0.001). For males, NZ Chinese were 2.15 cm shorter than European (P=0.002), and 3.22 cm shorter than Asian Indian (P<0.001).

Arm bone length was defined as the sum of humerus and radius bone lengths. After adjustment for measured height or DEXA height, NZ Chinese had the shortest arm bone length and Asian Indian had the longest in the 5 ethnic groups. For the same height, NZ Chinese female was 3.9 cm shorter than Asian Indian female (P<0.0001) and 1.6 cm shorter than European female (P=0.005). NZ Chinese male was 3.7 cm shorter than Asian Indian male (P<0.0001) and 1.2 cm shorter than European male (P=0.077). For the same DEXA height, NZ Chinese female arm was 2.4 cm (P<0.001) shorter than European female and 4.2 cm (P<0.001) than Asian Indian. Similar differences were found in the male group.

Figure 3.14a: Ethnic comparison of leg bone length adjusted for measured height (Mean ± SE)

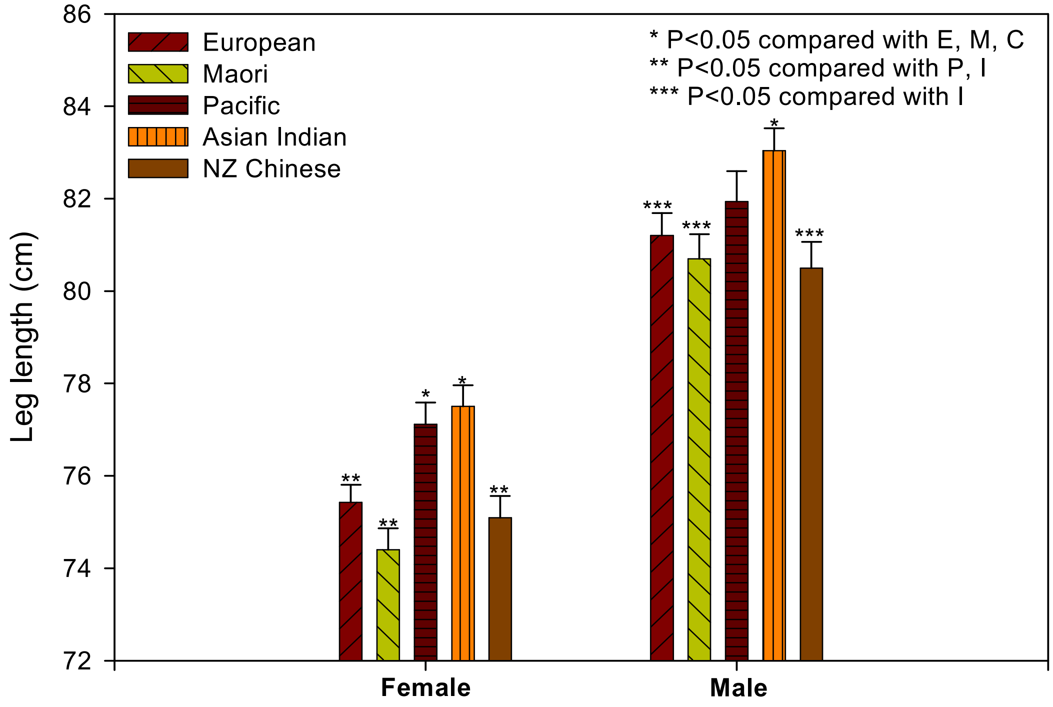


Figure 3.14b Ethnic comparison of leg bone length adjusted for DEXA height (Mean ± SE)

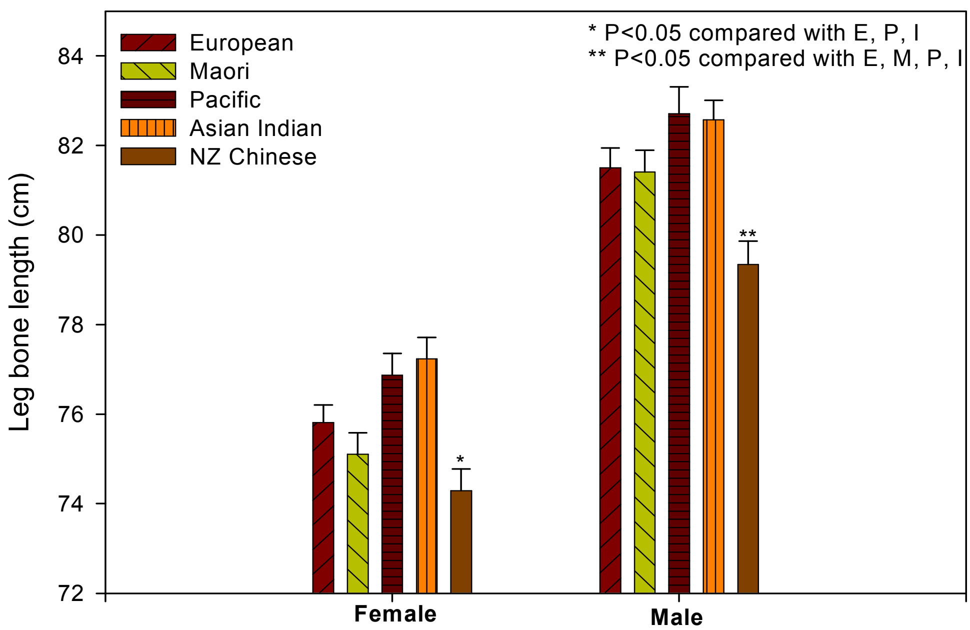


Figure 3.15a: Ethnic comparison of arm bone length adjusted for height (Mean ± SE)

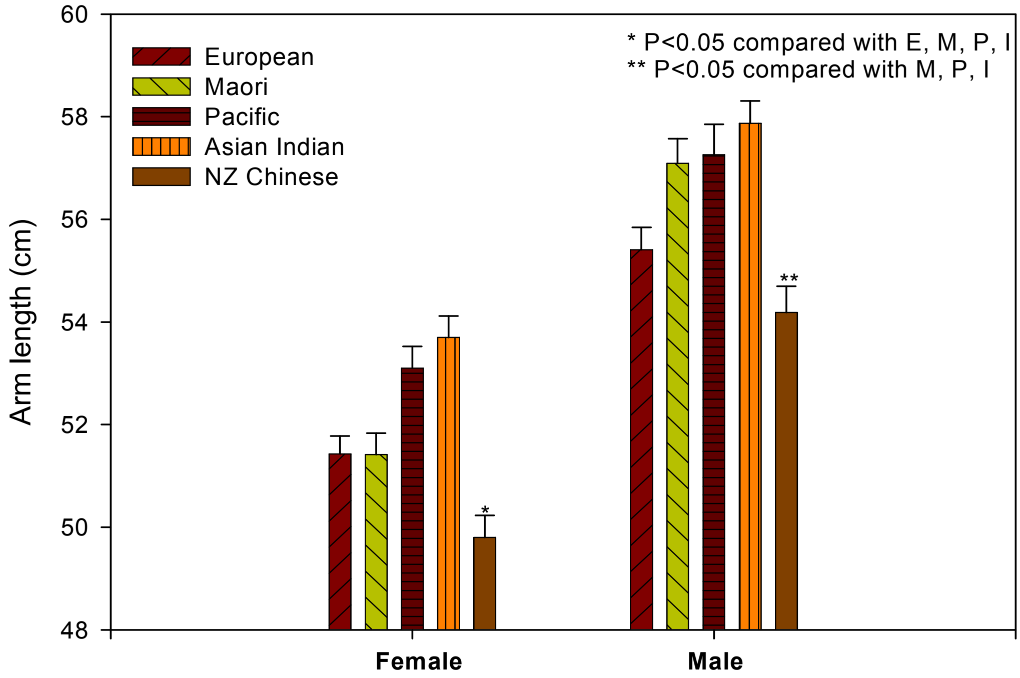
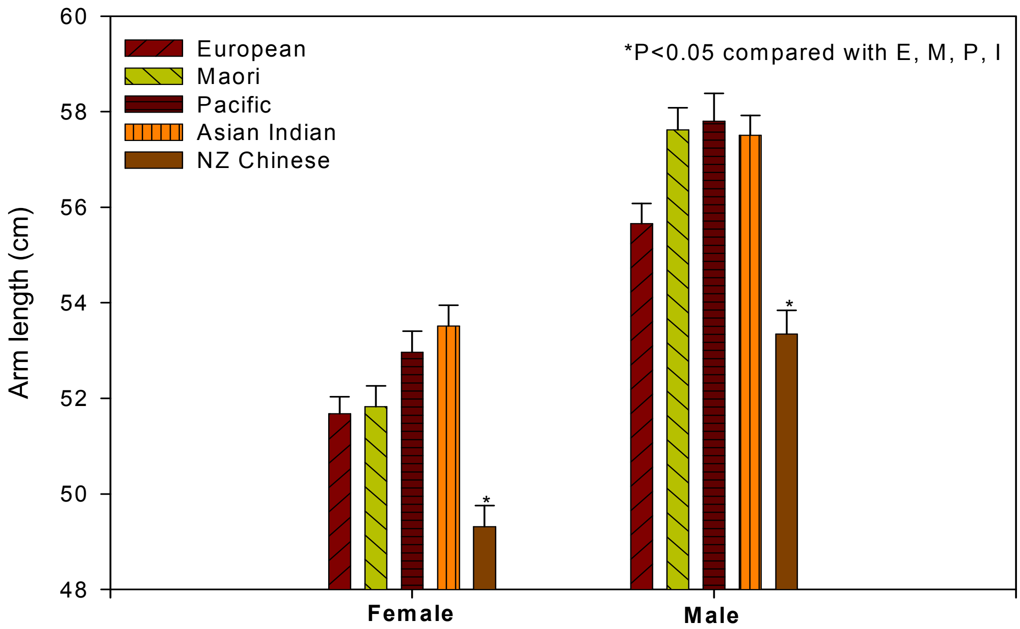


Figure 3.15b: Ethnic comparison of arm bone length adjusted for DEXA height (Mean ± SE)



3.2.7 Summary of ethnic differences

The NZ Chinese comparison to Asian Indian and European ethnic groups is summarized in the Table 3.35.

Table 3.35: NZ Chinese comparison to Asian Indian and European (Mean ± SE)

Variables	NZ Chinese compared to Asian Indian		NZ Chinese compared to European	
	Female	Male	Female	Male
Body fat	-	-	+	+
FFM	+	+	-	-
ApFM	-	-	NS-	NS-
C/Ap ratio	+	+	+	+
Abdominal fat	NS-	-	+	+
Thigh fat	-	-	≈	≈
A/T ratio	≈	≈	+	+
ApSM	≈	≈	-	-
BMD	NS+	+	≈	≈
Leg bone length	-	-	NS-	NS-
Arm bone length	-	-	-	NS-

+, more in NZ Chinese; -, less in NZ Chinese; ≈, similar; NS, not significant; FFM, fat free mass; ApFM, appendicular fat mass; ; C/Ap ratio, central- to-appendicular fat ratio; A/T ratio, abdominal-to-thigh fat ratio; ApSM, appendicular skeletal muscle; BMD, bone mineral density.

Comparing NZ Chinese to Asian Indian, for the same height and weight, NZ Chinese had (significant difference unless stated):

1. less body fat for both female and male.
2. higher FFM for both female and male.
3. less ApFM for both female and male.
4. higher central to appendicular fat ratio for both female and male.
5. insignificant less abdominal fat (g) than Asian Indian for female, but had significant less abdominal fat than Asian Indian for male.
6. less thigh fat (g) for both female and male.
7. similar abdominal to thigh fat ratio to Asian Indian for both female and male.
8. similar ApSM with Asian Indian for both female and male.

9. insignificant greater BMD than Asian Indian for female, but had significant greater BMD than Asian Indian for male.
10. shorter leg bone lengths for both female and male.
11. shorter arm bone lengths for both female and male.

Comparing NZ Chinese to European, for the same height and weight, NZ Chinese had (significant difference unless stated)

1. higher body fat for both female and male.
2. less FFM for both female and male.
3. insignificant less ApFM for both female and male.
4. higher central-to-appendicular fat ratio for both female and male.
5. more abdominal fat mass for both female and male.
6. similar thigh fat with European for both female and male.
7. greater abdominal- to-thigh fat ratio for both female and male.
8. less ApSM for female and male.
9. similar BMD with European for female and male.
10. insignificant shorter leg length than European for both female and male.
11. shorter arm length than European for female and insignificant shorter arm length than European for male.

In summary, 9 out of the above 11 body composition variables in NZ Chinese were different to Asian Indian. Seven out of the above 11 body composition variables, NZ Chinese were different to European. Overall, NZ Chinese was different to Asian Indian and European in total and regional body composition and proportions.

3.3 Section C: Other data collected by the questionnaire

3.3.1 Diet

All males ate a variety of food including meat. Only one female reported not eating lamb meat, while all others reported eating a variety of food including meat. The food frequency data collected from participants are presented in Tables 3.36 and 3.37. There were 27.9% of all participants had met the 5+ a day recommendation. Soy products eating frequency of 2-3 times a week or more was 67.4%, dairy products eating frequency 2-3 times a week or more was 81.4%, and seafood eating frequency was 46.5%. In addition, 11 (25.6%) of participants were taking vitamin and mineral supplements.

Table 3.36: Prevalence meeting the recommended fruit and vegetable intake

Variable	Females (N=23)	Males (N=20)	Total (N=43)
Fruit 2+ a day	11 (47.8%)	10 (50.0%)	21 (48.8%)
Vegetable 3+ a day	9 (39.1%)	9 (45.0%)	18 (41.7%)
Fruit $\geq$ 2 & vegetable $\geq$ 3 a day	6 (26.1%)	6 (30.0%)	12 (27.9%)

Values are number (%)

Table 3.37: Selected food eating frequency

Variable	Soy products	Dairy products	Fish and seafood products
None	0 (0%)	1 (2.3%)	2 (4.7%)
Less than once per week	14 (32.6%)	7 (16.3%)	21 (48.8%)
2-3 times a week	21 (48.8%)	15 (34.9%)	16 (37.2%)
Nearly once a day	5 (11.6%)	19 (44.2%)	4 (9.3%)
Nearly every meal	3 (7.0%)	1 (2.3%)	0 (0%)

Values are number (%)

The top 4 barriers to eating fruit and vegetables each day reported were:

- Fruit and vegetables are not available where I work
- Fruit is difficult to eat when I am 'on the go'
- Vegetables are difficult to eat when I am 'on the go'
- The supermarket I go to most doesn't carry a lot of different fruit and vegetables

3.3.2 Self-reported physical activity level and sleeping hours

In this study, physical activity (PA) levels were classified as sedentary (no physical activity at all), sufficiently active (active in 5 days or more in a week) and insufficiently active (active less than 5 days/week). The results for levels of PA and reasons behind being physically inactive are presented in Tables 3.38 and 3.39. There were 20.9% of participants reported having sufficient physical activity in the last 7 days. More than half of participants (51.2%) cited lack of time due to work and family responsibilities as being a main reason that prevented them from being physically active. Thirty (69.8%) participants reported that none of the 11 items about their neighbourhood put them off being physically active (refer to appendix 12 questionnaire section 1 question 7). In addition, the participants' mean self reported sleeping hour was 8.3 ± 0.2 (7.0-10.5).

Table 3.38: Prevalence of physical activity in the last 7 days for NZ Chinese participants

Variable	Females (N=23)	Males (N=20)	Total (N=43)
Sufficiently active	5 (21.7%)	4 (20.0%)	9 (20.9%)
Insufficiently active	10 (43.5%)	15 (75.0%)	25 (58.1%)
Sedentary	8 (34.8%)	1 (5.0%)	9 (20.9%)

Values are number (%).

Table 3.39: Reasons reported that kept the NZ Chinese participants from being physically active

Reasons	Influence the participant a lot
Lack of time due to work	14 (32.6%)
I would have to get someone to watch my children	10 (23.3%)
It's too hard to stick to a routine	10 (23.3%)
Lack of energy/too tired	9 (20.9%)
Lack of time due to family responsibilities	8 (18.6%)

Values are number (%)

Table 3.40 presents the %BF and %ApSM comparisons in the 3 different PA level groups. For females, the mean %BF in the sedentary (S) group was 3.9% higher than the insufficiently active (IA) group and 5.0% higher than the sufficiently active (SA) group. For males, the mean %BF of SA group was 2.6% less than that of IA group. However, these differences were not statistically significant. For females, there was a tendency that the more physically active females had higher %ApSM than those less physically active. For males, the sufficiently active group had higher %ApSM than the insufficiently active group, but again these differences of %ApSM were not statistically significant. The number of sedentary group for male was only one, thus the sample size was too small to compare.

Table 3.40: %BF and %ApSM comparison in different PA level groups

Sex	PA groups	N	%BF	P values	%ApSM	P values
Females	SA group	5	27.7 ± 4.2	0.110 (to S)	26.7 ± 1.7	0.219 (to S)
	IA group	10	28.8 ± 6.6	0.698 (to SA)	26.5 ± 2.2	0.833 (to SA)
	S group	8	32.7 ± 3.6	0.136 (to IA)	25.2 ± 1.6	0.216 (to IA)
Males	SA group	4	20.1 ± 10.7	0.713 (to S)	32.6 ± 4.4	0.580 (to S)
	IA group	15	22.7 ± 6.6	0.549 (to SA)	31.3 ± 2.8	0.452 (to SA)
	S group	1	17.0 ± 0.0	0.470 (to IA)	34.6 ± 0.0	0.318 (to IA)

Values are mean ± SD; P value calculated using two-tailed t-test; %BF: percentage body fat; %ApSM: percentage appendicular skeletal muscle mass; PA: physical activity; SA: sufficiently active; IA: insufficiently active; S: sedentary.

3.3.3 Tobacco and alcohol consumption

The response addressing tobacco and alcohol consumption are presented in Tables 3.41, 3.42 and 3.43 with males reporting a greater consumption of both substances than females.

Table 3.41: Distribution of frequency of tobacco smoking (cigarettes per day) in the last 30 days for NZ Chinese participants

Smoking frequency (cigarettes / day)	Females (N=23)	Males (N=20)	Total (N=43)
0	21 (91.3%)	17 (85.0%)	38 (88.4%)
1	1 (4.3%)	0	1 (2.3%)
2	1 (4.3%)	0	1 (2.3%)
10	0	3 (15.0%)	3 (7.0%)

Values are number (%)

Table 3.42: Frequency of alcohol intake in the last year for NZ Chinese participants

Alcohol frequency	Females (N=23)	Males (N=20)	Total (N=43)
Not in the last year	7 (30.4%)	5 (25.0%)	12 (27.9%)
Monthly or less often	12 (52.8%)	6 (30.0%)	18 (41.9%)
2-4 times a month	2 (8.7%)	4 (20.0%)	6 (14.0%)
2-3 times a week	2 (8.7%)	1 (5.0%)	3 (7.0%)
4 + a week	0	4 (20.0%)	4 (9.3%)

Values are number (%)

Table 3.43: Number of alcohol drinks on a typical day consumed by drinkers

Alcohol drinks on a typical day	Females (N=23)	Males (N=20)	Total (N=43)
0	7 (30.4%)	5 (25.0%)	12 (27.9%)
1-2	15 (65.2%)	13 (65.0%)	28 (65.1%)
3-4	1 (4.4%)	1 (5.0%)	2 (4.7%)
5-6	0	1 (5.0%)	1 (2.3%)
7+	0	0	0

Values are number (%)

3.3.4 Awareness of nutrition messages

Thirty participants (76.7%) knew that health experts recommend the people should eat more high fibre foods and less sugary and salty foods. Thirty-six participants (83.7%) did get the message of eating more vegetable and fruit, however, only 11 participants (25.6%) selected the correct answer for the servings of vegetable and fruit per day, 10 participants (23.3%) did not know, and 22 participants (51.2%) selected the incorrect answers.

CHAPTER 4: DISCUSSION

The previous chapter has provided detailed information about total and regional body composition of 43 healthy NZ Chinese; this data has been compared to existing data of other major NZ ethnic groups (especially European and Asian Indian) matched by age. Information about the birth history, smoking, alcohol, diet and physical activity was also examined in relation to the body composition of the NZ Chinese

4.1 Summary of major findings

Key findings of Section A considering NZ Chinese participants only:

- On average, female participants were shorter and lighter than male participants. However, mean relative sitting heights or bone lengths of the legs of females and males were the same. For the same height and weight, females had a significantly greater hip size, more total body fat, more central fat, more abdominal and thigh fat than males. The ratios of A/T and C/Ap fat for female were less than male.
- On average, males had more FFM, more BMC, higher BMD and more ApSM than females.
- For males with at least one CVD risk factor, their mean WC, WHR %BF and truncal fat (%) were significantly greater than those without any risk factors. This was not seen in females.
- Northern Chinese participants were not found to be different from Southern Chinese participants in body size and body composition measured by DEXA.
- The males demonstrated an association of lower birth weight with higher %BF measured at age of 30-39 years. Such association was not seen in females.

Key findings of Section B ethnic differences:

- For a fixed BMI, NZ Chinese had a higher percentage total body fat than European and less than Asian Indian ($P<0.001$). At a %BF equivalent to a BMI of 30 $kg.m^{-2}$ in Europeans (WHO threshold for obesity), BMI for Asian Indian and NZ Chinese women were 5.8 and 2.2 BMI units lower than European, respectively, and for Asian Indian and NZ Chinese men, 8.2 and 3.0 BMI units lower.

- A/T fat ratio of NZ Chinese was higher than that of European (P<0.001) and similar to that of Asian Indian. NZ Chinese had significant higher C/Ap fat ratio than both Asian Indian and European (P<0.001).
- For the same height and weight, NZ Chinese had significantly less FFM and ApSM than European, Maori and Pacific people.
- For the same weight, NZ Chinese, female and male, had similar BMD to European. NZ Chinese males had significantly higher BMD than Asian Indian males.
- Among the five ethnic groups, NZ Chinese had the shortest leg and arm bone length (measured by DEXA) for the same DEXA height.

Key findings of Section C:

- Less than a third (27.9%) of the studied 43 NZ Chinese participants reported meeting the 5+ a day recommendation. Half of the participants reported eating dairy products at least once a day but only one in five consumed soy products daily.
- One out of five participants reported undertaking sufficient physical activity in the previous 7 days.

Each of the above sections is discussed in detail below.

4.2 Section A: Main data collected

4.2.1 Sex differences of body composition in NZ Chinese

Compared with the 2002/03 New Zealand health survey (Scragg & Maitra, 2005), which included adult NZ Chinese aged 15+ years, the current study sample was 1.2 cm shorter, but weighed 3.7 kg more for male. BMI was 1.4 kg m^{-2} greater and WC was 3.0 cm greater than the national values. The mean weight and BMI of females in the current study were smaller than the national values, but the mean height and WC were larger than the national values (Table 4.1). As the recruitment was intended to find a wide range of body fatness, this may have contributed to the larger size in WC participants in this study. The participants of this study were not representative of NZ Chinese adults or for Chinese aged 30-39 years in NZ.

Table 4.1: Comparison anthropometric data of the Chinese sample aged over 15 years in 2002/03 New Zealand Health Survey to this study for NZ Chinese aged 30-39 years

Variables	Female		Male	
	NZHS (n=269)	This study (n=23)	NZHS (n=196)	This study (n=20)
Height (cm)	159.8	160.0	172.2	171.0
Weight (kg)	55.3	54.5	66.8	70.5
BMI ($kg.m^{-2}$)	21.7	21.2	22.6	24.0
Waist circumference (cm)	74.7	75.6	82.8	85.8

BMI, body mass index; NZHS, New Zealand Health Survey; Value obtained from Scragg et al. (2005).

For the same height, NZ Chinese males and females had the same sitting height. In addition, the bone measurements from the DEXA scans provide evidence that the proportion of the limb bone lengths did not differ in male and female. Therefore, NZ Chinese females and males had the same or similar proportions of trunk and limb bone lengths. However, the fat distribution on trunk and limbs were different between the males and females studied.

The greater mean WHR, C/Ap fat ratio and A/T fat ratio indicate that NZ Chinese males deposit proportionally more fat than females at the waist, trunk and abdomen than the hip, limbs and thigh, respectively. Therefore, physically, for the same height and weight, NZ Chinese males show significantly smaller hip size than females. These results are consistent with studies from Taiwanese (Chang et al., 2003) and oriental Asian (mainly Chinese, Japanese and Koreans) in America (Wu et al., 2007). This sex difference in fat distribution also existed in Asian Indian in NZ (Rush et al., 2007b) and European in America (Wu et al., 2007). In general, males, regardless of ethnicity, show more truncal or central body fat, relative to the total body fatness, than females.

NZ Chinese males with at least one CVD risk factor had significantly more body fat and central fat measured by anthropometry and DEXA than those without CVD risk factors. This finding is consistent with findings of Taiwan Chinese aged 17-81 (Wu et al., 1998). Wu et al. found that a relative excess central fat, assessed by DEXA, is associated with CVD risk factors, such as higher BP and LDL cholesterol level, in both males and females. In the present study, the association between CVD risk factors and central fat was found not to be significant in female participants. This could have been due to the relatively high oestrogen in the female participants aged 30-39 years. which was influencing the fat distribution (Hoffman et al., 2005).

4.2.2 Birth history

The results of the study demonstrate no difference in Northern and Southern Chinese in body composition measured by DEXA. In contrast, Deurenberg et al. found that Northern Chinese tend to be taller and more muscular than Southern Chinese (Deurenberg et al., 1999). They also found that Beijing Chinese (Northern Chinese) has significantly different body composition measured by DEXA from Singapore Chinese (Southern Chinese). It was possible that, lifestyle, environmental and socioeconomic status factors of the present Northern and Southern NZ Chinese participants were similar to each other, therefore, over time, the difference, if any, of body composition between Northern and Southern NZ Chinese would be decreased by similarity of lifestyle and environmental effects.

The study found that male participants with reported lower birth weight had more body fat (measured by DEXA) than those born with a higher birth weight. Furthermore, those participants born lighter did show a tendency of higher risk of CVD factors, at their 30s, than those born heavier. These results are in line with the foetal origins of adult diseases hypothesis (Barker, 2003). Therefore, if a NZ Chinese woman has a well balanced diet and a healthy body composition, it is likely that she will have an adequately sized baby and offer a way to prevent cardiovascular diseases in her offspring. Such an association between birth weight and body fat was not demonstrated in females. This might be due to the influence of oestrogen of these females on body composition and risk factors, but this was not included in the scope of this study.

4.3 Section B: Comparison to other ethnic groups

4.3.1 Relationship between BMI and percentage body fat

The present study found that at the age of 30-39 years, for the same BMI, NZ Chinese had a higher %BF than NZ Europeans, which is consistent with studies comparing

Dutch Europeans with Singapore Chinese (Deurenberg et al., 1999), Hong Kong Chinese (He et al., 2001), and Taiwan Chinese (Chang et al., 2003). The finding is also supported by a recent report (Wu et al., 2007). They reported that American Eastern Asian (mainly Japanese, Chinese and Korean) have higher %BF than American European. Analysis of these subjects was also by a single DEXA.

As discussed in the introduction, the ethnic differences in the relationship between %BF and BMI is partly due to different bone widths, body proportions and muscularity among ethnic groups (Deurenberg et al., 1999; Rush et al., 2004). As demonstrated by the current study results, at the same height and weight, NZ Chinese had significant less ApSM than NZ European. Furthermore, NZ Chinese had remarkably short relative leg bone length, measured by DEXA, than NZ Europeans. Less appendicular muscle and shorter leg bone length help explain the higher %BF in NZ Chinese than NZ European at the fixed BMI found in this study.

However, not all studies report consistent results. For example, as discussed prior, Deurenberg et al. (1997) found that Beijing Chinese are not different from the European population in relationship of %BF/BMI. Beijing Chinese might be more active than Dutch European due to less mechanisation and motorisation in Beijing compared to the Netherlands. Distinctly different levels of physical activity throughout the lifecycle might increase muscle mass in Beijing Chinese in relation to the more industrialised Dutch.

Most recently Lear et al. (2007) reported that Canadian Chinese have significantly less body fat mass than Canadian European at BMIs of 25 and 30 $kg.m^{-2}$. These investigators argued that the inconsistency with other studies is due to the use of body fat mass instead of %BF in their analysis. When the body fat mass was used in comparison in the study, NZ Chinese males had significantly more fat mass than NZ European males, and the NZ Chinese females had non-significant more fat mass than NZ European females after adjustment for height and weight. The small sample size of large BMI in this study (only 8 out of 43 (~18.6%) had a BMI of > 25 $kg.m^{-2}$, with a mean BMI of 21.2 ± 2.1 $kg.m^{-2}$ for female and 24.0 ± 3.5 $kg.m^{-2}$ for male), compared to the large Canadian Chinese sample size (n=219), with more than half with a BMI of > 25 $kg.m^{-2}$, with a mean BMI of 25.7 ± 3.6 $kg.m^{-2}$, may contribute to the inconsistency of the results. In addition, the differences in the %BF/BMI relationship between NZ

European and Canadian European cannot be excluded. Furthermore, the inconsistency may be the result of limitations in the size of the Chinese and European study samples in the two countries.

This study also demonstrates that NZ Chinese had significantly less %BF than Asian Indian at the same BMI. This result is consistent with a previous study of Singapore Chinese and Singapore Indian participants (Deurenberg-Yap et al., 2002), and with a recent study of Canadian Chinese and South Asian participants (Lear et al., 2007). However, the difference between NZ Chinese and Asian Indian can not be explained by the differences identified in muscle and leg length in this study: NZ Chinese did not have significantly more ApSM than Asian Indian. Most importantly, Asian Indian had a significantly longer relative leg bone length than NZ Chinese and European. Similarly, Singapore Indian were identified as having significantly shorter relative sitting height than Singapore Chinese (Deurenberg-Yap et al., 2002). However, Asian Indian had less BMD than NZ Chinese (significant in males not in females). This BMD difference and differences of bone width and length may contribute to the remarkable difference in body fatness between NZ Chinese and Asian Indian. These parameters including bone width (or slenderness) should be measured in future research in ethnic comparison of relationship of %BF/BMI.

Recently, the Asian Health Chart book reported that NZ Indian has a much higher prevalence of low birth weight than the total population and NZ Chinese (Ministry of Health, 2006). According to the Barker hypothesis, babies with lower birth weights are fatter in adulthood than those born with higher birth weights (Barker, 2003). Thus, the differences in %BF/BMI between NZ Chinese and Asian Indian at the age of 30-39 years might be related to the difference in birth weight and subsequent growth and development. In addition, it was speculated that the distinct differences in the association of %BF/BMI between NZ Chinese and Asian Indian might be the result of intergenerational effects of diet and environment in NZ Chinese and Asian Indian (Yajnik, 2001; Yajnik, 2004).

The above ethnic differences between Asian Indian and NZ Chinese indicate that Asian Indian and NZ Chinese can not be categorized by terms of the same BMI when screening for obesity in New Zealand. The BMI cut-offs for overweight and obesity in NZ Chinese is discussed below.

4.3.2 BMI cut-off points for overweight and obesity

Findings from studies for Chinese in Singapore, Taiwan and Hong Kong (Table 4.2) demonstrate that there were variations in BMI cut-offs among the Chinese in different countries. Different DEXA machines, which estimate different %BF results (Plank, 2005), may be responsible for the variation. In addition, different food and physical environments may cause differences in fat and energy intake and physical activity, and therefore muscle size in Chinese in different countries. Therefore the results may reflect true variation in the relationship between %BF and BMI for Chinese by country.

Table 4.2: Comparison of BMI cut-offs derived from regression models between DEXA %BF and BMI in Chinese from different countries

Author	Location	Number of subjects	Age (years)	BMI ($kg.m^{-2}$) equivalent to %BF cut-off points for overweight*		BMI ($kg.m^{-2}$) equivalent to %BF cut-off points for obesity*	
				Female	Male	Female	Male
Current study	New Zealand	23 F 20 M	30-39	21.2	22.6	24.2	25.9
Goh[1]	Singapore	771 F 298 M	30-70	23	25	25	27
He[2]	Hong Kong	190 F 140 M	20-80	NA	NA	22.6	24.6
Chen[3]	Hong Kong	1122 F	41-63	19.5	NA	23.3	NA
Chang[4]	Taiwan	570 F 509 M	≥ 20	20.0	21.1	23.0	24.7

BMI, body mass index; NA, not available; F: female; M: male; *30%BF for female and 20%BF for male for overweight, and 35%BF for female and 25%BF for male for obesity (World Health Organisation Expert Committee, 1995); [1]reference value obtained from Goh, Tain et al. (2004); [2] reference value obtained from He et al. (2001); [3]reference value calculated from the inverse regression equation after adjustment for age obtained from Chen et al. (2006); [4]reference value obtained from DXA regression models in Chang et al. (2003).

This study found that corresponding to WHO-recommended %BF cut-off points for overweight, which is 30% for female and 20% for male, and obesity, which is 35% for female and 25% for male (Goh et al., 2004b), the BMIs for NZ Chinese females aged 30-39 years were 21.2 and 24.2 $kg.m^{-2}$, respectively, and for NZ Chinese males aged 30-39 years were 22.6 and 25.9 $kg.m^{-2}$, respectively. As discussed in the literature review, cross-sectional studies in China, Singapore and Hong Kong on the relationship between CVD risk factors and BMI supported the fact that BMI cut-off between 23-25 $kg.m^{-2}$ may be appropriate for screening obesity in Chinese living in those countries. The results of this study are in line with those reported in other studies mentioned above. The present result for male is close to the proposed BMI cut –off used in the Asian health chart book, 23 $kg.m^{-2}$ for overweight and ≥ 25 $kg.m^{-2}$ for obesity (Ministry of Health, 2006). Therefore, the proposed BMI cut-off used in Asian health chart book might be more appropriate in NZ Chinese than in Asian Indian, who had demonstrated a much higher %BF than NZ Chinese at a fixed BMI in the present study.

To draw conclusions about the BMI cut-offs for overweight and obesity in NZ Chinese, further research on body composition for different age groups and especially BMI >25 $kg.m^{-2}$ groups is needed. A large sample longitudinal NZ Chinese study for the relationship between BMI and CVD risk factors and mortality would be also needed.

4.3.3 Fat distribution

In addition to BMI correlation with %BF, this study did show that WC was positively correlated to the abdominal fat mass (g) measured by DEXA in Maori, Pacific people, Asian Indian and NZ Chinese. Particularly, the association was very strong in males through the four ethnicities ($r \geq 0.90$, $P<0.001$). Furthermore, a recent systematic review of 21 cross-sectional studies in 11 countries (not including NZ) of the Asia-Pacific region, including 263,000 individuals (73% Asian), has shown that WC is more strongly related to the prevalence of diabetes in Asians and Europeans than BMI (Huxley et al., 2008). Therefore, the present study indicates that WC is an important measurement for identifying central obesity in NZ. The ethnic differences in central fat and fat distribution are discussed below.

For the same height and weight, NZ Chinese was found to carry 445g and 507g more abdominal fat, measured by DEXA, than NZ European for female and male respectively in this study. This finding is inconsistent with that of Lear et al. (2007) on ethnic differences of abdominal fat, SAT and VAT among aboriginal, Chinese, European and South Asian people aged 30-65 years in Canada. These authors found that Canadian Chinese and European have no difference in abdominal fat, measured by CT, at BMIs of both 25 and 30 $kg.m^{-2}$. The inconsistency of the findings might be a result of different methods used in the two studies for measuring abdominal fat and lack of large BMI sample of this study as mentioned before. In addition, the self-selected Auckland European sample might be biased to more physically fit and lean (personal communication with Professor Elaine Rush). Furthermore, Lear et al. (2007) reported in a separate analysis, not including BMI, that at the same body fat mass (>9.1kg), Canadian Chinese had significantly greater amounts of abdominal fat, VAT and SAT than Europeans.

This study has shown that the NZ Chinese sample had significantly less abdominal fat percentage (% of total mass of abdominal region) than Maori, Pacific and Asian Indian for female, which is consistent with previous findings in NZ (Orr-Walker et al., 2005) (Table 4.3). Orr-Walker et al. found that NZ Chinese females have much less abdominal fat percentage than Polynesian and Asian Indian females aged 18-51 years. However, the values reported in this study are 2-3 times greater than those reported in the Orr-Walker et al. (2005) study. Firstly, in this study, the region of abdominal fat was determined to be the maximum abdominal tissue area between the upper horizontal border (about parallel with the junction of the T12 and L1 vertebrae) and the lower border (on top of the iliac crest) and extended to the lateral margins of the body. Orr-walker et al. obtained the abdominal fat percentage from the DEXA scan of the lumbar spine, which included a limited area of abdominal tissue around the L1 to L4 vertebrae. Secondly, there were obvious BMI differences in subjects recruited for the two studies: in the Orr-Walker et al. study, the mean BMI is 21.4 (19.6-22.5) $kg.m^{-2}$ for Chinese females and 22.7 (20.4-24.7) $kg.m^{-2}$ for Indian females, compared to 21.2 (18.1-26.6) $kg.m^{-2}$ for NZ Chinese females and 26.9 (17.7-38.1) $kg.m^{-2}$ for Asian Indian females in this study. Therefore, the participants in this study covered a wider range of BMI than the Orr-Walker et al. study. This might indicate that this study had a better ability to characterize ethnic differences in fat distribution. Thus, the differences in recruitment and methods used in the two studies might contribute to the huge differences in values of abdominal fat percentage. However, the ranking of ethnic differences of abdominal fat percentage in the two studies is in agreement.

Table 4.3: Comparison of abdominal fat (% of regional mass) in females

Ethnicity	This study	Orr-Walker et al. (2005) study
European	29.6 ± 12.4 (9.0-53.2)	13.0 ± 7.0 (6.9-17.2)
Maori	42.8 ± 8.3 (26.7-55.9)*	18.5 ± 8.2 (11.8-23.9)*
Pacific	42.5 ± 8.2 (26.8-57.1)*	18.5 ± 8.2 (11.8-23.9)*
Asian Indian	45.6 ± 8.8 (19.8-57.6)*	20.3 ± 6.2 (16.1-24.2)*
NZ Chinese	33.8 ± 8.1 (15.3-44.6)	13.0 ± 5.7 (8.8-16.1)

Values are mean ± SD; Range in parentheses; *significantly different to NZ Chinese.

Lear et al. (2007) found that, Canada South Asian people have more abdominal fat at BMIs of 25 and 30 $kg.m^{-2}$ than European and Chinese, which is consistent with the results found in this study. In addition, Lear et al. reported that at the same body fat mass (<37.4kg), South Asian people have more VAT and SAT than European.

Therefore, this study shows that there are significant ethnic differences in fat distribution and supports that ethnic-specific WC cut-off is important for identifying central obesity. Unfortunately, the DEXA is unable to clarify the differences of VAT and SAT in NZ Chinese, and more studies would be necessary to understand VAT and SAT distribution in NZ Chinese.

In addition, this study demonstrates that NZ Chinese had a similar A/T fat ratio to that of Asian Indian, and a significantly higher A/T fat ratio than European ($P<0.001$). Furthermore, NZ Chinese had a significantly higher C/Ap fat ratio than both Asian Indian and European ($P<0.001$). Therefore, proportionally, NZ Chinese were centrally fatter than European and Asian Indian. For the same height, NZ Chinese had significantly shorter leg and arm lengths, which were determined by DEXA, than all other four ethnic groups. The short limbs in NZ Chinese resulted in the remarkably high C/Ap fat ratio. Therefore, the differences in skeletal dimensions might result in these ethnic differences of fat distribution.

4.3.4 Bone mineral density

This study found that total BMD was highest in Pacific people, lowest in Asian Indian, and Maori, European and NZ Chinese were intermediate. The highest BMD in Pacific people among the 5 ethnic groups is in agreement with that reported in previous studies (Cundy et al., 1995; Rush et al., 2004). This study also demonstrates that while the mean total body BMD of NZ Chinese was lower than European, BMD was not different after adjustment for body weight. This is consistent with previous findings for Chinese migrants in USA (Finkelstein et al., 2002) and in NZ (Cundy et al., 1995).

As discussed in the literature review, BMD is influenced by age, body weight, genetics, hormones, lifestyle and environmental factors, including nutrition, use of medicines, alcohol and tobacco use and amount of physical activity. Recently, Walker and his co-workers found that time outdoors and body weights are significantly positively associated with BMD in premenopausal Chinese-American females living in New York (Walker et al., 2007). Furthermore, they found that age at immigration is negatively associated with BMD in postmenopausal women. The latter finding was explained by two hypotheses. One is that a later age at immigration may result in less likelihood of a change to a Western diet (rich in Calcium), which may increase their BMD. Another explanation is that women above a certain age may not be able to increase BMD through lifestyle change (Walker et al., 2007). These hypotheses are considered below in relation to the present findings.

The average length of time that NZ Chinese lived in NZ in this study was 85 months (about 7 years), ranging from 36 months to 204 months (3 – 17 years). As discussed previously, recent Chinese migrants have increased their intake of dairy products after immigration (Tan, 2001; Xie, 2003). This might result as an exposure to more dairy products at a young age (before 30s), which might help increase BMD and reduce bone loss. Furthermore, all Chinese females in this study were premenopausal, therefore their BMDs were at or near their adult peak levels. Therefore, it may be speculated that the bone health of those Chinese who have recently immigrated to NZ at a later age, i.e., in their 50s or 60s, might not have BMD as optimal as the present study group. Further research and public health action on bone health may need to focus on this older age group.

Compared to Asian Indian, NZ Chinese had a much greater BMD before and after adjustment of body weight. This finding is not consistent with previous findings (Cundy et al., 1995; Goh et al., 2004a). The inconsistent results might be due to the difference in skeletal size between the two groups (Cundy et al., 1995; Goh et al., 2004a). The skeletal size was not adjusted for in this study. In addition the total body BMD was used in this study while the BMD of different sites was compared in the other 2 studies. Lifestyle and dietary factors were not controlled in all three studies, and therefore, further conclusions are impossible.

The present findings for ethnic differences of BMD among European, Asian Indian and NZ Chinese aged 30-39 years could not explain the high incidence of hip fraction incidence of NZ European females over 50 years, as discussed in the literature review. Further research of ethnic BMD differences for group over 50 years of age is needed.

The ethnic differences in BMD demonstrated in this study were likely to be multifactorial and reflect the complexity of genetic, lifestyle and environmental interactions. The prevalence of osteoporosis and hip fractions in sub Asian groups should be included in next health survey.

4.3.5 Bone length

In the present study, leg bone length was derived from DEXA scan. The leg bone length of the current study was likely to be more accurate than the leg length measured by anthropometry, especially with fat individuals when bony landmarks may be hard to locate. Among the five ethnic groups, NZ Chinese had demonstrated the shortest leg and arm bone length for the same DEXA height.

This study result for leg bone length difference in NZ Chinese and Asian Indian is in line with the findings in Singapore. In ethnic comparison in Singapore, Chinese was found to have a significantly greater sitting height to standing height ratio than Indian for both female and male (Deurenberg-Yap et al., 2002). A greater sitting height to standing height ratio indicates relatively shorter legs in Chinese than in Indian.

As discussed in the literature review, leg length is strongly related to parent height and developmental history of the individual, thus, the ethnic difference of leg bone length found in the present study reflected the genetic differences of height and leg length among the five ethnic groups, and might also indicate ethnic differences in breastfeeding, diet and energy intake during childhood and pre-pubertal years.

4.4 Section C: Other data collected by the questionnaire

Fruit and vegetables are high sources of essential vitamins and minerals with low energy contribution to a diet (Van Duyn MA & Pivonka E, 2000; Lock K et al., 2005). Therefore, the frequency of consumption of fruit and vegetables may serve as a surrogate of a healthy diet. This study demonstrates that even though the majority (83.7% of participants) did know they should eat more fruit and vegetables, and 25.6% did know the 5+ a day message, only 26.1% of females and 30.0% of males did meet the recommendation. This is lower than the prevalence of self-reported fruit and vegetable consumption in Chinese females (39.8%), and higher than males (25.9%) in the 2002/03 health survey (Ministry of Health, 2006). At the age of 30-39 years, Chinese are busy working and raising their family. The availability of fruit and vegetable at work and at the supermarket was reported to influence their intake. Therefore, provision of free or low cost fruit and vegetable at the work place and more varieties in the supermarket may increase the fruit and vegetable intake in this age group.

Dairy products were consumed more often than soy products by the present participants, with 44.2% reporting once a day consumption of dairy products vs. only 11.6% reporting once a day for soy products. The fact that dairy products are more available and cheaper than soy products in western countries (and in Auckland) may contribute to the higher intake of dairy products. This may contribute to the optimal BMDs in the Chinese participants.

In addition, this study demonstrates that the alcohol and tobacco consumption of present participants was low: only 11.6% smoked, 41.9% consumed alcohol monthly or less, 27.9% did not consume alcohol at all, and only 7% consumed 3-6 alcohol drinks on a typical drink day. The present result was consistent with other findings in NZ Chinese (Tan, 2001; Xie, 2003; Ministry of Health, 2006). Such low alcohol and tobacco consumption in NZ Chinese population should be encouraged to be maintained over their lifetime.

Sufficient physical activity is linked to low body fat levels and also other health benefits. There was a tendency of a lower %BF and higher %ApSM in sufficiently physically active groups than others in the participants. However, the prevalence of duration and intensity of physical activity amongst the participants was much lower than that of Chinese in 2002/03 Health Survey (see Table 4.3). This may reflect the true prevalence of PA for this age group, as most of participants reported that they were busy working and raising children, and had little time left for physical activity. The physical environment was not perceived barrier for keeping most of them away from physical activity.

Table 4.3: Comparison of prevalence of sufficient physical activity (150 minutes/week)

New Zealand Chinese in	Females	Males
Present thesis	21.7%	20.0%
2002/03 Health Survey	50.5%*	66.7%*

PA: physical activity; *reference value obtained from Ministry of Health (2006).

Therefore, the promotion of PA in such an age group may need to be at the work place or the child centre or schools, where they have the most of their daily contacts. Furthermore, they may be able to spare 30 minutes of their sleep time for physical activity, as their average number of sleeping hours was over 8 hours, which might indicate their tiredness from work and family responsibility. More PA may reduce their tiredness and enhance their health.

As discussed in the previous section NZ Chinese aged 30-39 years were characterized by short limbs, small appendicular skeletal muscles and large central fat. Maintaining physical activity in NZ Chinese is important to prevent limited movements in older age (resulted in loss of skeletal muscle mass as aging), and to prevent obesity and obesity-related diseases.

Given the low physical activity, the low nutritional knowledge and consumption of fruit and vegetables in the study group, there is a need to promote health messages of HEHA and 5+ A Day to the NZ Chinese group. It might be helpful to have health messages of HEHA and 5+ A Day available in the Chinese language to promote in the Chinese communities.

4.5 Limitations

The relatively small convenience sample in this study meant that the limited number of participants was not representative of the healthy Chinese population aged 30-39 years old in NZ. Besides, for the purposes of comparison across a range of body fatness, participants with a range of BMI as a surrogate for body fatness were recruited. The participants recruited were highly educated and had a good income, which indicated that the studied participants had high socioeconomic status. In addition, participants had been living in New Zealand between 3 and 17 years. They were migrants who arrived after 1987. As discussed in the literature review, the migrants of recent arrivals after 1987 are characterised as skilled, highly-educated and well-off Chinese (Ip, 2003b). Therefore, whether the results presented in this thesis could be extrapolated to NZ Chinese with low socio economic status and NZ born Chinese who have family histories of several generations' settlement in NZ is unknown.

As the WCs of European aged 30-39 years were not collected in the existing dataset, the relationship of WC and abdominal fat could not be analysed in detail. This is an important research area for the future.

The ethnic comparison was not controlled by smoking, physical activity, diet, hormones (including menstrual cycle for females), income and education, which may influence the body composition. It was beyond the scope of this study to address the influence of hormone variables on body composition.

In addition, the sample size of Pacific males was small (only 15, less than 20); hence providing lower statistical power when developing the regression equation of %BF on the logarithm of BMI for Pacific male aged 30-39 years.

Finally, not all measurements were made in the same time period. Europeans, Maori and Pacific people were measured in the 1990s, Asian Indians in 2004 and NZ Chinese in 2007. There could be time related changes within ethnic comparisons.

4.6 Strengths

This study was the first in New Zealand to use the whole body DEXA to compare body composition and fat distribution of NZ Chinese with other NZ ethnicities. DEXA is a gold standard measurement tool in the study of body fatness. There are many body composition data for different ethnic groups derived from DEXA. However, there are inter and intra-manufacturer differences in assessment of whole-body and regional-body composition using different DEXA machines (Plank, 2005). This study had used a **single** DEXA machine to measure the body composition of all volunteers of these five ethnic groups in NZ. Moreover, participants were recruited to cover a wide range of body fatness, height and weight, which enables the analysis of the sex and ethnic differences in the relationships among body fat, body size and fat distribution.

In addition, the participants of all five ethnic groups were recruited from Auckland, where one-third of New Zealand's residents live (Statistics New Zealand, 2008a), and therefore had a common physical and food supply environment.

Furthermore, those individuals who lifted weights more than once a week were excluded at the recruitment process. This exclusion may minimise the effect of physical training on the body composition as these people could have hypertrophied muscle mass.

As discussed in the literature review, the greatest percentage of the NZ Chinese population is between the ages of 25 and 44 years, followed by those aged between the ages of 15 and 24 years. The NZ Chinese immigrants who arrived after 1987 are better educated and skilled, and have much more investment than early settlers. The participants were 30-39 years with a high socio economic status. Even though the present participants were not representative of the NZ Chinese population, their results collected and discussed might be relevant to the majority of the NZ Chinese adults who arrived after 1987.

4.7 Conclusion and recommendations

The most significant finding is that NZ Chinese, for the same height and weight, had less body fat than Asian Indian. At a %BF equivalent to a BMI of 30 kg.m^{-2} in Europeans (WHO threshold for obesity), BMI for Asian Indian and NZ Chinese females were 5.8 and 2.2 BMI units lower than European, respectively, and for Asian Indian and NZ Chinese males, 8.2 and 3.0 BMI units lower. NZ Chinese and Asian Indian can not be categorized in one group in terms of BMI when screening obesity in New Zealand. In addition, abdominal-to-thigh fat ratio of NZ Chinese was significantly higher than that of European and similar to that of Asian Indian. NZ Chinese had a significantly higher central-to-appendicular fat ratio than both Asian Indian and European. NZ Chinese was centrally fatter than European and Asian Indian.

The ethnic differences in body composition presented in this thesis provides basic scientific evidence justifying the conclusion made by Rasanathan and co-workers: the 'Asian' category for the NZ health sector does not seem to identify a group of people with similar health status or health need (Rasanathan et al., 2006).

This study reported that the long relative leg length of Asian Indian did not contribute to a lower body fatness in Asian Indian and was further complicated by a low BMD of Asian Indian. Bone width should also be measured in future studies regarding of the relationship between %BF and BMI.

This study found that corresponding to WHO-recommended %BF cut-off points for overweight (30%F, 20%M) and obesity (35%F, 25%M) (Goh et al., 2004b), the BMIs for NZ Chinese females aged 30-39y were 21.2 and 24.3 kg.m^{-2}, respectively, and for NZ Chinese males aged 30-39y were 22.6 and 25.8 kg.m^{-2}, respectively. However, to draw conclusion about the BMI cut-offs for overweight and obesity in NZ Chinese, longitudinal studies may be needed to assess the health risks of low BMI levels among NZ Chinese. Further research on the relationship between WC, abdominal fat and health risk is needed. More studies are necessary to understand the relationships between VAT and SAT in NZ Chinese, which requires CT/MRI scans.

Furthermore, this study also demonstrates that those men born with a lower self reported birth weight had a greater percentage body fat (measured by DEXA) than those born with a greater birth weight. Therefore, foetal nutrition might set the percentage body fat condition in adulthood in NZ Chinese. A healthy lifestyle is not only important for an individual's health, but also influences that of their offspring.

Given the relatively high percentage body fat, low appendicular skeletal muscle mass, high central fat to appendicular fat ratio, low physical activity prevalence, low consumption of fruit and vegetables, and low nutritional knowledge of NZ Chinese aged 30-39 years demonstrated in this study, promotion of physical activity is vital to keep NZ Chinese fit and to prevent limited movements in older age. Health messages of HEHA and 5+ A Day in the Chinese language may help to encourage NZ Chinese increase their vegetable and fruit intake as well as levels of physical activity. The characteristic short limbs should be borne in mind in promoting physical activity in NZ Chinese. It is not the aim of this study to review the many benefits of being physically active at any age. However, probably the single most important health message for the NZ Chinese population is to achieve or maintain physical activity for fitness and well-being throughout their lives.

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APPENDICES

Appendix 1: Ethics approval letter

AUT
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TE WĀNANGA ARONUI O TAMAKI MAKAU RAU

MEMORANDUM

To:	Elaine Rush
From:	**Madeline Banda** Executive Secretary, AUTEC
Date:	Friday, 17 November 2006
Subject:	Ethics Application Number 06/172 **Body size, body composition, and fat distribution in New Zealand Chinese.**

Dear Elaine

Thank you for providing written evidence as requested. I am pleased to advise that it satisfies the points raised by the Auckland University of Technology Ethics Committee (AUTEC) at their meeting on 11 September 2006 and that as the Executive Secretary of AUTEC I have approved your ethics application. This delegated approval is made in accordance with section 5.3.2.3 of AUTEC's *Applying for Ethics Approval: Guidelines and Procedures* and is subject to endorsement at AUTEC's meeting on 11 December 2006.

Your ethics application is approved for a period of three years until 15 November 2009.

I advise that as part of the ethics approval process, you are required to submit to AUTEC the following:

- A brief annual progress report indicating compliance with the ethical approval given using form EA2, which is available online through http://www.aut.ac.nz/research/ethics, including when necessary a request for extension of the approval one month prior to its expiry on 15 November 2009;
- A brief report on the status of the project using form EA3, which is available online through http://www.aut.ac.nz/research/ethics. This report is to be submitted either when the approval expires on 15 November 2009 or on completion of the project, whichever comes sooner;

It is also a condition of approval that AUTEC is notified of any adverse events or if the research does not commence and that AUTEC approval is sought for any alteration to the research, including any alteration of or addition to the participant documents involved.

You are reminded that, as applicant, you are responsible for ensuring that any research undertaken under this approval is carried out within the parameters approved for your application. Any change to the research outside the parameters of this approval must be submitted to AUTEC for approval before that change is implemented.

Please note that AUTEC grants ethical approval only. If you require management approval from an institution or organisation for your research, then you will need to make the arrangements necessary to obtain this.

To enable us to provide you with efficient service, we ask that you use the application number and study title in all written and verbal correspondence with us. Should you have any further enquiries regarding this matter, you are welcome to contact Charles Grinter, Ethics Coordinator, by email at charles.grinter@aut.ac.nz or by telephone on 921 9999 at extension 8860.

On behalf of the Committee and myself, I wish you success with your research and look forward to reading about it in your reports.

Yours sincerely

Madeline Banda
Executive Secretary
Auckland University of Technology Ethics Committee

Cc: Jewel Ji Yang Wen jewel.wen@aut.ac.nz

Appendix 2: Participant information sheets in English

Participant Information Sheet

Date Information Sheet Produced:
20 November 2006

Project Title
Body size, body composition, and fat distribution in New Zealand Chinese.

An Invitation
You are invited to participate in a study that investigates body composition of New Zealand Chinese. Your involvement in this study is voluntary, and it is your choice as to whether or not you wish to participate. An interpreter is available on your request. The project will be explained to you in Cantonese, Mandarin or English, whichever you prefer.

What is the purpose of this research?
Increased body fatness is a risk factor for chronic diseases such as diabetes. The aim of the study is to investigate the body size, body composition and fat distribution in New Zealand Chinese. The research also identifies factors influencing body composition, e.g., birth weight, physical activity and dietary patterns, and informs ways of improving the health of Chinese in New Zealand.

This research is part of an overall research agenda where ethnic comparisons are made among the major NZ ethnic groups. It will add to the context of understanding of health disparities among ethnic groups with New Zealand.

In addition, the information from this research will be used by Ji Yang (Jewel) WEN to obtain an academic qualification (Master of Philosophy) from the Auckland University of Technology. It is anticipated that after completion of the analysis the results will be published in an international journal and presented in related health conferences.

How was I chosen for this invitation?
This study will involve 40 healthy Chinese (20 females and 20 males) aged 30-39 years that have been living in New Zealand for at least 3 years. It will exclude breastfeeding and pregnant women, those individuals who lift weights more than once a week, have major health conditions or use steroids. Ji Yang (Jewel) WEN, a New Zealand Chinese who has been living in Auckland for 11 years, is responsible for the recruitment of participants. She will use her direct contacts and advertisement notices in the Chinese community to recruit participants. Flyers will be distributed to members of Chinese community association.

What will happen in this research? What are the discomforts and risks? How will these discomforts and risks be alleviated?

The body composition measurements will be conducted in the Department of Surgery, University of Auckland, 3rd floor, Auckland Hospital. The overall study will take 16 to 20 months to complete. One visit to the body composition unit in the Department of Surgery will be required from each participant. It will take about 1 hour. We will arrange these visits in the mornings and you will be asked not to eat or drink anything except water for at least 8 hours before the tests. First your height and weight will be measured followed by measurements of your waist and hip circumferences. You will lie on a bed for 15-45 minutes while a machine passes over you measuring the amount of bone, fat and lean tissue in your body. This machine uses a very small dose of X-rays. The measurements expose you to a trivial dose of radiation, which is less than one fifth of background radiation. The radiation is less than that experienced from flying to Australia from Auckland. The total lifetime risk to a participant of any hazard received from the radiation (1 μSv) is less than 1 in a million. To estimate the water content of your body a tiny current, which you cannot feel, will be passed between your hand and your foot for a few seconds. At the visit we will ask you to complete a questionnaire about your dietary patterns, physical activity level, birth weight, knowledge/awareness of nutrition messages and socio-demographic data.

Finally, you will be undertaking health-screening tests, which include blood pressure measurements and tests of fasting glucose, cholesterol and triglyceride levels made by finger prick. Three drops of blood will be taken from your fingertip, and placed on test strips for blood glucose, cholesterol and triglycerides levels. The process will be brief, and will not be harmful for your health. The results of these tests will be given to you with a recommendation to visit your doctor if the levels are outside the reference range.

What are the benefits?

This research may help you become more aware of your unique body composition and the importance of maintaining health-promoting activities through your lifetime. In addition you will benefit by being screened for lipid profile, blood pressure and blood glucose level.

What compensation is available for injury or negligence?

Compensation is available through the Accident Compensation Corporation within its normal limitations. If you have any questions about ACC, please contact the nearest ACC office.

How will my privacy be protected?

No material that could personally identify you will be used in any reports on this study. During and following the study, records will be held in filing cabinets in locked areas of the Department of Surgery, University of Auckland and Faculty of Health and Environmental Science, Auckland University of Technology with access only by authorized investigators.

What are the costs of participating in this research?

In this research, body composition measurements and health screening results are free to all participants. Furthermore, we will provide each participant with a $20 petrol voucher to cover the travel expenses of the visit.

What opportunity do I have to consider this invitation?

You may like to think about it for a day or two before you make a decision.

You do not have to take part in this study. Should you choose not to take part this will not affect any future care or treatment or your academic progress if you are a student. If you do agree to take part you are free to withdraw from the study at any time, without having to give a reason and this will in no way affect your future health care and / or academic progress. If you have any queries or concerns regarding your rights as a participant in this study you may wish to contact a Health and Disability Advocate, telephone 0800 555 050 for Northland to Franklin.

How do I agree to participate in this research?

Please complete the attached consent form.

Will I receive feedback on the results of this research?

A copy of the body composition result will be available to each participant immediately after the completion of the measurements. The overall results of this study can be made available to you at your request.

What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor: Elaine Rush, Ph 921 9999 ext 8091 elaine.rush@aut.ac.nz.

Concerns regarding the conduct of the research should be notified to the Executive Secretary, AUTEC, Madeline Banda, *madeline.banda@aut.ac.nz* , 921 9999 ext 8044.

Whom do I contact for further information about this research?

Please feel free to contact the following researchers if you have any questions about this study.

Researcher Contact Details:

Elaine Rush, Ph 921 9999 ext 8091 elaine.rush@aut.ac.nz

Lindsay Plank, Ph 373 7599 ext 86949 l.plank@auckland.ac.nz

Caryn Zinn, Ph 921 9999 ext 7842 caryn.zinn@aut.ac.nz

Ji Yang (Jewel) Wen, Ph 021 1029339 jewel.wen@aut.ac.nz

Project Supervisor Contact Details:

Elaine Rush, Ph 921 9999 ext 8091 elaine.rush@aut.ac.nz.

This study has received ethical approval from the Auckland University of Technology Ethics Committee on 17/11/06 and reference number:06/172.

Appendix 3: Participant information sheet in Chinese

Participant Information Sheet In Chinese

立题日期:

2006 年 11 月 20 日

课题名称:

纽西兰华人体型,体格和脂肪分布研究调查。

邀请函

您被邀请参与一个关于纽西兰华人的体格研究。您是否参与这个研究完全是出于自愿的. 如有需要,可以提供为您翻译人员。按你的要求, 我们可用粤语, 国语或英文向你解释这个项目。

研究目的

身体脂肪增多是引起慢性病如糖尿病的原因之一。这个课题的目的是研究纽西兰华人的体格大小, 身体成分和脂肪在身体的分布。同时, 一些个体特征如出生体重, 活动量, 饮食习惯等对体格的影响也将纳入研究范围。 研究也要讨论有关增进纽西兰华人健康的策略。

这个研究是对纽西兰主要族群的体格比较研究的一小部分。研究结果会加深对纽西兰各族健康状况差异的理解。

温激扬将用这个研究所得的信息来完成在奥克兰理工大学的硕士学位。这个研究的结果可能会被发表在国际学术杂志及在相关的学术交流活动上研讨。

谁能被邀请参与这个研究?

这个研究需要在纽西兰至少居住三年以上,年龄在 30 到 39 岁之间的 40 位健康华人 (20 位女性,20 位男性)。 正在怀孕或哺乳期间的妇女,举重爱好者(每周一次以上), 和正在使用激素者将不能参与这个研究。 温激扬是一位在奥克兰居住了 11 年的华人。她将通过对华人社团的直接接触和在社团打广告对所有的参与者进行培训。

研究的具体过程,可能带来的不适和危险性及怎样减轻这些不适和避免危险的发生

身体成分的测试将在奥克兰大学附属奥克兰医院 3 层的临床医学部进行. 整个研究将可能持续 16 到 20 个月. 每位参与者至少参与一次在临床医学部进行的身体成分测试. 这个测试可能会持续一个小时左右。参与者在测试的当天早晨至少 8 小时前除了喝水以外不能吃和喝任何东西。

首先测量你的身高和体重，然后是腰围和臀围。测试者需要躺在床上 15-45 分钟来配合测量仪测试身体的骨质，脂肪和瘦肉组织。这个测量仪使用很少量的 X-光，测量时对身体的幅射相当于自然幅射的五分之一。测量的幅射量少于你从奥克兰飞到澳大利亚所受到的辐射量。参与者从照射方面带来的生命危险是少于百万分之一。评估你身体的水分是用一你感受不到的微弱电流，电流将通过手和脚几秒钟。调查结束后，你需要完成一份调查表，内容包括：你的饮食习惯，日常活动量，出生体重，关于营养知识的认识和个人情况。

最后，你要进行一系列健康模式测试，测试包括：血压，餐前葡萄糖，胆固醇，甘油三酸酯（戳刺手指的方法，也就是从指尖取三滴血来测试葡萄糖，胆固醇，甘油三酸酯含量）。整个过程在短时间内即可完成，不会对你的健康有任何危害。并且，如果检测结果不在正常值之内，这将会提供给你的医生一个参考数据。

研究的益处

这个研究可以帮助你更多地了解你的身体组成和保持健康活动的重要性。同时，你将受益于血脂，血压和血糖的测试。

意外受伤补偿

意外事故补偿公司提供所有的正常补偿。可通过最近的 ACC 机构了解详细的补偿措施，条例等等。

保护个人隐私

在这个研究中，任何能确定你个人的资料都不会在研究中被公开使用。所有记录将会收藏并锁在奥克兰大学临床医学部生和奥克兰理工大学健康与环境科学系的柜中，有关人员才能阅览。

参与者费用

调查中，所有参与者的身体成分测量和健康测试都是免费的。并且，我们会提供所有参与者每人$20 汽油票。

考虑参与这个调查的期限

作决定之前，你也许会考虑一到两天。

你不用必须参与这个研究。如果你是一个学生，你不选择参与这个将不会影响未来的任何学术发展。不用解释任何原因，这绝不会影响你将来的卫生保健或学术发展。如果你有任何关于参加这个学习的权利的疑问，请联系 Health and Disability Advocate,每年电话 0800 555 050。

参与研究的方法

请填好附上的志愿加入表格

我能收到调查后的结果吗？

测量后，每个参与者都会得到一份身体组成成分结果的复印件。如果你需要的话，所有的调查结果都会提供给你。

如对这个调查研究有怀疑

任何关系到此调查研究性质应该首先通知项目经理 Elaine Rush， 电话：921 9999，转 8091，email: elaine.rush@aut.ac.nz.

任何关于调查的管理应联系执行秘书 AUTEC, Madeline Banda, 电话：921 9999 转 8044，email: madeline.banda@aut.ac.nz

关于这个调查的详细信息的联系人

如有任何关于此调查的问题，请联系以下研究人员：

Elaine Rush, Ph 921 9999 ext 8091 elaine.rush@aut.ac.nz

Lindsay Plank, Ph 373 7599 ext 86949 l.plank@auckland.ac.nz

Caryn Zinn, Ph 921 9999 ext 7842 caryn.zinn@aut.ac.nz

Ji Yang (Jewel) Wen, Ph 021 1029339 jewel.wen@aut.ac.nz

调查项目经理：

Elaine Rush, Ph 921 9999 ext 8091 elaine.rush@aut.ac.nz.

此研究已于 2006 年十一月十七日得到 AUT 大学人伦委员会的确认通过
AUTEC 编号: 06/172

Appendix 4: Consent form in English

Consent Form

Body size, body composition, and fat distribution in New Zealand Chinese.

Researchers:

Elaine Rush	Professor of Nutrition	Ph 9219999 ext 8091 elaine.rush@aut.ac.nz
Lindsay Plank	Associate Professor	Ph 3737599 ext 86949 l.plank@auckland.ac.nz
Caryn Zinn	Senior Lecturer NZ registered dietician	Ph 9219999 ext 7842 caryn.zinn@aut.ac.nz
Ji Yang(Jewel) Wen	Master of Philosophy student	Ph 021 1029339 jewel.wen@aut.ac.nz

I have read and I understand the information sheet dated August 2006 for volunteers taking part in the study designed to investigate body size, body composition and fat distribution in New Zealand Chinese. I have had the opportunity to discuss this study. I am satisfied with the answers I have been given. I understand that taking part in this study is my choice and that I may withdraw from the study at any time and this will in no way affect my future health care. I understand that my participation in this study is confidential and that no material that could identify me will be used in any reports on this study. I understand the compensation provisions for this study. I have had time to consider whether to take part. I know whom to contact if I have any questions about the study.

I wish to have an interpreter. YES/NO

I wish to receive a copy of the results. YES/NO

I_________________________(Full name) hereby consent to take part in this study.

My contact details are : ____

Signature: __________________________________ Date: _______________

Project Explained by: Petrol Voucher No.

Project role: Receiver signature:

Signature:

Date:

This study has approved by the Auckland University of Technology Ethics Committee on 17/11/06 AUTEC Reference number:06/172

Note: The Participant should retain a copy of this form

Appendix 5: Consent form in Chinese

Consent Form
(In Chinese)

紐西蘭華人体型,体格和脂肪分布調查研究志愿參加者意向書

研究人員:

Elaine Rush	營養專家, 教授	Ph 9219999 ext 8091 elaine.rush@aut.ac.nz
Lindsay Plank	体格專家, 副教授	Ph 3737599 ext 86949 l.plank@auckland.ac.nz
Caryn Zinn	注冊營養師, 高級講師	Ph 9219999 ext 7842 caryn.zinn@aut.ac.nz
Ji Yang(Jewel) Wen	研究生	Ph 021 1029339 jewel.wen@aut.ac.nz

我已經閱讀和明白了2006年十月份的有關該研究課題需要志愿人員的資料. 我有机會討論過該項目. 我滿意我得到的解答. 我是志愿參加該項目的. 我明白我可以在任何時候退出該研究, 而且不會因此影響我以后的健康醫療權利. 我了解我參加該項研究的資料是保密的, 而且任何暴露我身份的資料都不會出現在報告中. 我了解該研究項目的有關賠償損失的規定. 我已有充分的時間來考慮是否參加. 如果我有任何關于該研究項目的疑問, 我知道向誰聯系.

我希望有位翻譯人士. 是/否.

我希望得到一份結果. 是/否.

我, 姓名 ______________________________(全名) 同意作為研究對象參加該項目.

我的聯系方式是:____

簽名:____________________________________ 日期:________________________

研究項目講解人:

在該項目的職責:

簽名:

日期:

此研究已于2006年十一月十七日得到AUT大學人倫委員會的确認通過

AUTEC 編號: 06/172

注意: 志愿者必需保留此表复印件.

Appendix 6: Advertisement in English and Chinese

Volunteers Required

Body size, body composition, and fat distribution in New Zealand Chinese

We are looking for volunteers to assist us in a study on the body size, body composition and fat distribution of New Zealand Chinese.

This study will involve 40 healthy Chinese (20 females and 20 males) aged 30-39 years that have been living in New Zealand for at least 3 years.

In this research, body composition measurements and health screening tests are free to all participants. Furthermore, we will provide each participant a $20 petrol voucher to cover the travel expenses of the visit.

If you would like to have more information and/or take part in the study please phone:
Ji Yang WEN 021 1029339 or e-mail jewel.wen@aut.ac.nz

徵集志願人員

紐西蘭華人體型,體格和脂肪分佈研究調查研究

我們需要一些志願人員協助我們進行關於紐西蘭華人體格,結構和身體脂肪分佈的研究工作.

這項研究需要 **40** 位已經在紐西蘭住滿 **3** 年以上的華人, 年齡在 **30** 到 **39** 的健康人士(男女各 **20** 名).

所有這些關於體格結構和健康的檢查是免費的. 並且, 我們將提供每位參與者一張 **20** 元的汽油禮品券, 以此爲參加研究的路費津貼.

如對此研究感興趣, 並希望參加的話, 請聯繫:

溫激揚**(JEWEL) 021 1029339 jewel.wen@aut.ac.nz**

Appendix 7: Protocol sheet

Body size, Body Composition and fat distribution in NZ Chinese

PROTOCOL SHEET

Subject No. C0
Date
Time
Age
Gender
Consent

Ask the subject to WC
Clothing

	Reading 1	Reading 2	Average	
Height				0.1cm
Sit Height				cm
Weight				0.1kg
Right Arm				cm
Waist				cm
Hip				cm
Chest Thickness				cm
Tummy Thickness				cm

DEXA

Questionnaire

Stage of Cycle

Pill

Bioimpedance Left

	Reading 1	Reading 2	Reading 3	Average
Impedance (Z)				
Phase (P)				
Resistance (R)				
Reactance (X)				

Blood Pressure / Resting Pulse Right

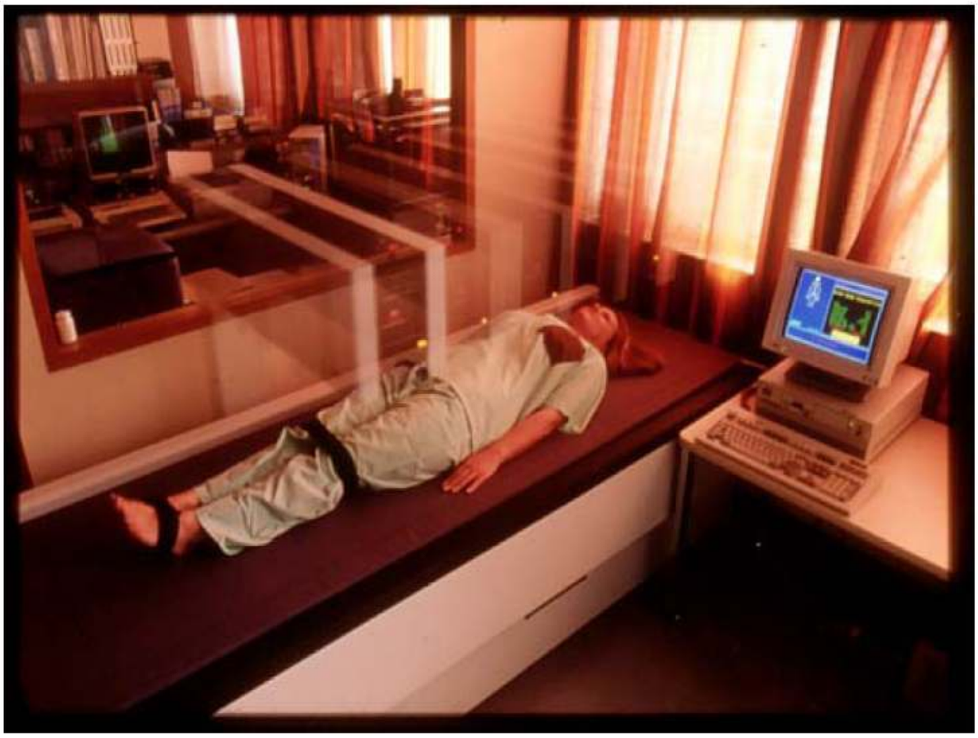
	Reading 1	Reading 2	Reading 3	Average	
Systolic					mmHg
Diastolic					mmHg
Pulse					bpm

Blood testing

	Reading 1	Reading 2		
Cholesterol			mmol/L	<5.0
Triglycerides			mmol/L	<2.0
Glucose			mmol/L	3.5~5.6

Petrol Voucher

Appendix 8: DEXA scan photo



Appendix 9: LUNA DEXA instruction

LUNAR DPX INSTRUCTIONS 20061123 for Body composition of Chinese

Directory = LUNAR
Type dpx

(Version 3.65)

F3 QA run everyday about 10’
Use the Standard block
A QA report will be automatic printed out

F1 Scan patient (should be total body options otherwise F6)
F4 Add new patient
First name
Last Name
Height
Weight
Sex
Ethnic (Asian)
-other

F1 optional information
Social security – Normal
Department ID - Chinese Study
Comment 1 Ethnicity

Esc
Total body acquisition F1 to change
Fast up to 22cm thick
Medium 22-28 cm
Slow > 28 cm
Note version lunar 3.65
When scan speed changed go HOME
ESC positions scanner (Move subjects glasses/watches/hair clips/metal staff)
ESC turns SOURCE ON

(after head scanning finishes, can put a pillow on the head and start ask questions)

(after total scan finishes, stay lying and do BP and BIA)

ESC
F2 analyse Scan
ESC select Scan F1 if more than 1 patient
ESC
Automatically does standard analysis
F1 about analysis
Grey Scale- Press 2 for RHS line (use arrows)

F4 Redraw image

HOME
F2 Auto analysis

F2 Should say standard but means extended

Page up – to neck – clear shoulders and bottom of chin

Page down – to right arm (line through humeral head)
F1 0
1
2

Right Rib- vertical ribs close to but not touching spine
Centre

Dorsal – at first rib

Pelvis – one pixel above (just above pelvic bnm)

Pelvis tip last

Only press ESC at end

ESC
F1 save to hard disk
Print (2 copies)
(2 copies)

F4
Change Headings
To see FM

Appendix 10: DEXA scan print out

DPX TOTAL BODY RESULTS
UNIVERSITY DEPARTMENT OF SURGERY
AUCKLAND HOSPITAL

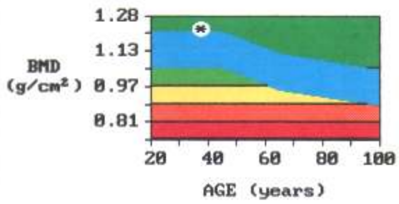
PATIENT ID:	SCAN:	3.65	15.02.2007
NAME:	ANALYSIS:	3.65	15.02.2007

LUNAR®

IMAGE NOT FOR DIAGNOSIS

ID: SCAN DATE: 15.02.2007

TOTAL Comparison to Reference



TOTAL BMD (g/cm²)1	1.228 ± 0.01
TOTAL % Young Adult2	109 ± 3
TOTAL % Age Matched3	109 ± 3

Age (years).........	38	Large Standard......	278.01	Scan Mode.......	Fast
Sex.................	Female	Medium Standard.....	206.53	Scan Type...........	DPX
Weight (Kg).........	50.0	Small Standard......	146.90	Collimation (mm).....	1.68
Height (cm).........	157	Low keV Air (cps)....	798226	Sample Size (mm).....	4.8x 9.6
Ethnic..............	Asian	High keV Air (cps)..	482910		
System..............	6531	Rvalue (%Fat).......	1.349(22.1)		
Current (uA)........	150				

REGION	BMD[1] g/cm²	Young Adult[2] %	T	Age Matched[3] %	Z
HEAD	2.466	-	-	-	-
ARMS	0.931	110	1.08	110	1.08
LEGS	1.211	105	0.61	105	0.61
TRUNK	0.964	105	0.63	105	0.63
RIBS	0.706	-	-	-	-
PELVIS	1.150	104	0.40	104	0.40
SPINE	1.131	99	-0.07	99	-0.07
TOTAL	1.228	109	1.29	109	1.29

1 - See appendix E on precision and accuracy. Statistically 68% of repeat scans will fall within 1 SD.
2 - USA Total Body Reference Population, Ages 20-45. See Appendices.
3 - Matched for Age.
- Standard Analysis.

DPX TOTAL BODY RESULTS
UNIVERSITY DEPARTMENT OF SURGERY
AUCKLAND HOSPITAL

PATIENT ID:		SCAN:	3.65	15.02.2007
NAME:		ANALYSIS:	3.65	15.02.2007

BODY COMPOSITION**

Region of Interest	R Value	Tissue % Fat	Region % Fat	Tissue (g)	Fat (g)	Lean (g)	BMC (g)
LEFT ARM	1.352	20.7	19.4	2117	438	1679	138
LEFT LEG	1.349	22.3	21.3	7812	1744	6068	386
LEFT TRUNK	1.351	21.2	20.6	11686	2481	9205	377
LEFT TOTAL	1.350	21.6	20.6	23651	5112	18539	1183
RIGHT ARM	1.351	21.3	20.1	2270	484	1786	137
RIGHT LEG	1.346	23.7	22.6	8380	1987	6393	398
RIGHT TRUNK	1.349	22.3	21.5	10846	2414	8431	385
RIGHT TOTAL	1.348	22.7	21.6	23659	5372	18287	1250
ARMS	1.352	21.0	19.8	4387	923	3465	275
LEGS	1.348	23.0	22.0	16192	3730	12462	784
TRUNK	1.350	21.7	21.0	22531	4891	17640	762
TOTAL	1.349	22.1	21.1	47310	10478	36833	2433

ANCILLARY TOTAL BODY RESULTS**

		Name	Cut Locations Actual	Relative
Total Bone Calcium (g)..	925	Neck	27	27
Air Points..............	12563	Left Arm	-	-
Tissue Points...........	9141	Left Rib	-	-
Bone Points.............	4300	Right Rib	-	-
Total Points............	21720	Right Arm	-	-
R-Value Points..........	3715	Spine	62	62
Averaged Points.........	143	Pelvis	70	70
		Top of Head	0	
		Center	-	

**Ancillary results for research purposes, not clinical use.
Standard Analysis.

Appendix 11: Region of interest photo

Appendix 12: Questionnaire in English

Body size, body composition, and fat distribution in New Zealand Chinese.

Questionnaire

Please do not answer if you are unsure or do not wish to answer.

Section 1: The first section is about your lifestyle and health.

1. How would you describe your eating pattern? (Please mark one only)

☐ Eat a variety of all foods, including animal products

☐ Eat eggs, dairy products, fish and chicken but avoid other meats

☐ Eat eggs and dairy products but avoid all meats and fish

☐ Eat eggs but avoid dairy products, all meats and fish

☐ Eat dairy products but avoid eggs, all meats and fish

☐ Eat no animal products

☐ Other *(Please specify)* ___________________________________

2. On average, how many servings of fruit (fresh, frozen, canned or stewed) do you eat per day? Do not include fruit juice or dried fruit. A "**serving**" of fruit means: 1 medium piece of fruit or 2 small pieces of fruit or ½ cup of stewed fruit, **e.g**. 1 apple + 2 small apricots = 2 servings.

☐ I don't eat fruit
☐ Less than 1 serving per day
☐ 1 serving per day
☐ 2 servings per day
☐ 3 servings per day
☐ 4 servings per day
☐ 5 or more servings per day

3. On average, how many servings of vegetables (fresh, frozen, canned or stewed) do you eat per day? Do not include vegetable juice. A "**serving**" of vegetables means: 1 medium potato/kumara **or** 1/2 cup cooked vegetables **or** 1 cup of salad vegetables) **e.g.** 2 medium potatoes + 1/2 cup of peas = 3 servings.

☐ I don't eat vegetables
☐ less than 1 serving per day
☐ 1 serving per day
☐ 2 servings per day
☐ 3 servings per day
☐ 4 servings per day
☐ 5 or more servings per day

4. The following is a list of possible things that keep some people from eating fruit and vegetables each day. For each one, please indicate how much each influences the number of fruit and vegetables you eat each day.

	Doesn't influence me at all ↓						Influence me a lot ↓
Fruit costs too much	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Vegetables cost too much	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Fresh fruit spoils too quickly	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Fresh vegetables spoil too quickly	☐1	☐2	☐3	☐4	☐5	☐6	☐7
I prefer to eat other snacks (like chips and biscuits)	☐1	☐2	☐3	☐4	☐5	☐6	☐7
They don't give me 'quick energy' like a chocolate bar does	☐1	☐2	☐3	☐4	☐5	☐6	☐7
I'm not a good cook	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Fruit and vegetables are not available where I work	☐1	☐2	☐3	☐4	☐5	☐6	☐7
The supermarket I go to most doesn't carry a lot of different fruit and vegetables	☐1	☐2	☐3	☐4	☐5	☐6	☐7
I can't get good quality fruit and vegetables at my local shops	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Fruit takes too much time to prepare (clean, cut up, cook)	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Vegetables take too much time to prepare (clean, cut up, cook)	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Fruit isn't filling enough	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Vegetables aren't filling enough	☐1	☐2	☐3	☐4	☐5	☐6	☐7
I don't like most fruit	☐1	☐2	☐3	☐4	☐5	☐6	☐7
I don't like most vegetables	☐1	☐2	☐3	☐4	☐5	☐6	☐7
My family doesn't like fruit	☐1	☐2	☐3	☐4	☐5	☐6	☐7
My family doesn't like vegetables	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Fruit is difficult to eat when I'm 'on the go'	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Vegetables are difficult to eat when I'm 'on the go'	☐1	☐2	☐3	☐4	☐5	☐6	☐7

5. The next questions ask about physical activity that you may have done in the past 7 days. Please answer each question even if you do not consider yourself to be an active person. Think about the activities you do at work, as part of your housework and gardening, to get from place to place, and in your spare time for recreation, exercise or sport. The questions ask you separately about brisk walking, moderate activity and vigorous activity. Do not count the same time more than once:
Example 1. You run for 20 minutes. Count this time as vigorous activity only, not also as moderate.
Example 2. A 45 minute ball game with 30 minutes at moderate intensity then 15 minutes at vigorous intensity. Count this activity as 30 minutes moderate and 15 minutes vigorous.

a Walking

During the last 7 days, on how many days did you **walk at a brisk pace?** (A pace at which you are breathing harder than normal.) This includes walking at work, walking to travel from place to place, and any other walking that you did solely for recreation, sport, exercise or leisure. Think about **only** that walking done for at least 10 minutes at a time.

☐ 0 days	☐ 1 day	☐ 2 days	☐ 3 days
☐ 4 days	☐ 5 days	☐ 6 days	☐ 7 days

How much time did you **usually** spend doing such brisk walking on each of those days? (Write in number)

( ) minutes a day or ( ) hours a day

b Moderate physical activity

During the last 7 days, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking. (Moderate physical activity will cause a slight, but noticeable, increase in breathing and heart rate.) Think about **only** those physical activities done for at least 10 minutes at a time.

☐ 0 days	☐ 1 day	☐ 2 days	☐ 3 days
☐ 4 days	☐ 5 days	☐ 6 days	☐ 7 days

How much time did you **usually** spend doing moderate physical activities on each of those days? (Write in number)

( ) minutes a day or ( ) hours a day

c Vigorous physical activity

During the last 7 days, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, running, rugby, netball, or fast bicycling? (Vigorous activity is activity that makes you “huff and puff”, and where talking in full sentences between a breath is difficult.) Think about **only** those physical activities done for at least 10 minutes at a time.

☐ 0 days	☐ 1 day	☐ 2 days	☐ 3 days
☐ 4 days	☐ 5 days	☐ 6 days	☐ 7 days

How much time did you **usually** spend doing vigorous physical activities on each of those days? (Write in number)

( ) minutes a day or ( ) hours a day

6. **Crucial Question!** Please answer carefully. Thinking about all your activities (brisk walking, moderate, or vigorous), on how many of the last 7 days were you **active**? (“Active” means doing 15 minutes or more of vigorous activity, or a total of 30 minutes or more of moderate activity or brisk walking.)

☐ 0 days	☐ 1 day	☐ 2 days	☐ 3 days
☐ 4 days	☐ 5 days	☐ 6 days	☐ 7 days

7. The following is a list of possible things that keep some people from being physically active. For each one, please indicate how much each influences your own activity level.

	Doesn't influence me at all ↓						Influence me a lot ↓
Lack of energy/too tired	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Lack of time due to work	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Lack of time due to family responsibilities	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Arthritis or other health problems	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Costs too much (clothes, equipment, etc.)	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Facilities (parks, gyms) too hard to get to	☐1	☐2	☐3	☐4	☐5	☐6	☐7
It's too hard to stick to a routine	☐1	☐2	☐3	☐4	☐5	☐6	☐7
No one to do physical activities with	☐1	☐2	☐3	☐4	☐5	☐6	☐7
I worry about my safety	☐1	☐2	☐3	☐4	☐5	☐6	☐7
I would have to get someone to watch my children	☐1	☐2	☐3	☐4	☐5	☐6	☐7
I'm too old	☐1	☐2	☐3	☐4	☐5	☐6	☐7
I get bored quickly	☐1	☐2	☐3	☐4	☐5	☐6	☐7
There are other things I'd rather do during my free time	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Others discourage me from being physically active	☐1	☐2	☐3	☐4	☐5	☐6	☐7
I have too many household chores to do	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Physical activity is uncomfortable for me	☐1	☐2	☐3	☐4	☐5	☐6	☐7
I'm too out of shape to start	☐1	☐2	☐3	☐4	☐5	☐6	☐7
I feel I am too overweight to be physically active	☐1	☐2	☐3	☐4	☐5	☐6	☐7
I don't know how to be physically active	☐1	☐2	☐3	☐4	☐5	☐6	☐7
I don't like to sweat	☐1	☐2	☐3	☐4	☐5	☐6	☐7
I don't like feeling out of breath	☐1	☐2	☐3	☐4	☐5	☐6	☐7
I don't like other people to see me being physically active	☐1	☐2	☐3	☐4	☐5	☐6	☐7
Physical activity takes too much effort	☐1	☐2	☐3	☐4	☐5	☐6	☐7

8. Which of the following (if any) apply to your neighbourhood and put you off being physically active?

☐ There are not enough footpaths

☐ Footpaths are not well maintained

☐ Traffic is too heavy

☐ There are steep hills

☐ There is not enough street lighting

☐ There is not enough cycle lanes or paths

☐ There are too many stop signs/lights

☐ The scenery is not that nice

☐ I rarely see people walking or being physically active

☐ There is a lot of crime

☐ Dog nuisance

☐ None of the above

9. During the past 30 days, on about how many days did you smoke cigarettes? (If you did not smoke at all in the last 12 months, write in a X)

( ) days

10. During the past 30 days, on the days you smoked, about how many cigarettes a day did you usually smoke? (If you did not smoke at all, write in a X)

( ) cigarettes each day

11. Have you had a drink containing alcohol in the last year?

☐ Yes ☐ No ☐ Don't know

12. How often do you have a drink containing alcohol?

☐ Monthly or less ☐ 2 to 4 times a month

☐ 2 to 3 times a week ☐ 4 or more times a week

13. How many drinks containing alcohol do you have on a typical day when you are drinking? (As a guide, a drink is a can or small bottle of beer/ a small glass of wine/a nip of spirits)

☐ 1 or 2 ☐ 3 or 4 ☐ 5 or 6

☐ 7 to 9 ☐ 10 or more

14. How often do you have 5 or more drinks on one occasion?

☐ Never ☐ less than monthly ☐ Monthly

☐ Weekly ☐ Daily or almost daily

15. In general, would you say your health is …

☐ Poor ☐ Fair ☐ Good ☐ Very good ☐ Excellent

16. How would you describe your weight?

☐ Very underweight ☐ Slightly underweight

☐ About the right weight ☐ Slightly overweight

☐ Very overweight/obese

17. Are you trying to…

☐ Gain weight ☐ Lose weight ☐ Neither of these

18. What time do you usually go to bed? (   )
What time do you usually get up? (   )

19. How often do you usually eat these foods?

	I don't eat them at all	Less than once per week	2-3 times per week	Nearly once every day	Nearly every meal
Dairy products (low fat or high calcium) (milk, cheese, yogurt)					
Soy Products (tofu, soybean, soymilk)					
Fish (tuna, salmon, sardines)					

20. Do you take any nutritional supplementation regularly?

☐ Yes. Please specify_________________________________

☐ No

Section 2: The second section is about your birth history.

1. Your birth weight was (   ) kg

2. Your birth height was (   ) cm

3. Please indicate your birth order among your biological mother's children:
(   ) of (   )

4. Please indicate your biological grandparents' origin:

Grandparents	Place/Area in China or other countries
Your mother's mother	
Your mother's father	
Your father's mother	
Your father's father	

5. Was your mother smoking when she was pregnant with you? Yes or No or Not sure. Did she inhale smoke due to the work or home environment when she was pregnant with you? Yes or No or Not sure.

Did you inhale smoke due to the environment during your childhood?
Yes or No or Not sure

Section 3: The third section is about you awareness of nutrition messages.

1. Do you think health experts recommend that people should be eating more, the same amount, or less of these foods? (Tick one per food)

	More	Same	Less	Not sure
Vegetables				
Sugary foods				
Meat				
Starchy foods				
Fatty foods				
High fibre foods				
Fruit				
Salty foods				

2. How many servings of fruit and vegetables a day do you think experts are advising people to eat?

☐ Less than 1 serving per day ☐ 1 serving per day

☐ 2 servings per day ☐ 3 servings per day

☐ 4 servings per day ☐ 5 or more servings per day

☐ **Not sure**

Section 4: The fourth section is about your gender, age and other personal details, which would definitely contribute to our study. They are strictly confidential.

1. Are you…

☐ **Male** ☐ **Female**

2. Your date of birth: (dd/mm/yy)

3. How long have you been in New Zealand? ( ) years ( ) months

4. Are you…

☐ single ☐ married/living with partner

☐ separated/divorced ☐ widowed ☐ Other

5. Do you have any children?

☐ No ☐ 1 ☐ 2 ☐ 3 ☐ More than 3

6. What is the highest level of education you have completed? Don't count incomplete qualifications or qualifications that take less than 3 months of full-time study to get.

☐ Secondary school qualification

☐ Bachelors degree, e.g. BA. BSc. LLB

☐ Bachelors degree with honours

☐ Masters degree, e.g. MA, MSc

☐ PhD

☐ Diploma (not Post Graduate)

☐ Diploma - Post Graduate

☐ Trade or technical certificate which took more than 3 months full time study

☐ Professional qualifications like ACA, teachers, and nurses

☐ Other *(Please specify)* ____

7. Which one of the following best describes you? (Mark **one** box - if more than one category applies, mark the one you spend most time doing over a week.)

☐ Working full-time

☐ Working part-time

☐ Unemployed/Actively seeking a job

☐ At home

☐ Retired

☐ Sick/invalid

☐ Student (full time, including secondary school)

☐ Other *(Please specify)* ____

8. What was the total income before tax that you and your family got in the last 12 months? That includes benefit and retirement income, as well as paid income from all sources.

☐ Income is less than $14999

☐ Income is between $20000-$29999

☐ Income is between $30000-$44999

☐ Income is between $45000-$59999

☐ Income is more than $60000

Appendix 13: Questionnaire in Chinese

紐西蘭華人體型,體格和脂肪分佈研究調查問卷

第一部分：關於你的生活習慣和健康情況

1.請陳述你的衣食習慣（只選一個）

□ 吃各種食物，包括動物食品
□ 吃蛋，乳製品，魚和雞肉，但避不吃其他的肉類
□ 吃蛋，乳製品， 不吃任何肉類和魚
□ 吃蛋，不吃乳製品，任何肉類和魚
□吃乳製品，不吃蛋類，魚類和肉類
□ 不吃動物食品
□其他（請詳述）__________________________________

2. 一般來講，你吃多少水果（新鮮的，冷凍的，罐裝的或水煮的）？不包括果汁和幹水果。1 份是指 1 個中型大小的水果或 2 個小水果，或半杯煮過的水果，例如：1 個蘋果+2 個小杏=2 份

□ 我不吃水果	□ 每天少於一份
□ 每天1份	□ 每天2份
□ 每天3份	□ 每天4份
□ 每天5份或更多	

3. 一般來講，你吃多少蔬菜（新鮮的，冷凍的，罐裝的或水煮的）？不包括蔬菜汁。1 份是指 1 個中型大小的土豆或 1/2 煮過的蔬菜，或 1 杯蔬菜沙拉，例如：2 個中型土豆+1/2 杯豌豆=3 份

□ 我不吃蔬菜	□ 每天少於1份
□ 每天1份	□ 每天2份
□ 每天3份	□ 每天4份
□每天5份或更多	

4.以下是阻礙人們每天吃水果和蔬菜的事項，請你說出每項對你自己吃水果和蔬菜的影響程度

	影響很大 ↓					沒有一點影響 ↓	
水果太貴	□1	□2	□3	□4	□5	□6	□7

蔬菜太貴	□1	□2	□3	□4	□5	□6	□7
新鮮水果太容易壞	□1	□2	□3	□4	□5	□6	□7
新鮮蔬菜太容易壞	□1	□2	□3	□4	□5	□6	□7
我偏愛吃其他的零食比如署片和餅乾	□1	□2	□3	□4	□5	□6	□7
這些東西不像巧克力那樣給我快速的能量	□1	□2	□3	□4	□5	□6	□7
我不是好廚師	□1	□2	□3	□4	□5	□6	□7
我工作的地方沒有水果和蔬菜	□1	□2	□3	□4	□5	□6	□7
我常去的超市水果和蔬菜不多	□1	□2	□3	□4	□5	□6	□7
在我附近的商店買不到高品質的水果和蔬菜	□1	□2	□3	□4	□5	□6	□7
水果會花很多時間準備（洗，切，燒）	□1	□2	□3	□4	□5	□6	□7
蔬菜會花很多時間準備（洗，切，燒）	□1	□2	□3	□4	□5	□6	□7
水果不能填飽肚子	□1	□2	□3	□4	□5	□6	□7
蔬菜不能填飽肚子	□1	□2	□3	□4	□5	□6	□7
多數水果我不喜歡	□1	□2	□3	□4	□5	□6	□7
多數蔬菜我不喜歡	□1	□2	□3	□4	□5	□6	□7
我的家人都不喜歡水果	□1	□2	□3	□4	□5	□6	□7
我的家人都不喜歡蔬菜	□1	□2	□3	□4	□5	□6	□7
我忙碌的時候水果不方便吃	□1	□2	□3	□4	□5	□6	□7
我忙碌的時候蔬菜不方便吃	□1	□2	□3	□4	□5	□6	□7

5. 以下的問題是關於過去7天裏尼所作的活動量，即使你覺得不愛動，也請你回答每一問題。 考慮你在工作中的活動量，在家務上和園子裏的活動，去這去那，娛樂活動，鍛煉和體育活動。以下問題要分別調查散步，適度運動和激烈運動，不能重複算同樣的時間。

例1：你跑了20分鐘，這時間只能算是積累運動，不能同時算是適度運動；
例2：一個45分鐘的打球運動，先是30.分鐘中等強度的運動，然後是15分鐘的劇烈運動。這只能算30分鐘的中等加15分鐘的劇烈運動時間。

a 散步

在過去7天裏，有多少天你散步了（是使你比平常呼吸難一點兒的）？這包括在工作中的走動，去這去那的走動，還有娛樂運動鍛煉中的走動，請只考慮至少做了10分鐘的走路。

□ 0 天　□ 1 天　□ 2 天　□ 3 天
□ 4 天　□ 5 天　□ 6 天　□ 7 天

這些天你花了多少時間做這些運動？（填寫數字即可）
(　　　　) 分鐘每天　或 (　　　　) 小時每天

b 中等強度運動

在過去的7天裏，有多少天你做了中等強度的運動？比如：搬運輕的東西，騎自行車作規律運動，或打網球？不包括走路（中等強度的運動會輕微的，不是顯而易見的，增加呼吸量和心臟跳動）。請只考慮至少10分鐘的中等強度運動

□ 0 天　□ 1 天　□ 2 天　□ 3 天
□ 4 天　□ 5 天　□ 6 天　□ 7 天

這些天你花了多少時間做這些運動？（填寫數字即可）
( ) 分鐘每天　或 ( ) 小時每天

c 激烈運動

在過去的7天裏，有多少天你做了激烈的運動？比如：舉起重物，挖掘，有氧健身，跑步，玩橄欖球，籃球或快速騎自行車（激烈運動可以使你上下喘氣，也就是呼吸急促）。請只考慮至少10分鐘的中等強度運動

□ 0 天　□ 1 天　□ 2 天　□ 3 天
□ 4 天　□ 5 天　□ 6 天　□ 7 天

這些天你花了多少時間做這些運動？（填寫數字即可）
( ) 分鐘每天　或 ( ) 小時每天

6. 至關重要的問題！ 請認真回答。 在過去的7天中有多少天你做了運動（散步，中等強度和激烈運動？做運動意思是做了15分鐘或以上的激烈運動或做了總共30分鐘或以上的中等強度運動或散步。

□ 0 天　□ 1 天　□ 2 天　□ 3 天
□ 4 天　□ 5 天　□ 6 天　□ 7 天

7. 以下是一些保持人們做運動的事項，請指出每項對你的活動的影響程度

	影響很大 ↓						沒有一點影響 ↓
缺乏能量/太累	□1	□2	□3	□4	□5	□6	□7
因爲工作缺乏時	□1	□2	□3	□4	□5	□6	□7
因爲家庭責任缺乏時間	□1	□2	□3	□4	□5	□6	□7
關節炎或其他健康問題	□1	□2	□3	□4	□5	□6	□7
花費太高（衣服，儀器等）	□1	□2	□3	□4	□5	□6	□7
很難到達公園，體育館等	□1	□2	□3	□4	□5	□6	□7
很難成爲常規事情	□1	□2	□3	□4	□5	□6	□7
沒有人一起做運動	□1	□2	□3	□4	□5	□6	□7
我擔心我的安全問題	□1	□2	□3	□4	□5	□6	□7
我需要找人照顧我的小孩	□1	□2	□3	□4	□5	□6	□7
我太老了	□1	□2	□3	□4	□5	□6	□7
我很快厭煩	□1	□2	□3	□4	□5	□6	□7
在我空閒時間我喜歡幹其他的事情	□1	□2	□3	□4	□5	□6	□7
有人不鼓勵我做運動	□1	□2	□3	□4	□5	□6	□7
我有很多家務雜事要處理	□1	□2	□3	□4	□5	□6	□7
運動對我來說不舒服	□1	□2	□3	□4	□5	□6	□7

我已經走樣了而不能開始	□1	□2	□3	□4	□5	□6	□7
我感覺我已經超重而不能做運動	□1	□2	□3	□4	□5	□6	□7
我不知道怎樣做運動	□1	□2	□3	□4	□5	□6	□7
我不喜歡出汗	□1	□2	□3	□4	□5	□6	□7
我不喜歡上氣不接下氣的	□1	□2	□3	□4	□5	□6	□7
我不喜歡其他人看見我做運動	□1	□2	□3	□4	□5	□6	□7
要花費太多努力做運動	□1	□2	□3	□4	□5	□6	□7

8. 以下有哪些（如果有的話）適用於對你的鄰居和阻礙你做運動的因素？

□ 沒有足夠的小路
□ 小路沒有維修好
□ 交通擁擠
□ 有陡峭的斜坡
□ 沒有足夠的街燈
□ 沒有足夠的迴圈線路
□ 太多的停止標誌和燈
□ 景色不太好
□ 我很少看見人們走或作運動
□ 有很多犯罪行爲
□ 討厭的狗
□ 沒有以上的任何一項

9. 在過去的30天內，有多少天你抽煙？（如果在過去的12個月不抽煙的話，打X）

( ) 天

10. 在過去 30 天你抽煙的日子裏，通常每天抽多少？（如果不抽煙，打 X）

( )煙 /每天

11. 過去的一年中， 有沒有喝過含酒精的飲料？

□ 有 □ 沒有 □ 不知道

12. 通常喝酒精飲料的頻率？

□ 每月或更少 □ 2 到4次每月
□ 2 到3次每星期 □ 4次以上每星期

13. 當你喝酒精飲料的時候，通常每天喝多少？（例如：1 = 1 聽或小瓶的啤酒或以小杯紅酒或 1 小口酒精）

□ 1 或 2 □ 3 或 4 □ 5 或6
□ 7 到 9 □ 10 或更多

14. 一次你能喝5或更多的飲料的頻率？

□ 從來沒有 □ 少於1個月 □ 每月
□每週 □ 每天或幾乎每天

15. 你覺得你的健康通常是

□ 很差 □ 中等 □ 好 □ 很好 □ 特別好

16. 你覺得你的體重？
□ 過於輕 □ 有點輕
□ 正好 □ 有點重
□ 很重

17. 你正在進行
□ 增加體重 □ 減輕體重 □ 既不增也不減

18. 通常什麼時間上床睡覺 ( )
什麼時間起床（)

19. 通常吃這些食物的頻率

	不吃	每週少於1次	每星期2-3次	每天一次	幾乎每頓
乳製品（低脂或高鈣）（牛奶，乾酪，優酪乳）					
大豆產品（豆腐，醬油，豆奶）					
魚 （金槍魚, 鮭魚, 沙丁魚)					

20. 你會吃一些營養補充物嗎？
□ 是，請指出：___________________________________
□不是

第二部分：關於你的出生歷史

1. 你出生的重量是( ) 公斤

2. 你出身的身高是 ( ) 釐米

3. 請指名你在你母親孩子中的次序
( )個中的第 ( )個

4. 請指名你祖父母在中國的祖籍

祖父母	地點/在中國的範圍
你母親的母親	
你母親的父親	
你父親的母親	
你父親的父親	

5. 你母親懷你時抽煙嗎? 是 不是 不確定
你母親懷你時有吸二手煙嗎? 是 不是 不確定

你幼年時吸二手煙嗎?　　是　　不是　　不確定

第三部分：關於你對營養資訊的瞭解

1. 你怎樣認爲健康專家對於人們飲食的建議？選擇吃的多，正好，少， 不確定

	多	正好	少	不確定
蔬菜				
含糖食物				
肉				
澱粉食物				
脂肪食物				
高纖維食物				
水果				
鹹味食品				

2. 你認爲專家建議人們每天吃多少單位的水果和蔬菜？

□ 每天少於1份　　□ 每天1份
□ 每天2份　　□ 每天3份
□ 每天4份　　□ 每天5或更多份
□ 不確定

第四部分：關於你的性別，年齡和其他個人資訊，可以對我們的調查有幫助。對於這些我們嚴格保密。

1. 你是。。。□ 男　　□ 女

2. 你的出生日期 (日/月/年)

3. 你在新西蘭多久了(　　) 年　　) 月

4. 你是。。。

□ 單身　□ 已婚/和同伴一起住　□ 離婚　□寡居　□ 其他

5. 你有孩子嗎？

□ 沒有　□ 1　□ 2　□ 3　□多於3個

6. 你的最高教育是什麼？不包括沒有完成的學位或少於三個月全職學習的學位

□ 中學
□ 學士 ， 比如：農學士，理學士，法學士
□ 榮譽學士
□ 碩士， 比如：文學碩士，理學學士
□ 博士
□ 畢業證書 (不是研究生)
□ 畢業證書（研究生）
□ 貿易或技術證書少於3個月全職學習

□ 職業證書。象會計師，教師，護士
□其他 *（請指名)* ____

7. 下面哪一個是對你最好的描述？（選一個-如果多於一個，指出你在一周內花最多的時間的）
□ 全職工作
□ 兼職工作
□ 失業/正找工作
□ 在家
□ 退休
□ 病/殘疾
□ 學生 (全職, 包括中學)
□ 其他 *(請指名y)* ____

8. 在過去的12個月中，你和你的家庭在稅前的總收入是多少即所有的收入
□ 收入<$15000
□ 收入少於已於人$14999
□ 收入在$30000-$44999
□ 收入在$45000-$59999
□ 收入多於$60000

Appendix 14: Statistic results for section 3.2 comparison to other ethnic groups

Table 14.1: Estimated marginal means from univariate analysis of variance.

Variables		Female					Male				
		E	M	P	I	C	E	M	P	I	C
TBF (kg)	Mean	26.15	26.39	23.62	31.31	27.57	18.66	17.63	15.15	26.44	21.22
	SE	0.54	0.67	0.74	0.64	0.72	0.75	0.85	1.10	0.77	0.92
ApFM (kg)	Mean	13.02	12.02	11.08	15.24	11.94	7.98	6.88	6.48	10.98	7.80
	SE	0.37	0.46	0.51	0.44	0.49	0.36	0.41	0.52	0.37	0.44
C/Ap fat ratio	Mean	0.95	1.20	1.18	1.06	1.36	1.33	1.55	1.38	1.45	1.81
	SE	0.04	0.05	0.05	0.04	0.05	0.05	0.06	0.07	0.05	0.06
AF (g)	Mean	2030	2189	1738	2623	2475	1583	1566	1206	2547	2091
	SE	67.27	82.72	91.96	79.42	89.44	87.39	99.00	127.48	88.76	106.14
TF (g)	Mean	2717	2695	2317	3334	2600	1642	1566	1403	2206	1689
	SE	78.40	96.41	107.18	92.56	104.24	74.46	84.35	108.61	75.62	90.44
A/T ratio	Mean	0.59	0.86	0.88	0.80	0.83	0.88	1.03	1.01	1.16	1.15
	SE	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.06
FFM (kg)	Mean	44.52	44.63	47.17	39.22	42.43	61.48	62.59	64.81	53.46	58.32
	SE	0.55	0.68	0.76	0.65	0.74	0.77	0.88	1.13	0.79	0.94
ApSM (kg)	Mean	17.37	17.41	18.45	15.51	16.00	25.94	26.69	28.02	23.20	23.94
	SE	0.27	0.33	0.37	0.32	0.36	0.42	0.48	0.62	0.43	0.51
BMD (g.cm-2)	Mean	1.18	1.17	1.23	1.16	1.18	1.26	1.28	1.29	1.18	1.25
	SE	0.01	0.01	0.02	0.01	0.02	0.01	0.02	0.02	0.01	0.02
Leg (cm)	Mean	75.42	74.40	77.12	77.50	75.09	81.20	80.70	81.94	83.04	80.49
	SE	0.38	0.47	0.47	0.46	0.47	0.49	0.53	0.65	0.49	0.57
Arm (cm)	Mean	51.43	51.41	53.10	53.69	49.80	55.41	57.09	57.26	57.87	54.19
	SE	0.35	0.43	0.43	0.42	0.43	0.44	0.48	0.59	0.44	0.51

Abbreviations: E, European; M, Maori; P, Pacific; I, Asian Indian; C, NZ Chinese; SE, standard error; TBF, total body fat; ;ApFM, appendicular fat mass; C/Ap ratio, central- to-appendicular fat ratio; AF, abdominal fat; TF, thigh fat; A/T ratio, abdominal-to-thigh fat ratio; FFM, fat free mass; ApSM, appendicular skeletal muscle; BMD, bone mineral density. Mean Values: The mean values of TBF, ApFM, AF, TF, FFM and ApSM were adjusted for weight and height; The mean values of BMD were adjusted for weight; Leg and Arm bone lengths were adjusted for measured height.

Table 14.2: The differences between NZ Chinese with other ethnic groups selected from pairwise comparisons.

Variables		Female				Male			
		E	M	P	I	E	M	P	I
Total body fat (kg)	MD	1.43	1.19	3.95	-3.74	2.56	3.59	6.07	-5.21
	P	0.105	0.251	0.001	<0.001	0.033	0.007	<0.001	<0.001
ApFM (kg)	MD	-1.07	-0.08	0.86	-3.30	-0.18	0.92	1.33	-3.18
	P	0.077	0.913	0.271	<0.001	0.752	0.144	0.069	<0.001
C/Ap fat ratio	MD	0.42	0.16	0.18	0.30	0.48	0.26	0.44	0.36
	P	<0.001	0.015	0.007	<0.001	<0.001	0.003	<0.001	<0.001
Abdominal fat (g)	MD	445	286	737	-148	507	524	885	-456
	P	<0.001	0.027	<0.001	0.206	<0.001	0.001	<0.001	0.001
Thigh fat (g)	MD	-117	-95	282	-734	47	124	286	-516
	P	0.357	0.525	0.089	<0.001	0.690	0.344	0.058	<0.001
A/T fat ratio	MD	0.24	-0.03	-0.05	0.03	0.27	0.12	0.14	-0.01
	P	<0.001	0.659	0.433	0.670	<0.001	0.132	0.111	0.904
FFM (kg)	MD	-2.09	-2.20	-4.74	3.21	-3.16	-4.27	-6.49	4.86
	P	0.021	0.039	<0.001	0.001	0.011	0.002	<0.001	<0.001
ApSM (kg)	MD	-1.37	-1.42	-2.45	0.49	-2.00	-2.75	-4.09	0.74
	P	0.002	0.007	<0.001	0.296	0.003	<0.001	<0.001	0.251
BMD (g.cm-2)	MD	0.01	0.02	-0.04	0.03	-0.01	-0.03	-0.04	0.07
	P	0.627	0.460	0.091	0.216	0.797	0.208	0.149	0.001

Abbreviations: E, European; M, Maori; P, Pacific; I, Asian Indian; C, NZ Chinese; SE, standard error; TBF, total body fat; ;ApFM, appendicular fat mass; C/Ap ratio, central- to-appendicular fat ratio; AF, abdominal fat; TF, thigh fat; A/T ratio, abdominal-to-thigh fat ratio; FFM, fat free mass; ApSM, appendicular skeletal muscle; BMD, bone mineral density; MD, mean difference (NZ Chinese minus other ethnicity).

Table 14.3: Leg bone length differences after adjustment for measured height and DEXA height

NZ Chinese different to	Differences after adjustment for measure height (cm)		Differences after adjustment for DEXA height (cm)	
	Female	Male	Female	Male
European	-0.3 (P=0.595)	-0.7 (P=0.356)	-1.5 (P=0.016)	-2.2 (P=0.002)
Asian Indian	-2.4 (P<0.001)	-2.5 (P=0.001)	-2.9 (P<0.001)	-3.2 (P<0.001)

Table 14.4: Arm bone length differences after adjustment for measured height and DEXA height

NZ Chinese different to	Differences after adjustment for measure height (cm)		Differences after adjustment for DEXA height (cm)	
	Female	Male	Female	Male
European	-1.6 (P=0.005)	-1.2 (P=0.077)	-2.4 (P<0.001)	-2.3 (P=0.001)
Asian Indian	-3.9 (P<0.001)	-3.7 (P<0.001)	-4.2 (P<0.001)	-4.2 (P<0.001)

Appendix 15: Feedback Sheet

Feedback Sheet

Body size, body composition, and fat distribution in NZ Chinese

Dear______________________

Thank you very much for taking part in this study. Your time, body and co-operation in the data collection are appreciated, as without these the study would have been failed.

A summary of overall results of the study is enclosed for you as you have requested in your consent form. The copy of your body composition result and health screening results had been given to you immediately after you had the measurements.

If you have any queries or wish to discuss the results further please do not hesitate to contact us. Our contact details are:

Elaine RUSH, Ph 921 9999 ext 8091 elaine.rush@aut.ac.nz

Ji Yang (Jewel) WEN, Ph 021 1029339 jewel.wen@aut.ac.nz

Thanks again for your help.

Regards

Ji Yang (Jewel) WEN
Elaine RUSH (Primary supervisor)

Summary of overall results for participants

Body size, body composition, and fat distribution in NZ Chinese

This study is part of an overall research agenda where ethnic comparisons are made among the major NZ ethnic groups. The summary presented here were results of 116 men and 131 women aged 30-39 years including European (M29, W37), Maori (M23, W23), Pacific people (M15, W23), Asian Indian (M29, W25), and NZ Chinese(M20, W23) people. The key findings are:

On average, at the same body fat as European with a BMI of 30 kg m^{-2} NZ Chinese

Men had a BMI of 27.0 kg m^{-2}

Women had a BMI of 27.8 kg m^{-2}

Scaled to the same height and weight, NZ Chinese men and women had:

More body fat than European but less body fat than Asian Indian

Higher central fat to limb fat ratio than Asian Indian and European.

Less muscle on the arms and legs than European but about the same as Asian Indian.

Similar bone mineral density as European but greater than Asian Indian

Shorter arm and leg bone lengths than European and Asian Indian

A lower birth weight was associated with a higher percentage body fat at 30-39 years for NZ Chinese men.

In conclusion

- The relationship between percent body fat and BMI for Asian Indian and NZ Chinese differs from Europeans and from each other. Therefore, different BMI thresholds for obesity may be required for these Asian ethnic groups.
- Given the relatively low limb muscle mass and high central fat to appendicular fat ratio of NZ Chinese aged 30-39 y demonstrated in the study, the NZ Chinese community should be advised to keep fit, prevent limited movements in older age, and to prevent obesity and obesity-related diseases.