Anthropometric Assessment Tools as Postoperative Risk Indicators in Adult Orthopaedic Patients: A Pilot Study.

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All your dreams can come true, if you have the courage to pursue them.
Walt Disney (1901-1966)
Abstract

Obesity is not only known to contribute to health risks such as cardiovascular disease (CVD) and type II diabetes mellitus, but can also be associated with post operative complications (Amin, Sales & Brenkel, 2006; Best, 2005; Flier & Maratos-Flier, 2005; Ministry of Health [MOH], 2009a; Von Haehling, Horwich, Fonarow, & Anker, 2007; WHO, 2006). The body mass index (BMI) is the mostly commonly used tool to assess obesity, however the limitations of the BMI are widely debated (Duncan, Schofield, Duncan, Kolt & Rush, 2004; Han, Sattar & Lean, 2006; Rush, Plank & Robinson, 1998; WHO 2006; MOH, 2009a). The measurement of central obesity using the waist circumference (WC) is thought to be a more useful indicator of type II diabetes mellitus and CVD than using BMI alone (Deurenberg & Yap, 1999; Duncan et al., 2004).

In the preadmission clinic and admitting unit (AU) of the hospital used for this study, nurses implement physical assessments to evaluate patient’s fitness for surgery along with educating and promoting healthy living for those not fit for surgery. The BMI is used routinely by nurses and the multidisciplinary team and follow the Ministry of Health (MOH) BMI guidelines to help implement a scoring system to assess the patients’ fitness for surgery. However the hospital dietitian uses both the BMI and WC measurements. Informal enquires regarding the utility of the BMI to assess obesity and fitness for surgery and the use of two different assessment tools underpinned the research question “Which anthropometric measurement tool is best able to effectively indicate the risk of potential post-operative complications”?

This is the report of a pilot study, the aim of which was to explore if either one of two different anthropometric measures have any better utility than each other in indicating the risk of potential postoperative complications. A total of 148 participants who were admitted for joint replacement surgery and met the inclusion criteria, were recruited over 18 months. Data were collected at three points, pre surgery, within 24 hours post surgery and after 24 hours post surgery until discharge. Descriptive statistics (measures of variability, frequency, and central tendency where appropriate) of individual and clinical characteristics were inspected. Due to the small participant numbers and multiple variables, the pilot study was unable to
conduct inferential statistical analysis to test the research question. Ethical and cultural considerations were made throughout the study.

As no inferential statistics were conducted, only trends could be observed. The trends for overall complications during the first 24 hours post operation showed that the most frequencies were seen in the BMI < 40 (morbidity obese) group (47%) and the female > 88cm (unhealthy) WC group (38.2%) and male < 102cm (healthy) WC group (37.5%). The highest frequency of overall operative complications after 24 hours post operation was observed in the BMI 18.5-24.99 (normal range) group (75%) and the female > 88cm (unhealthy) WC group (75%) and in the male > 102cm (unhealthy) WC group (54.2%). However the frequency difference between healthy and unhealthy WC for both genders was marginal.

The findings of the pilot study and the literature support the trend between obesity and post operative complications. The BMI appeared to be a useful indicator for co-morbidities but appeared to be less useful as an indicator for post operative complications. The WC appeared to be a useful indicator of co-morbidities and complications during the immediate postoperative period but appeared to be less useful after 24 hours post surgery. The WC appeared to be a stronger indicator of CVS in obese females than obese males. Although more males were defined as obese it appeared more obese females had post operative complications when WC was used. The question around the BMI formula and WC as effective assessment tools to define obesity continues to be debated and still remains an area worthy of taking this study further as well as other ongoing research in this area.
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<tbody>
<tr>
<td>ACC</td>
<td>Accident Compensation Corporation</td>
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<tr>
<td>Afib</td>
<td>Atrial Fibrillation</td>
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<td>ASA</td>
<td>American Society of Anaesthesiologists Physical Status Classification</td>
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<tr>
<td>AU</td>
<td>Admitting Unit</td>
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<td>BF %</td>
<td>Body fat percentage</td>
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<td>BMI</td>
<td>Body Mass Index</td>
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<tr>
<td>BP</td>
<td>Blood Pressure</td>
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<tr>
<td>CDHB</td>
<td>Canterbury District Health Board</td>
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<td>CCU</td>
<td>Coronary Care Unit</td>
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<tr>
<td>CHD</td>
<td>Coronary heart disease</td>
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<tr>
<td>CPTA</td>
<td>Computerised tomographic pulmonary angiography</td>
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<td>CT</td>
<td>Computed tomography</td>
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<td>CVD</td>
<td>Cardiovascular disease</td>
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<tr>
<td>CVS</td>
<td>Cardiovascular system</td>
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<tr>
<td>COPD</td>
<td>Chronic obstructive pulmonary disease</td>
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<tr>
<td>CPAP</td>
<td>Continuous positive airway pressure</td>
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<tr>
<td>DEXA</td>
<td>Dual-Energy X-ray Absorption</td>
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<tr>
<td>DHB</td>
<td>District Health Board</td>
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<tr>
<td>DVT</td>
<td>Deep Vein Thrombosis</td>
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<td>ECG</td>
<td>Electrocardiograph</td>
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<tr>
<td>ED</td>
<td>Emergency Department</td>
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<tr>
<td>EWS</td>
<td>Early Warning Score</td>
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<tr>
<td>GI</td>
<td>Gastrointestinal</td>
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<tr>
<td>GP</td>
<td>General Practitioner</td>
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<tr>
<td>GORD</td>
<td>Gastric oesophageal reflux disease</td>
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<tr>
<td>HB</td>
<td>Haemoglobin</td>
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<tr>
<td>HRCNZ</td>
<td>Health Research Council of New Zealand</td>
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<tr>
<td>ICU</td>
<td>Intensive care unit</td>
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<td>IHD</td>
<td>Ischemic heart disease</td>
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<td>IV</td>
<td>Intravenous</td>
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<tr>
<td>LOS</td>
<td>Length of stay</td>
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<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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<td>--------------</td>
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<tr>
<td>MRI</td>
<td>Magnetic resonance imaging</td>
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<tr>
<td>MOH</td>
<td>Ministry of Health</td>
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<tr>
<td>NHANES</td>
<td>National Health Examination and the Health and Nutrition Examination Surveys</td>
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<tr>
<td>NLASP</td>
<td>Nurse Led Anaesthetic Support Preadmission</td>
</tr>
<tr>
<td>NZ</td>
<td>New Zealand</td>
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<tr>
<td>OA</td>
<td>Osteoarthritis</td>
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<td>OSA</td>
<td>Obstructive sleep apnoea</td>
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<td>O2</td>
<td>Oxygen</td>
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<tr>
<td>PACU</td>
<td>Post Anaesthetic Care Unit</td>
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<tr>
<td>PE</td>
<td>Pulmonary embolism</td>
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<tr>
<td>PONV</td>
<td>Post operative nausea and vomiting</td>
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<td>SAT</td>
<td>Subcutaneous Tissue Fat</td>
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<td>SCU</td>
<td>Special Care Unit</td>
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<tr>
<td>SD</td>
<td>Standard deviation</td>
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<td>SOB</td>
<td>Shortness of breath</td>
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<td>SOU</td>
<td>Surgical Orthopaedic Unit</td>
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<td>SPSS</td>
<td>Statistical pro</td>
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<tr>
<td>SVT</td>
<td>Sinus ventricular tachycardia</td>
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<tr>
<td>TAT</td>
<td>Total Adipose Tissue fat</td>
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<tr>
<td>TIA</td>
<td>Transient ischemic attack</td>
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<tr>
<td>TKR</td>
<td>Total knee replacement</td>
</tr>
<tr>
<td>THR</td>
<td>Total hip replacement</td>
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<tr>
<td>TNI</td>
<td>Troponin</td>
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<tr>
<td>UK</td>
<td>United Kingdom</td>
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<tr>
<td>USA</td>
<td>United States of America</td>
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<tr>
<td>VAT</td>
<td>Visceral Adipose Tissue fat</td>
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<tr>
<td>VQ scan</td>
<td>Ventilation-perfusion scan</td>
</tr>
<tr>
<td>WC</td>
<td>Waist Circumference</td>
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<td>WHO</td>
<td>World health organisation</td>
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<td>WHR</td>
<td>Waist Hip Ratio</td>
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Glossary

Apronectomy  A surgical procedure of the lower abdomen and waist to remove surplus skin and fat hanging down over the pubic area.

Autoclave  Term used for steam-under pressure sterilizer.

Lipophilic  Applied to molecular entities (or parts of molecular entities) having a tendency to dissolve in fat-like (e.g. hydrocarbon) solvents.

Body mass index wheel  Hard plastic disc that calculates BMI using a slide window. A BMI wheel works like a pregnancy due date wheel.
Chapter 1 Introduction

1.1 Background

During 2006/2007 a Nurse Led Anaesthetic Supported Preadmission (NLASP) model of care was introduced within a primary centre for elective orthopaedic surgery in Christchurch. The NLASP model of care came about following the Orthopaedics Initiative launched in 2004 to improve the patient journey. The Orthopaedic Initiative introduced the BMI guidelines to help assess patients for elective joint replacement surgery and helped to develop the Dietitian led weight loss program prior to surgery for patients with Body Mass Index (BMI) > 35 and the NLASP model of care. After a pilot trial of various care models, the NLASP model was introduced to help improve medical and surgical outcomes for patients receiving elective primary hip and knee replacement. The NLASP model involves a four step process for nurses to manage and care for all patients who meet the medical criteria. The four step process includes: nurse led medical screening of a patient before they are placed onto the surgical waiting list; nurse led pre admission; nurse led admission (on the day of surgery); nurse led discharge. Figure 1 highlights the nurse led component of the patient journey.

Figure 1 Patient Journey for Primary Hip and Knee Replacement. From “Nurse Led Anaesthetist Supported Preadmission Trial- final report”, CDHB, 2008 p.7)
1.1.1 NLASP and the patient journey

The patient journey begins with a consultation with the patient’s General Practitioner (GP) where an assessment for the possible need for joint replacement surgery is made. The GP refers the patient to the hospital pre admission clinic where further assessment is provided by physiotherapists. Physiotherapists assess the level of disability and the assessment includes measuring the height and weight to calculate the BMI. The BMI is used as part of a validation scoring system to assess the patient’s suitability and fitness for surgery.

The next step in the patient journey requires the patient to be referred to a surgeon for pre surgery assessment. The surgery proceeds depending on the BMI cut off point as outlined in the recommended guidelines for primary hip and knee replacement (see table 3, section 2.8) (CDHB, 2007/08). The patient is referred to a designated weight loss program with the hospital dietitian if the BMI cut off is > 40. The New Zealand Dietetic Association guideline for waist circumference measurements is used by the dietitian along with the BMI to measure obesity and weight loss of the patient (The Heart Foundation of New Zealand, 2007).

After the patient has been assessed as a suitable candidate for surgery by the multidisciplinary team, the patient is sent a preoperative health questionnaire. Nurses involved in the first step of the NLASP model assess the patient’s suitability for surgery using the pre operative health questionnaire before the patient is booked for surgery. Patients who are booked for surgery further receive a medical and physical assessment during the second step of the NLASP at the preadmission clinic by nurses and anaesthetists. A surgery date is then confirmed when the patient has been finally assessed as medically fit for surgery.

1.2 Identification of the research problem

Following the introduction of the NLASP, new surgical facilities were built in 2007. The restructuring of the surgical services also included the merger of the post anaesthetic care unit (PACU) with the Admitting Unit (AU). A third step of the NLASP model was introduced into the AU where the PACU nurses applied new skills and tasks. This included using a BMI wheel assessment tool (a plastic disc that calculates BMI using a slide window) which facilitated the calculation and documentation of the BMI measurements for all patients admitted for elective surgery. The BMI and medical criteria are used in the AU to guide the nurses as they assess the patients’ fitness for surgery.
The NLASP initiative appeared to be working well. However, following informal discussions between the author of this thesis and various members of the multidisciplinary team, including nurses, physiotherapists and anaesthetists, questions around the BMI measurement arose. These discussions led to further inquiries about the validity of the BMI assessments and about the most useful anthropometric measurement of obesity as a prerequisite for other elective orthopaedic surgery and lead to this research. These questions were especially relevant as both the WC measurement and the BMI wheel were used throughout the patient journey. There had been various obesity assessment research projects conducted within the hospital by the dietitian, physiotherapists and medical team (CDHB, 2008a). However, it was felt by the author that this was an opportunity to look at obesity assessments from a nursing perspective.

Obesity is identified worldwide as a growing major health concern that contributes to many health problems including CVD (the world’s number one cause of death) and type II diabetes mellitus (Amin, Sales & Brenkel, 2006; MOH, 2008a; Von Haehling, Horwich, Fornarow, & Anker, 2007; WHO, 2011). Obesity not only affects the health status of the individual but it also contributes to the fiscal burden of health care services and society. The indirect economic cost of the health consequences attributable to obesity includes health care resources and equipment and treatment for osteoarthritis (OA), heart disease, hypertension, type II diabetes mellitus, asthma and some cancers (Access Economics, 2008; Dowsey & Choong, 2008; Thompson, Edelsberg, Colditz, Bird & Oster, 1999; Neovius, Johansson & Neovius, 2008; Stein & Colditz, 2004; Swinburn et al., 1997).

1.3 Obesity and post operative complications/considerations

It is widely accepted that the rate of obesity is increasing globally. In New Zealand the prevalence of obesity has increased from 17% in 1997 to 26.5% in 2007 (MOH, 2009a; Ministry of Social Development, 2010). It is essential therefore, that important clinical decisions in patients’ health status and potential postoperative risks are made using reliable and effective assessment tools. Having an effective and reliable assessment tool that helps to identify obesity in all ethnic groups may ensure that the appropriate services are made accessible and help meet the MOH Health Strategy to reduce health inequalities in New Zealand (MOH, 2000; MOH, 2002).
Obesity contributes to an increased risk of post operative complications and anaesthetic risk and can affect the life expectancy of joint replacement components (Amin, Sales & Brenkel, 2006; Naylor, Harmer & Herd, 2008). Therefore the planning of the appropriate resources is necessary to meet the post operative needs of the obese patient. To ensure safe and efficient nursing care is provided for the obese patient, extra resources and appropriate equipment may need to be available. Examples include large blood pressure (B/P) cuffs, wide stretchers and beds, lifting devices and long rollers for transferring immobile patients. The affects of obesity and the metabolism of anaesthetics and other medication need to be considered in patient care along with other body systems such as the cardiovascular system (CVS) and respiratory system (Dunn, 2005; Flier & Maratos-Flier, 2005; Hatfield & Tronson, 2004, Pelosi & Gregoretti, 2010). Within the primary care centre for elective orthopaedic surgery, nurses in the preadmission clinic and AU, in collaboration with the multidisciplinary team, play a pivotal role in assessing the patients’ level of health and wellness, evaluating their fitness for surgery and planning for their post operative care. Nurses have the opportunity to educate and promote healthy living for those not fit for surgery.

1.4 Background to the the BMI

The BMI is the most common assessment tool used to measure total body fat and gives a useful predictor of health risks (Han et al., 2006; MOH, 2009a; WHO, 2011). Techniques such as MRI and bioelectrical impedance may be more accurate tools to assess body fat, but these can be impractical in the clinical setting as these methods can be complicated to use, and transportability of the equipment along with the expensive and time required to measure large groups (Deurenberg & Yap, 1999). The BMI formula was first introduced 200 years ago by Adolphe Quetelet a Flemish scientist and statistician (Han et al., 2006). Despite this history, the BMI has only been adopted over the last 40 years for health insurance assessments, Government health planning and for medical assessments in the clinical setting (Bray, 1998; MOH, 2000; MOH, 2009a). The BMI formula is calculated by dividing the weight (Kg) by the height squared (m²) (Bray, 1998; Eknoyan, 2008; Mandel, Zimlichman, Mimouni, Grotto & Kreiss, 2004). The research question underpinning the pilot study was to explore the utility of BMI and WC as useful indicators of potential postoperative complications.
1.4.1 Limitation of BMI cut offs and Ethnicity

The literature shows that there are limitations to the BMI being used as a morbidity and mortality risk indicator due to its inability to distinguish between fat and fat free mass (muscle mass and total body water) (Duncan, Schofield, Duncan, Kolt & Rush, 2004; WHO, 2006; Rush, Plank, & Robinson, 1998). Studies have long debated the limitations of the BMI cut off and ethnicity. The BMI and body fat distribution has been found to vary across ethnic groups which may influence the reliability of the BMI cut off for different ethnic groups. Therefore it has been suggested that the BMI cut off points should be reclassified by consideration of ethnic populations, age and gender and other risk factors (Duncan et al., 2004; WHO, 2004; WHO, 2011; Rush et al., 1998).

1.5 Waist circumference

Waist circumference (WC) has also been found to be a useful predictor of health risks particularly for CVD and type II diabetes mellitus. Individuals with a large WC have been associated with an increased health risk such as hypertension, shortness of breath (SOB) and poor quality of life. Studies have suggested that using the BMI to estimate body fat percentage together with the WC measurement to measure abdominal fat, are more likely to identify health risks than using only the BMI (Duncan et al., 2004; Deurenberg & Yap, 1999).

Hence the research question for this thesis was generated as a result of the ongoing debate in the literature and the practical implications in the clinical setting. This pilot study was undertaken and this thesis reports the findings of this work.

1.6 Structure of the Thesis

The thesis is structured as follows. Chapter one present has presented an introduction to the thesis as a whole. A background to the research question has been given along with the aims and objectives of the pilot study. Chapter two provides a review of the literature to help underpin the research question. A brief definition of obesity and its associated health risks will introduce the systematic review. The BMI and WC cut off points to assess obesity will be critiqued with relevance to health risk indictors, ethnicity, gender and comparison studies will be reviewed. The application of BMI and WC to clinical practice concludes this chapter.
Chapter three presents the methods used. An outline of the study design, participant recruitment process and ethics approval is given. A description of the biophysiological measures, variables and data collection points is included. Chapter four presents the results of the analysis. A discussion in chapter five will identify the limitations of the research and implications for future research.

1.7 Aim and Objectives

Aim
The pilot study aimed to explore which anthropometric (BMI or WC) measurement tool is best able to effectively indicate the risk of potential post-operative complications of elective joint replacement patients.

Objectives:
- To consider the difference between BMI and WC as effective risk indicator tools to aid in identifying potential post-operative complications for patients who receive elective joint replacement surgery
- To consider if there is an association between the BMI and WC and the parameters for overweight and obesity cut off points.

1.8 Summary

This chapter has provided a background to the theme of the thesis and has explored a number of the key concepts fundamental to the pilot study. The aim and objectives of the study are provided and an overview of the structure of the whole thesis is given. This overview leads naturally into the literature review to explore the concepts in question in more detail.
2 Literature Review

2.1 Introduction

The literature review focuses on a comparison between the BMI and WC measurements and explores their reliability and validity and will provide a background to underpin the research question. A search strategy outlines how the literature search was conducted. A brief definition of obesity and its associated health risks introduces the literature review. The limitations of the BMI will be critiqued with relevance to BMI classified cut off points for ethnicity and gender. The BMI will be compared with the strengths and limitations of WC. As the literature search found BMI and comparison studies also included waist–to–hip ratio (WHR), the WHR will be briefly discussed in the literature review. The limitations of the review and implications for future research will also be discussed.

2.2 Search Strategy

The databases searched covered the period from 2001-2011, however as there was little current research, a selection of peer reviewed articles were also searched prior to 2001. Databases included the following: OVID, CINAHL and Med line. Other databases were Pubmed ProQuest, Academic Premier and Science Direct database and Google scholar. The Cochrane Library was also explored, however there were no relevant reviews on this database. The option of scholarly journals and peer reviewed articles, literature reviews, research and quantitative studies were selected where this option was available. Key words included the following; obesity, anthropometric, body mass index, waist circumference, health assessment tool, nursing assessment, pre-surgery health assessment, heath risk indicator.

2.3 Obesity

2.3.1 Definition of Obesity

The WHO defines obesity as “Abnormal or excessive fat accumulation that may impair health” (WHO, 2011, para.1). Obesity is often viewed as relating to increased body weight. However, lean but very muscular individuals may be overweight without having increased
adiposity (Flier & Maratos-Flier, 2005). The New Zealand MOH builds upon the WHO definition by suggesting that over weight is defined as “excess weight for height” and obesity is an “excessively high amount of body fat or adipose tissue in relation to lean body mass” (MOH, 2009a, para.1).

BMI is often used to firstly, define obesity and or body fat distribution and secondly, to determine a healthy body weight. However, the use of BMI to define obesity in this way has limitations, which will be discussed further in the literature review. The distinction between obesity and body fat is an important one. The definition of obesity can be more usefully used to assess its link to morbidity and mortality, whereas body composition in obesity or adiposity is defined by a high to very high body fat percentage (BF\%) (Deurenberg & Yap, 1999; Flier & Maratos-Flier, 2005).

2.3.2 Obesity and health risks

Obesity is not only an epidemic health issue but is fast becoming a pandemic problem. Obesity is identified globally as a growing major health concern that contributes to CVD and type II diabetes mellitus (Amin et al., 2006; MOH, 2009a; Von Haehling et al., 2007; WHO, 2006; WHO, 2011). The impact that obesity has on health is widely documented. Excessive body fat can lead to CVD, which is currently the world’s number one cause of death each year. Other health risks include insulin resistance diabetes, which has become a global epidemic, pulmonary disease, OA, some cancers and increased risk when anaesthesia is required (Amin et al., 2006; Dunn, 2005; Flier & Maratos-Flier, 2005; Von Haehling et al., 2007; WHO, 2011). The annual deaths attributed to obesity related diseases in the United States of America (USA) was estimated to be 300,000 in 1999, with 80% of these in individuals with a BMI > 30 (Allison, Fontaine, Mason, Stenvos, Van Itallie , 1999).

A number of recognised factors have influenced the increasing incidence of obesity not only in high-income countries, but also in low and middle-income countries, particularly in urban settings (WHO, 2006a, WHO, 2011). The worldwide change in diet has seen a rise in eating convenience foods high in fats and sugars but low in vitamins and minerals. Changes in lifestyles and urbanisation have resulted in less daily exercise and activity due to more deskbound working environments and more passive daily transportation (Flier & Maratos-Flier, 2005; WHO 2011).
A survey carried out by the National Health Examination and the Health and Nutrition Examination Surveys (NHANES) from 1960 to 2002 reported that, on average American adults had become an inch taller and 25 pounds heavier over the 40 year period. This indicated that the average BMI had increased from 25 in 1960 to 28 in 2002 (Ogden, Fryar, Carroll & Flegal, 2004). The increase of obesity in the USA for both men and women has gone from 14.5% in 1980 to 30.5% in 2000. In the United Kingdom obesity percentage for both genders has risen from 6-8% in 1980 to 15-17% in 1995 (Deurenberg & Yap, 1999; Flier & Maratos-Flier, 2005).

Obesity in New Zealand has likewise increased. In 1989, the prevalence was 11%, in 1997 it was 17% and in 2007 it had increased to 26.5%. The 2006/2007 New Zealand Health Survey found that 1,128,500 New Zealand adults were overweight and 826,100 were obese. One in three New Zealand adults were overweight (36.3%) and one in four obese (26.5%). The percentage of obese Maori adults was 41.7%. The percentage of adult obesity for Pacific peoples was 63.7% and for the Asian population 11% (MOH, 2009a).

A study carried out jointly by the MOH and the University of Auckland in 2003 found that individuals with a higher than optimal BMI contributed to approximately 3,200 deaths in New Zealand in 1997. These deaths were mainly due to the development of type II diabetes mellitus, ischemic heart disease (IHD) and stroke (MOH 2009). This burden is likely to be even higher these days given that the mean BMI of the adult population has increased since 1997.

2.3.3 Burden of health care

Obesity not only directly affects the health of the individual but also results in a major economic burden to society and health care systems. A comparison study conducted by Thompson et al. (1999) examined the lifetime cost of health consequences attributed to obesity and the health consequences attributed to smoking. Smoking is the number one risk factor for morbidity and mortality in the USA. The findings estimated that excess health care costs linked with obesity were nearly as high as those associated with smoking.

The economic cost of obesity can be broken down into two categories; direct and indirect health care costs. Direct health care costs include the running of hospitals, nursing homes, GP
specialist services, cost of pharmaceutics and allied health services. Indirect health care costs includes community care services, mobility aids, equipment, loss of productivity and short and long-term employment through absenteeism from work due to obesity related diseases, financial cost of government and other payouts, and life expectancy (Access Economics, 2008; Neovius, et al., 2008; Stein & Colditz, 2004; Swinburn et al., 1997).

The cost of the health consequences attributable to obesity includes treatment for OA, heart disease, hypertension, type II diabetes mellitus, asthma and some cancers. Overweight adults are at greater risk of developing OA in the knees and twice more likely to develop OA in the hips than adults within the normal weight range (Dowsey & Choong, 2008; Stein & Colditz, 2004). The total financial cost in Australia for OA associated with obesity was estimated at A$855 million in 2005 (Dowsey & Choong, 2008). Type II diabetes mellitus and its associated complications has a significant impact on health care cost. The annual cost of type II diabetes mellitus in the USA was US$190.5 billion in 2005. The direct relationship between obesity and type II diabetes mellitus has a large socio-economical influence on individuals, family and society. Public sector spending in the USA remained substantial in 2006 in its contribution towards the health care costs of obesity. The medical spending for an obese person was on average US$1,429 more than that spent for a person of normal weight (Finkelstein, Trogdon, Cohen & Dietz, 2009).

The 2006 WHO European ministerial conference on counteracting obesity reported that adult obesity contributed to 6% of health care costs in the WHO European region (WHO, 2006b). Access Economics (2008) reported that Australia’s total financial cost of obesity in 2008 was A$58.2 billion. The direct cost of health care was A$8 billion. Indirect health care cost totalled A$49.9 billion. The Australian government contributed to 42% of the total financial health care cost of obesity, whereas in the USA, obesity contributed 5.5% - 9.1% of the total cost of health care in 2002. This figure remained unchanged in 2008. The direct medical cost of obesity was estimated to be as high as US$92.6 billion (Sullivan, Ghushchyan & Ben-Joesph, 2007).

Finkelstein et al.’s (2009) study reported that the rise in obesity added US$40 billion to the annual health care costs between 1998-2006. The annual health care cost in 2008 was estimated to be as high as US$147 billion. The financial burden for the public funding sector expenditure included 8.5% Medicare and 11.8% Medicaid with added prescription drug
benefits accounting for US$600 more for obese patients than normal weight patients. The study prompted the Centres for Disease Control and Prevention (CDC) to discuss the findings at a Washington conference. The discussion included new recommendations for preventing and reducing the impact of obesity (Finkelstein et al., 2009).

Wang, Beydoun, Laing, Caballero and Kumanyika, (2008) proposed that the health care cost attributable to obesity and being overweight will more than double each decade. The authors estimated that between 2010–2030, 90% of all Americans would become overweight or obese. Of that number, 51% would become obese. By 2030 health care costs could range from US$860 to US$956 billion which would account for 15.8 -17.6% of the total health care costs. The summarised findings of Wang et al. (2008) study is an estimation and the true impact of the cost of obesity to health care in the future may be greatly under estimated.

A study by Swinburn et al. (1997) compared six obesity related conditions prevalent in New Zealand over a 12 month period in 1991. The six conditions included type II diabetes mellitus, coronary heart disease (CHD), hypertension, gallstones, post-menopausal breast cancer and colon cancer. Swinburn used a formula previously used by Coditz (1992) and Segal, Carter & Zimmet (1994) based on a population of 3.4 million. Swinburn et al. (1997) estimated that the total cost of these six obesity related health conditions was NZ$409 million. The total amount accredited to obesity was approximately NZ$135 million. Hypertension, CHD and type II diabetes mellitus were the three main contributors to the total cost of obesity with CHD contributing approximately 42% to the total cost. This represented approximately 2.5% of the total health care cost similar to other countries in 1991 (Swinburn et al., 1997).

The MOH health survey of 2006/2007 estimated that the direct health care costs of obesity in New Zealand was approximately NZ$460 million in 2004 (MOH, 2008a). A recent literature search could not find any current figures to update this information. The New Zealand Government 2006 budget committed NZ$76 million over a 4 year investment to campaign against the rise of obesity. The campaign aimed to focus on initiatives with schools, primary health care, social agencies and food industry bodies (MOH, 2006).
2.4 Obesity and considerations for surgery preparation

2.4.1 Planning the appropriate resources

It is widely acknowledged that obesity is associated with increased risk of postoperative complications. The co-morbidities associated with obesity include hypertension, obstructive sleep apnoea (OSA), restrictive lung disease, type II diabetes mellitus and delayed gastric emptying. These factors can increase surgical risks, impair wound healing and slow patient recovery (Flier & Maratos-Flier, 2005). Nurses play a pivotal role in clinical decision making regarding direct patient care which is a view supported by Bakalis & Watson (2002). The decision making involves gathering patient information, evaluation of the information and making judgments that result in providing safe and effective nursing care. Nurses are in a key position to provide support and advice for obese and overweight patients (Bakalis & Watson, 2002; Drummond, 2002).

Using a pre-surgery health assessment tool to assess excessive body fat assists both the hospital staff and the patient to prepare for surgery. Considerations are needed to ensure the appropriate equipment is available, such as large blood pressure (B/P) cuffs, wide stretchers and long rollers for transferring bariatric operating tables and lift devices for immobile patients (Dunn, 2005; Flier & Maratos-Flier, 2005). The cost implications for this equipment is self evident.

Establishing venous access can be difficult in obese patients and finding the landmarks for spinal or epidural anaesthesia may be equally challenging. The needles used may not be long enough to penetrate to the depth of the spine. Considerations need to be made for positioning intra operatively. The obese patient is at greater risk of skin break down and nerve damage because the adipose tissue is not vascular. Incorrect positioning can also affect the cardio and respiratory function (Dunn, 2005; Flier & Maratos-Flier, 2005).

2.4.2 Peri-operative health risk factors

2.4.2.1 The Respiratory System

Intubation and ventilation can be difficult because obese adults tend to have relatively shorter necks due to the excess tissue. Flexion and extension of the head can impede
intubation. The larynx can be hard to view therefore fiber optic equipment may be required (Dunn, 2005, Hatfield & Tronson, 2004, Pelosi  & Gregoretti 2010). These can all cause difficulties for effective airway management and adequate ventilation to the patient. The obese patient has poor respiratory function efficiency, particularly post operatively. Chest expansion is restricted, lung capacity is reduced and an increase in the oxygen expenditure of the myocardium can occur. This can cause the patient to become hypoxic or develop pulmonary hypertension (Dunn, 2005; Flier & Maratos-Flier, 2005).

Obese patients have a predisposition to develop OSA, which often leads to the need for a continuous positive airway pressure (CPAP) machine at night. Post operatively the obese patient is more likely to develop atelectasis and pneumonia complications that may require mechanical intervention such as CPAP. There is a higher possibility of aspiration of the gastric contents into the lungs during the post operative period because of the increased intra abdominal pressure while the patient is on bed rest (Dunn, 2005; Hatfield & Tronson, 2004, Pelosi  & Gregoretti 2010).

2.4.2.2 The Cardiovascular System

Obesity is associated with increased risk of CV complications and mortality. For each additional kilogram of body fat there is an increase in the cardiac workload which leads to a greater demand for cardiac output and oxygen use. In obese adults with high blood pressure a persistently larger stroke volume can increase the chance of an acute myocardial ischemia or infarction, heart failure, complex ventricular arrhythmias events or unexpected fatality (Dunn, 2005; Hatfield & Tronson, 2004).

2.4.2.3 Venous Thromboembolism

The obese patient is at greater risk of developing deep vein thrombosis (DVT) or pulmonary embolisms (PE) resulting from polycythaemia (thickening of the blood) an increase in the abdominal pressure restricting venous flow from the legs along with prolonged inactivity. Obesity is also associated with a decrease in fibrinolytic activity, which adds to the risk of developing a blood clot. Extra anti thrombolytic therapy may need to be considered including anticoagulant drugs, a mechanical leg compression device, compression stockings, and early mobilisations (Dunn, 2005; Hatfield & Tronson, 2004).
2.4.2.4 Medication

The pharmacokinetics of drug therapy may not function as anticipated in obese patients. Many anaesthetic drugs are lipophilic and are stored in the body fat. The adipose cells release the anaesthetic drug back into the blood vessels and can therefore reseedate the obese patient. In some obese patients there may be less efficacy of the drug therapy as protein binding drugs may be blocked and the renal elimination of certain drugs is increased due to enlarged kidneys (Casati & Putzu, 2005; Dunn, 2005; Hatfield & Tronson, 2004).

2.5 Measuring Obesity

2.5.1 Body Mass Index

The BMI is the most commonly used assessment tool to measure body fatness and evaluate the risks of morbidity and mortality (MOH, 2009; WHO, 2011). The BMI gives an indication of weight relative to height and is considered in general to be a valid index of adiposity. At a population level, the BMI provides a useful predictor of total body fat and related health risks, which could be used for both genders, and all ages of adults. Other benefits of the BMI include that the relative ease of collecting the data routinely in clinical practice which can then be added to existing databases and contribute to local, national or global health statistics (Han et al., 2006; WHO, 2011).

2.5.2 History of the BMI

In 1832, Adolphe Quetelet (1796-1874), a Flemish scientist and statistician, first developed height and weight tables to study the relationship between the two. Quetelet’s primary interest was in social sciences. His pioneering studies found that based on European body types, the weight generally increases with the square of the height with the exception of the growth spurts after birth and during puberty. The equation used to calculate the index was known as the Quetelet's Index (QI) which was calculated as weight (Kg) divided by height squared (m$^2$) (Bray, 1998; Eknoyan, 2008; Mandel et al., 2004). The QI was initially used to help define the characteristics of “normal man”, fitting the distribution around the norm rather than to assess obesity. Interestingly Florence Nightingale (1820-1910) greatly admired Quetelet’s work and used his statistical methods to support new concepts within nursing care (Ashwell, 2009; Eknoyan, 2008).
In 1972 Ancel Keys renamed the QI as BMI (Eknoyan, 2008). After the 1975 Fogarty Centre Conference, the concept of BMI gradually became an accepted tool to evaluate those who were overweight in both epidemiology studies and in individual case settings. The Metropolitan Life Insurance Company began to publish the BMI table to replace the previously used body frame size tables to assess mortality risks. The BMI equation remains internationally favoured as a tool to quantify obesity and continues to be used globally. Over the past 40 years the BMI has become a useful tool for medical assessments in the clinical setting, government health planning and health insurance companies to help evaluate the risks of morbidity and mortality (Amin et al., 2006; Bray, 1998; Eknoyan, 2008; Flegal, 2007; Han et al., 2006; MOH, 2000; MOH, 2009a; WHO, 2011).

2.5.3 Classification of the BMI

In 1998 the WHO standardised an international classification of underweight, overweight and obese adults according to the BMI (see table one). Primarily the BMI cut off points were devised from data populations of European origin (Eknoyan, 2008; MOH, 2009a; WHO, 2006; WHO, 2011). The WHO (2006) suggested that the BMI be used as an estimated guide as it may not correspond to the same degree of body fat distribution in different individuals. This is significant as the standard BMI cut offs for overweight and obesity may not represent the same level of body fat in the populations that differ significantly from the typical European phenotype (Duncan et al., 2004).

It has been debated for many years that the BMI thresholds should be reclassified by consideration of ethnic populations, change in population height and visceral fat that leads to other risk factors (Duncan et al., 2004; Rush et al., 1998; WHO, 2011). The international debate has focused particularly on BMI cut off points for the Asian and Pacific population (Duncan et al., 2004; Rush et al., 1998; WHO, 2011). This debate will be discussed further in the limitation of BMI cut offs and ethnicity section of this literature review. The WHO convened an expert consultation in Singapore in 2002 to review the BMI cut offs to define risks in the Asian populations and whether population-specific cut-off points for BMI were necessary. It was recommended to include additional cut off points as an international classification to help identify risk in the ethnic population (WHO, 2004).

The scientific evidence from the WHO expert consultation suggested that Asian populations have different correlations between BMI, percentage of body fat, and health risks
than European populations. The recommended BMI cut off point for overweight (≥25) used to indicate the risk of type II diabetes and CVD was lower in the Asian population and the BMI cut-off point for overweight and obesity varied within different Asian populations. The BMI cut-off point for observed risk varied from 22 to 25 and BMI cut-off point for high risk varied from 26 to 31.

Table 1  The international classification of adult underweight, overweight and obesity according to BMI. Sourced: (WHO, 2006b)

<table>
<thead>
<tr>
<th>Classification</th>
<th>Principal cut-off points</th>
<th>Additional cut-off points</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Underweight</strong></td>
<td>&lt; 18.50</td>
<td>&lt; 18.50</td>
</tr>
<tr>
<td>Severe thinness</td>
<td>&lt; 16.00</td>
<td>&lt; 16.00</td>
</tr>
<tr>
<td>Moderate thinness</td>
<td>16.00 - 16.99</td>
<td>16.00 - 16.99</td>
</tr>
<tr>
<td>Mild thinness</td>
<td>17.00 - 18.49</td>
<td>17.00 - 18.49</td>
</tr>
<tr>
<td><strong>Normal range</strong></td>
<td>18.50 - 24.99</td>
<td>18.50 - 22.99</td>
</tr>
<tr>
<td></td>
<td></td>
<td>23.00 - 24.99</td>
</tr>
<tr>
<td><strong>Overweight</strong></td>
<td>≥ 25.00</td>
<td>≥ 25.00</td>
</tr>
<tr>
<td>Pre-obese</td>
<td>25.00 - 29.99</td>
<td>25.00 - 27.49</td>
</tr>
<tr>
<td></td>
<td></td>
<td>27.50 - 29.99</td>
</tr>
<tr>
<td><strong>Obese</strong></td>
<td>≥ 30.00</td>
<td>≥ 30.00</td>
</tr>
<tr>
<td>Obese class I</td>
<td>30.00 - 34.99</td>
<td>30.00 - 32.49</td>
</tr>
<tr>
<td></td>
<td></td>
<td>32.50 - 34.99</td>
</tr>
<tr>
<td>Obese class II</td>
<td>35.00 - 39.99</td>
<td>35.00 - 37.49</td>
</tr>
<tr>
<td></td>
<td></td>
<td>37.50 - 39.99</td>
</tr>
<tr>
<td>Obese class III</td>
<td>≥ 40.00</td>
<td>≥ 40.00</td>
</tr>
</tbody>
</table>

2.5.4  Limitations of BMI as a Health Risk Indicator

The BMI may be a good predictor of total body fat but it has limitations when used as a morbidity and mortality risk indicator. Principally this is due to its inability to distinguish between fat and free fat mass (muscle mass) and visceral fat with its associated health risks at a population level (Duncan et al., 2004; Han et al., 2006; Rush et al., 1998; WHO, 2011).
According to Flier and Maratos-Flier (2005), serious health problems are more strongly linked to intra abdominal and/or upper body fat than the BMI, which measures overall adiposity. There is general agreement that although the BMI assesses the health risks of obesity, it does not differentiate between the over muscled and overweight. Therefore the BMI may hide any differential health consequences associated with fat mass and fat free mass (Ashwell, 2009; Duncan et al., 2004; Fontaine, Redden, Wang, Westfall & Allison, 2003). Ashwell (2009) suggested that it is only a “proxy” for total body fat and does not allow for individual fat distribution.

2.5.5 Limitations of the BMI Assessment Tool

Han et al. (2006) postulated that BMI in a clinical setting is conceptually a complex tool. BMI not only requires measuring height and weight but also requires a chart or calculation and the weighing scales need to be calibrated regularly. For an accurate measurement of an individual’s BMI, subjects should ideally be lightly clothed and shoes off, fasted and with an empty bladder and repeat comparison measures conducted at the same time of day. Duncan et al. (2004) suggested that a BMI cut of point ≥ 25 increased the risk of cardiovascular, metabolic and cancer morbidity and therefore the cut off for obesity should be lowered. Further weaknesses suggested by Han et al. (2006) included less reliability in discriminating health risk when BMI < 30 and potentially confounded variances in ethnic groups due to differences in muscle mass.

2.5.6 Limitation of BMI Cut Offs and Gender

A quantitative study, over a 20 year period, by Mandel et al. (2004) compared the height related changes in BMI of 16,204 females and 19,747 males aged between 20-22 years at the time of their completion of military service in the Israeli Army. The results showed that BMI varied between males and females in relation to height weight variance. In males, the BMI increased as the height increased. Taller men on average tended to be fatter and shorter men leaner. Conversely, in women the BMI decreased with increased height. Taller women on average were inclined to be leaner and short women fatter. Mandel et al. (2004) acknowledged that the results require a degree of circumspection, as excess BMI in tall men may be affected, because of an increase in fat free mass (muscle mass). The decreased BMI in tall women may be due to a decrease in fat free mass. At the opposite end of the height range, the reverse could be said.
The researchers questioned whether the commonly used BMI \( \geq 30 \) cut off to define obesity was applicable for very tall or short people and that the BMI validity of adiposity is limited by its correlation with fat free mass. The study recommended that a BMI cut off of 28.6 in females and 29.1 in males be used as an upper limit for the normal range. The study suggested further research is needed to confirm these values in the general population (Mandel et al., 2004).

2.5.7 Limitation of BMI cut offs and Ethnicity

The WHO (2006c) acknowledges that the association between BMI, percentage of body fat and body fat distribution differ across different ethnic groups, gender and age. The WHO expert consultation on BMI in Asian populations concluded that some Asian populations are at greater risk of CVD and type II diabetes mellitus at the lower BMI cut off point of 25. For some Asian populations the BMI cut off for high risk varies from 26 to 31. According to the current WHO classification of overweight and obesity, health risks can therefore increase in some ethnic populations with a BMI cut off point below 25 (MOH, 2009a; WHO, 2004; WHO 2006c). Mandel et al. (2004) supported this theory in their quantitative study. The study by Mandel et al. (2004) acknowledged that the ethnicity difference between Occidental Jews (of western origin including Europe, the Americas, Australia or South Africa), Oriental Jews (of Asian, Turkish, North African origin) and Israeli-born Jews significantly influenced the BMI cut off points.

The New Zealand 2006 census reported a diverse ethnic population which included Europeans 67.6%, Māori 14.6%, Asians 9.2% and Pacific Peoples 6.9% (Statistic New Zealand, 2006). In the 1997 National Nutrition Survey and the 2002/03 New Zealand Health Survey, the MOH used the WHO ethnic-specific BMI cut-off points to classify overweight and obesity. The BMI cut off point to define overweight for New Zealand Europeans was 25.0 to 29.9. The BMI cut off to define overweight for Māori and Pacific Peoples was 26.0 to 31.9.9. The BMI cut off to define obesity for New Zealand Europeans, Asians and other ethnicity’s was \( \geq 30 \). The BMI cut off for obesity for Māori and Pacific Peoples was \( \geq 32 \) (MOH, 2004). However the 2006/07 New Zealand Health Survey used both waist circumference and BMI recommended by the WHO, to define overweight and obesity (MOH, 2008a). The previously used ethnic-specific BMI cut-off points were not used, although the
survey agreed with Swinburn et al. (1998) that Māori and Pacific Peoples have a lower percentage of body fat than New Zealand European adults based on an equivalent BMI.

The 2006/2007 New Zealand Health Survey found that adopting the WHO international BMI cut-off points for all adults affected results for Māori and Pacific Peoples, but not New Zealand European/Other or Asian adults. The change resulted in a decrease in the percentage of Māori and Pacific Peoples in the normal and overweight categories, and an approximately 11% increase in the number of Māori and Pacific Peoples classified as obese. For adults overall, this change had no impact on the percentage of adults classified as underweight. A slight decrease in the percentage of adults in the normal and overweight categories was observed, and the number of adults classified as obese increased by approximately 2%. (MOH, 2008a).

Duncan et al. (2004) questioned the relevance that the standardised BMI thresholds have for all populations and suggests that the BMI cut off points should be reclassified with consideration of ethnic populations and other risk factors such as waist circumference. They stated that Pacific Peoples tend to have lower levels of body fat than Europeans at a given BMI. In contrast, many Asian ethnic groups have a higher level of body fat than Europeans at a specific BMI which therefore puts them at greater risk of obesity related diseases at relatively low BMI scores. Some studies have suggested that compared to Europeans, Asian adults are more commonly prone to visceral and central obesity. Asian Indians are particularly more predisposed to central obesity than Malay and Chinese Asians (Duncan et al., 2004).

A comparative study by Duncan et al. (2004) discussed the difference between the BMI and the percentage of body fat amongst New Zealand European, Māori, and Pacific Peoples. The study found that Māori and Pacific Peoples were inclined to have a lower percentage of body fat and higher fat free mass (muscle mass). Therefore, Pacific Peoples and Māori adults were leaner than New Zealand Europeans of the same body size at a given BMI. According to Duncan et al. (2004) “Māori and Pacific Peoples have a higher proportion of lean mass to fat mass than New Zealand Europeans at a given BMI, as a population they also maintain a greater total fat mass”. Undeniably, when higher BMI cut offs are applied to Māori and Pacific Peoples to counteract the high lean-to-fat mass ratio of 26 and 32 for overweight and obesity, respectively, these two groups remain two times more likely to be obese than New Zealand Europeans and other population groups.
Consequently the prevalence of type II diabetes mellitus is higher in Māori and Pacific Peoples than Europeans. Further, it is important to note that type II diabetes mellitus amongst New Zealand Indians exceeds that observed in Māori and Pacific Peoples. By 2021 it is predicted that Asians will account for 13% of the New Zealand’s population. In spite of the Asian population growth this ethnic group has been largely neglected by New Zealand health and research policies. To be able to understand the public health needs and to tailor preventative health strategies it is important that future studies make a distinction between the ethnic groups in New Zealand (Duncan et al., 2004).

A study by Rush et al. (1998) compared 42 Caucasian women and 40 Polynesian women aged 18-27 to determine if ethnic differences in body fat estimation were verifiable using three well established equations for determining percentage body fat from waist measurements. First, Rush et al. (1998) used Tran and Weltman’s (1989) equation to measure the body density. Second, Brozek et al.’s (1963) formula was used to calculate the percentage of body fat. Lastly, the total body water was calculated using the multipoint method from urinary concentrations of the oxygen-18 dilation. The findings of the study concluded that assessments of body fat based on waist measurements between the two ethnic groups varied significantly. This suggested that calculations specific to ethnic populations should be used in future studies (Rush et al., 1998).

2.6 Waist circumference

It appears that the measurement of abdominal fat using WC measurement with weight and height measures is more likely to be associated with the risk of CVD and type II diabetes mellitus than BMI alone, which measures both total body fat and muscle mass (Deurenberg & Yap, 1999; Duncan et al., 2004). People with a large waist circumference have an increased risk of compromised health such as diabetes, hypertension, shortness of breath and poor quality of life. These increased risks also apply in people whose BMI is normal but who have a large waist circumference relative to the hips (hip to waist ratio) (Han et al., 2006).

Other techniques such as MRI and bioelectrical impedance may be more accurate assessment tools, however, these can be impractical in the clinical setting due to large population groups, cost and limited simplicity of use (Deurenberg & Yap 1999). It is
interesting to note that a WHO working group is currently reviewing data to evaluate the relationship between WC and morbidity and the interaction between BMI, waist circumference and health risk (WHO, 2006c).

According to Flier and Maratos-Flier (2005) and Deurenberg and Yap (1999), abdominal and intra abdominal subcutaneous fat has more significance in relation to morbidity than subcutaneous fat present in the buttocks and lower extremities. Waist circumference has minimal relevance to height, therefore adjustments for height (waist to height ratio) does not increase its correlation to intra abdominal adipose or poor health (Han et al., 2006; Lean, Han & Morrison, 1995). Waist circumference is potentially a better indicator of abdominal obesity and it has also been suggested that it could be used as part of routine clinical patient assessment as an indicator for CVD and other health risk factors associated with obesity (Dobbelsteyn, Joffres, MacLean & Flowerdew, 2001). Studies agree that WC is a simpler assessment tool, is potentially a better indicator of health risks, and gives a better prediction of visceral and total fat (Dobbelsteyn et al., 2001; Han et al., 2006).

There is conflicting evidence as to whether or not the WC measures are as good an indicator of total body fat as BMI, waist to hip ratio or skin fold thickness method (Deurenberg & Yap 1999; Flier & Maratos-Flier, 2005; Han et al., 2006; Lean et al., 1995). Rush et al.’s (1998) study affirmed that waist measurements provide a simple method for estimation of body fat that can be used over a wide range of percentage body fat. Untrained lay people understand the WC more easily than the waist hip ratio or BMI. Although BMI charts can be useful, the WC is easier to comprehend, as there are no calculations required. Limitations of the WC measurements includes, the cut off points differing between men and women, and the databases are still accumulating, but are not as yet collected as part of approved clinical assessments and health registers (Han et al., 2006).

2.6.1 Standardising Measuring Points for Waist Circumference

While the WHO has accepted an international standard for identifying overweight and obesity in the adult populations using the BMI, the literature largely agrees that currently there is no globally agreed standard measurement of abdominal obesity (Ashwell, 2009; Dobbelsteyn et al., 2001; WHO 2006c). There are two commonly used land mark sites utilised to measure WC for adults and children. The first method recommended by the MOH (2008b) and WHO (2000) defines the natural waist as at the midpoint between the tenth rib
(lowest rib margin) and the iliac crest. The second method is to measure at the umbilicus. Some instructions suggest to measure at the narrowest point of the waist (Ashwell 2009). Ashwell (2009) acknowledged that this can be difficult to do on an obese individual and the umbilicus is the best landmark as it is fixed but not an ideal method. However in practice the author has found that the position of the umbilicus does in fact change especially in the morbidly obese population where the umbilicus is lower than the waist line. Other factors altering the position of the umbilicus include the presence of hernias and patients who have had an apronectomy.

The NHANES III (2007) protocol is commonly used in health research. In order to define the level at which WC is measured, a bony landmark is first located and marked. The subject stands and the examiner, positioned at the right of the subject, palpates the upper hip bone to locate the right iliac crest. Just above the uppermost lateral border of the right iliac crest, a horizontal mark is drawn, then crossed with a vertical mark on the midaxillary line. The measuring tape is placed in a horizontal plane around the abdomen at the level of this marked point on the right side of the trunk. The plane of the tape is parallel to the floor and the tape is snug, but does not compress the skin. The measurement is made at a normal minimal respiration. (See figure 2).

To measure WC, it is universally accepted to ask the subject to remove upper clothing, and not to hold in their stomach. Using a spring loaded tape device and a constant tension reduces potential errors from over keenness in tightening during the measurement (Han et al., 2006; Rush et al., 1998).

![Figure 2 Measuring tape position for waist circumference. (Source: National Heart, Lung, Blood Institute [nhlbi], 1998, p 59).](image)

A study conducted by Kagawa, Byrne & Hills (2008), on Australian adults compared waist to height ratio using different sites for waist measurements. In order to standardise the
waist measurement protocol the study examined which waist site was “superior” to the other. This was a small study of 95 male and 121 female university students with an average age of 20 years. The majority of the participants were defined as Caucasian and a cross section of ethnic groups was a limitation in the study. A control measurement using Dual-Energy X-ray Absorption (DEXA) was taken to measure the trunk fat deposition of all the volunteers prior to the WHR measurements. The researchers chose DEXA to measure trunk fat in preference to VAT measured by CT or MRI due to cost and convenience. Trunk fat is also associated with a number of metabolic markers and cholesterol indicating its usefulness in assessing risk of obesity-related metabolic complication associated with abdominal obesity.

Three circumferences were measured; waist circumference, abdominal circumference (AC), and hip circumference. The height and weight was used to calculate the BMI. The WC was measured at the narrowest point between the lowest rib and the top of the iliac crest. Abdominal circumference was measured at the level of the umbilicus and hip circumference was measured at the greatest posterior protuberance. BMI and WHR using WC (WHR-W) and AC (WHR-A) were calculated. Using Spearman’s correlation coefficients the relationship between the different waist values was considered. The results are discussed below.

The study criteria included overweight or obese participants who were not taking medication or had no medical history that influenced their daily lifestyle. The study did not give a definition of “healthy” and no baseline biophysical measures were included. Because it is well known that overweight and obesity is associated with health problems, this may suggest that there is a contradiction in the criteria defining healthy for obese or overweight individuals. The study did not clarify the definition of overweight or obese. The data collected showed that the BMI for men ranged from 19.9-36.1 and for females 17.7-39.8. This gives some indication of the range of normal to overweight to obesity using a standardised BMI cut off (Kagawa et al., 2008).

Although males showed greater BMI, WC and AC, females presented with significantly greater body fat deposition. Females showed a greater difference between the two circumferences (6.6cm) compared with males (3.0cm) (p < 0.01). Males displayed significantly greater WHR compared to females (p < 0.01) but no gender difference with BMI or WHR-A was observed. The study showed that WHR, using different waist definitions, correlated highly with percentage of body fat in both genders (r = .730-.821). The WHR and
umbilical measurement indicated a greater fat sensitivity and also increased the sensitivity of indentifying potential health risk in individuals compared with WHR using the narrowest circumference. Kagawa et al.’s (2008) study concluded that AC may be a better measurement to calculate WHR for early health assessments in Australian adults.

The study suggested that the WHR can be used to screen the general population across a wide age range using the same cut off point (0.5). BMI needs to consider different cut off points according to age. The WHR is a more “fat sensitive index” compared with that of BMI and has the potential to reduce misclassification of individuals as has been reported for BMI. The study showed that both BMI and WHR have comparable associations with percentage of total body fat in both genders. The authors acknowledged the ethnic group limitation in their study and suggested that this should be included in future studies to compare their findings (Kagawa et al., 2008).

2.6.2 Standardising Waist Circumference Cut Off Points.

Dobbelsteyn et al. (2001) suggested that WC cut off points for men should be 90cm and for women 80cm. Two reasons for this suggestion were proposed. Firstly that they were simple numbers to remember especially if used in the community and in the clinical setting. Secondly, using ROC analysis, the cut off points used in the study were the most predictive of two or more risk factors (including CVD), which fell into the middle of the range in terms of risk factor prevalence.

The authors proposed that by adjusting the WC cut off points by 10cm (depending on age and risk factors), individuals could potentially be at risk but fall below the standardised WC cut off points. They further suggested that the base values could be adjusted 2cm down for every 10 years in age < 35 years and 2cm up for every 10 years in age > 45 years. (Dobbelsteyn et al., 2001). The study contradicted its earlier claims on the simplicity of use. The suggested adjustment to base measurement according to age changed simple WC cut off points into a time consuming and complicated formula that may not be so user friendly in the clinical setting. The study recommended that further studies be undertaken to determine population specific cut-off points for WC and appropriate guidelines should be developed. The majority of the participants in the Dobbelsteyn et al. (2001) study were Caucasian and therefore comparisons to ethnic diversity in the population and their specific cut off points were not made.
Flegal’s (2007) comparison study described the frequency distribution of WC between healthy and unhealthy male and females in the USA. Participants were recruited via the national health and nutrition examination survey conducted between 1988-1994. The cohort included 7772 males and 8513 non pregnant females. However missing values for waist circumference and biophysical measures reduced the sample size to 7041 males and 7612 females. Data were collected through home interviews and medical examination. The medical examination included comprehensive biophysical measurements of blood pressure measurements and blood tests to define hypertension, diabetes and cholesterol levels. Participants were divided into one of five categories of health levels. The best health level was set at 5 and the lowest health level at 0. The researchers used gender specific cut offs of 102cm for males and 88cm for females using the national heart, lung, blood institute (NHLBI) guidelines.

The findings of Flegal’s (2007) study confirmed that WC measured for the healthy study participants corresponded with the NHLBI closely to the 95th percentile. This suggested that only a small number of healthy people had WC values above the gender specific cut off points. The predictive values suggested that the healthier the individual, the more chance of the WC measurement was below the gender specific cut off. The WC values were much higher for women than for men, with more than half the woman in the older age groups having WC > 88cm. Most of the participants who had a WC above the cut off point also fell into the unhealthy level. However there were a small number of participants who fell into the unhealthy category also fell below the gender specific cut off. This suggested that there was an overlap of WC values between healthy and unhealthy people and that the overlap could potentially provide misleading health risk factors.

2.6.3 Waist to Hip ratio

Waist hip ratio (WHR) was established initially as part of a Swedish research project (Lissner et al., 2001). The hypothesis purported that WHR was better at predicting fat disruption than using waist circumference alone and that there is a relationship between larger hip circumference and increased health risks. However Lissner et al. (2001) found that in fact the larger hip circumference was found to be linked with lower risks of diabetes and coronary heart disease. This could be because hip circumference indicates muscle mass, which is reduced in type II diabetes mellitus and a sedentary life style (Han et al., 2006). A distinction
between normal and abnormal waist hip ratio can most easily be made by determining an abnormal ratio for women > 0.9 and for men > 1.0 (Flier & Maratos-Flier, 2005).

A quantitative study by Han et al. (2006) agreed with Flier and Maratos-Flier (2005) that the waist hip ratio may be the best predictor of health risks for all ethnic groups, in particular cardiovascular risks. Franzosi’s (2006) study stated that the key metabolic factor that contributes to cardiovascular risk is the measurement of visceral fat, which cannot be assessed by the BMI. Flier and Maratos-Flier (2005) and Franzosi (2006) agreed that although individuals may have the same BMI they could have a difference in the percentage of fat and lean body mass, a factor that could also be an indicator of cardiovascular risks. Cardiovascular mortality in women may be seen with BMI as low as 25 (Flier & Maratos-Flier, 2005).

Ashwell (2009) proposed a new way of defining body shape by using the Ashwell Shape Chart® and calculator to assess central fat distribution and its use to assess health risks of obesity. BMI measures total body fat whereas WHR measures fat distribution, which is more closely associated with central obesity and health risks. Ashwell has simplified the fat distribution of WHR calculation by the Ashwell Shape Chart® and reclassified the classic pear and apple shapes to: chilli-pear, pear-apple or apple. The chart, similar to that of a BMI chart, uses waist and height measurements as opposed to weight and height. The data is entered into the Ashwell shape calculator. The calculator identifies body shape categories and gives health advice according to the body shape. Although a relatively new concept, the Ashwell shape chart® and calculator has the potential to be used as a user-friendly guide not only in the primary health sector but also in the clinical hospital setting (Ashwell, 2009). However more research needs to be undertaken to evaluate the uses and effectiveness of this method.

2.7 Comparison Studies:

2.7.1 Comparing Waist Circumference with BMI to estimate the amount of adipose tissue.

A comparison study by Oka et al. (2009) compared WC with BMI to estimate the amount of adipose tissue. This included visceral adipose tissue fat (VAT), subcutaneous tissue fat
(SAT) and total adipose tissue fat (TAT). A computed tomography (CT) scan was used as a control measurement of VAT and SAT. The study was medically funded and participants were recruited during routine medical check ups provided to all public school workers, which was funded by the various public servant associations. A total of 2,470 healthy Japanese adults aged 38-60 years (1,432 male and 1,038 female) volunteered for the study. Almost all (98%) were teachers, of whom 58% were post menopausal women. Forty one participants were excluded, the reasons for the exclusion were unclear. What is interesting about this study is that all the participants were defined as healthy, yet 22% of males and 2.7% females were smokers, 3.4% males and 0.9% females were taking medication for diabetes, 13.8% males and 11.2% females were taking medication for high blood pressure. The study did not provide a definition of “healthy” and baseline biophysical measures were not included (Oka et al., 2009).

While the results showed no difference between WC and BMI to estimate the amount of VAT, SAT and TAT in women, but men there was a significant association between WC and BMI for VAT in men (p < 0.05). The study found both SAT and VAT and age were positively associated (p < 0.001). The results found that women had a steady increase of VAT with age, pre and post menopause, more so than SAT (p < 0.05). This could be because the body shape of postmenopausal woman changes due to the change in the distribution of body fat. Men had a steady increase of SAT with age more so than VAT (p < 0.05).

The results should be regarded with circumspection due to the limitations of the study. The research results were difficult to interpret and data were found to be omitted in the article. Oka et al. (2009) acknowledged that having more men in the study could lead to bias and was more likely to reach a statistical significance. There is potential that either WC or BMI can be used as a measurement for adipose tissue the advantage is less expensive than CT scan, however, there has to be an uniformed formula or model to measure WC. Furthermore a definition of “healthy” needs to be determined using a wider cross section of age with a community based sample.

2.7.2 Using BMI, WC and WHR in predicting health outcomes in the older person population

Some studies suggest that although the best possible values of the WC are age dependant, there is no ideal single cut off point for age and for the various cardiovascular risks. Visceral
obesity contributes to abdominal adiposity and metabolic diseases such as type II diabetes mellitus and coronary heart disease (CHD). It has been suggested that the younger population may have less amounts of visceral adipose tissue than older people and therefore higher cut off points for a younger age group may need to be considered (Depress, Prud’homme, Pouliot, Tremblay, Bouchard, 1991; Dobbelsteyn et al., 2001; Han, Van Leer, Seidell & Lean, 1996; Lemieux, Prud’homme, Bouchard, Tremblay & Depress, 1996). Menopause is suggested to contribute to the increase in abdominal adipose tissue in women. A study found that the body fat composition of women remained unchanged until reaching the age of 60 years when there appears to be a change in the body fat distribution (Enzi et al., 1986; Oka et al., 2009).

Woo, Ho, Yu & Sham (2002) examined the effect of age on the relationship between BMI and WC and the usefulness of BMI, WC and WHR in predicting three outcomes in the elderly population; mortality, diabetes and hypertension. This was a Chinese longitudinal observational study conducted over 36 months used a cohort of 2,032 males and females with a mean age of 80.1 years. Baseline data were gathered through interviews and medical examination and then followed up at 36 months. Data from a younger age group of 1,010 cohort with a mean age of 45.5 years were used to compare the BMI and WC relationship between younger and older participants. Waist circumference measurements were taken from the smallest circumference between the umbilicus and xiphoid process and was measured to the nearest 0.5cm. Hip circumference was measured as the largest circumference around the buttocks and symphysis pubis to the nearest 0.5cm (Woo et al., 2002).

Woo et al. (2002) concluded that WC is the best indicator to measure abdominal adipose tissue and suggested that age, gender and ethnic differences also influenced the cut off values and the predictive power of WC as a risk indicator. The study acknowledged that waist and hip circumferences measure different aspects of body composition. Fat distribution had independent and opposite effects on cardiovascular risk factors. The relationship between BMI and WC and mortality was conflicting and no association between WHR and mortality was observed. The BMI and WC was positively associated with diabetes in males but not in females. Waist circumference was positively associated with hypertension in both men and females. The WHR was not associated with any outcomes. Waist Circumference appeared to be the best indicator for VAT but not so much for metabolic risk factors influenced by age, gender and ethnicity (Woo et al., 2002).
2.7.3 BMI versus WC as health assessment tools for non fatal health conditions

Turley, Tobias and Paul (2006) studied the relationship between BMI and WC and selected non fatal health conditions. A complex cluster sample design was used on an area based sampling frame. A response rate of 72% included 10,026 randomly selected adults aged 25 years and over. Data were obtained from the 2002/2003 New Zealand health survey. Participants were classified according to measured BMI and WC. BMI classes were divided into four classes depending on the cut off point. See table two.

Table 2 Classification of measurement of obesity classes

<table>
<thead>
<tr>
<th>Anthropometric Measurement</th>
<th>Class I</th>
<th>Class II</th>
<th>Class III</th>
<th>Class IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI</td>
<td>18.5-24.9,</td>
<td>25.0-29.9,</td>
<td>30-34.9,</td>
<td>&gt;35.0</td>
</tr>
<tr>
<td>WC Men</td>
<td>&lt; 94</td>
<td>94-102</td>
<td>&gt;102 cm</td>
<td></td>
</tr>
<tr>
<td>WC Women</td>
<td>&lt; 80</td>
<td>80-88</td>
<td>&gt;88 cm</td>
<td></td>
</tr>
</tbody>
</table>

(Adapted from Turley, Tobias and Paul, 2006).

Adjustments were made using logistic regression for age, ethnicity, socio-economic factors using the New Zealand Index of Deprivation 2001. Diet and the amount of physical activity were not included as these risk factors were primarily causes rather than outcomes of high BMI and/or WC. The findings showed an association with BMI and WC and the increasing prevalence rate ratios for CVD, type II diabetes mellitus, high blood pressure, high cholesterol, OA, asthma and sleep disorders for both genders. The higher classes of BMI (BMI ≥ 35.0) and WC (WC class >102 male, >88cm female) were three and a half times more likely to have diabetes (all p < 0.05) and two to three times more likely to have high blood pressure (all p < 0.05) compared to those in the lower classes (Turley et al., 2006). The results of the BMI and WC and associated health conditions in the study is provided as a breakdown in the following health risk groups; depression, smoking, CVD, type II diabetes mellitus, OA, asthma, sleep disorder and cut off points.

**Depression**

There was no significant association with depression for either BMI or WC.

**Smokers.**

Male smokers were less likely to have an elevated BMI or WC than non smokers however this association was not evident amongst women.
Cardiovascular disease
The correlation between BMI and CVD was statistically significant in BMI class III for men and BMI class II and IV for women. The association with WC and CVD was only seen in males in WC class III. Elevated BMI and WC were similarly and robustly associated with high blood pressure and raised cholesterol levels.

Diabetes
Diabetes was associated with BMI in men in class III (seven times more likely than men in class I) and IV and class IV for women. Compared to WC and diabetes men and women were equally strongly associated with WC class III. With both gender 4-5 times more likely to have diabetes then both genders in class I.

Osteoarthritis
Osteoarthritis (OA) was three times more likely in men with BMI class IV than class I however this correlation was only half as strong in women. There was no significance with OA and WC among women although this was significant in men.

Asthma
For asthma the significance in men aged 25-44 years in the BMI class IV were 70-80% more likely to have asthma. In women this was up to 50%. Compared to WC men and women in the highest class of WC who were 60 % more likely to have asthma.

Sleep disorder
Sleep disorders were 100% prevalent for men and 40 % for women with elevated BMI. There was no significance associated with WC for either men or women.

Cut off points
The results found that there was a stronger association with BMI and health risk factors than WC. However the study suggested that this may be associated with the categorised cut off points and that the interpretation of the two anthropometric measurements and the robust correlation with health risk factors should not be over analysed. Turley et al. (2006) agrees that this does not necessarily mean that BMI is a better predictor of health risks than WC. Both WC and BMI are moderately to strongly associated with each other and both may be useful in measuring body fat in future population based surveys. It was also suggested that if WC is to replace BMI then the current cut off points may need to be more accurately classified.
2.7.4 BMI versus WC and WHR as health assessment tools for cardiovascular disease

A comparative cross sectional Canadian study by Dobbelsteyn et al. (2001) evaluated the cut off points of WC, BMI and WHR ratio used as predictors of CVD. A total of 9,913 males and females aged 18-74 years, participated in a home interview and a clinic visit. The survey response rate was 78%. Data collected included physical activity, smoking, diabetes, fasting blood samples and hypertension. Blood pressure was taken at the beginning and end of the interview and repeated twice in subsequent clinic visits. Anthropometric measurements were taken in the morning following a 12 hour fast.

The study found that although WHR appeared to be a better screening tool for cardiovascular risk factors than BMI, there was no significant difference between WC and WHR. The WC cut off points were consistently more accurate in predicting all considered risk factors compared to BMI cut off points (Dobbelsteyn et al., 2001). The WC had several advantages over both BMI and WHR. One of which was the simplicity of the use of a tape measure and interpretation of the WC in the clinical setting. Dietitians use WC as it is an easy tool for patients to observe a change in weight loss (New Zealand Heart Foundation, 2007). The flaw found with the WHR was the biological interpretation. The formula used to determine this value means that both lean and morbidly obese individuals may end up having the same WHR. The study found that for both men and women who were smokers, the mean WC and BMI across the age groups was lower than that of WHR, which had a slightly higher mean. This study could be used to strengthen the argument that WC has potential in both the community and clinical setting as a simple assessment tool and could be an effective predictor of CVD and type II diabetes mellitus.

Data gathered from the British National Diet and Nutrition Survey 2000-2001 compared BMI, WC and WHR as central fat distribution and the association with cardiovascular risk factors (Ashwell & Gibson, 2009). A cut off value of WHR > 0.5 was used to define central obesity. Their findings showed that 35% of men and 14% of women who were within the normal BMI range (18.5-25) also had WHR > 0.5 suggesting that cardiovascular health risk factors could have been missed if relying on BMI alone. Ashwell and Gibson (2009) suggested that by using BMI alone as a CVD health risk assessment in the total population, 17% of all men and 6% of all women could potentially have been insufficiently assessed. What follows next is an overview of how BMI and WC is applied in the clinical practice of the author’s hospital.
2.8 Applying BMI and WC to Clinical Practice.

During 2006/2007, a physiotherapy screening trial for the Canterbury CDHB elective primary hip and knee replacement patient group identified a number of areas where early intervention could improve the patient’s medical and surgical outcomes. The key areas for concern identified were:

Impact of high BMI on surgical outcomes and the anaesthetic risk.
Risk of fall.
Sedentary lifestyles due to inability to exercise- causing further medical complication and co-morbidities while the patient was on the wait list.
Limited ability to assess patients occupational therapy needs in the home setting i.e. aids at home.

(CDHB, 2007-08) (p2).

The screening trial identified that 78% of the 732 patient cohort were classified as overweight, with a BMI 25-30, 57% were obese with a BMI 30-40 and 7% were morbidly obese with a BMI > 40. The trial supported other studies that have identified the risk obesity and orthopaedic surgery has an impact on potential surgical complications, anaesthetic risks and effect on joint replacement prosthetics (Amin et al., 2006; Naylor, Harmer & Heard, 2008). The literature also supports the findings of the physiotherapy screening trials that joint replacements do not perform so well postoperatively in patients with a high BMI (Amin et al., 2006; CDHB, 2008). A comparative study reports that obese and morbidly obese patients who believe their inactive lifestyle is a result of having osteoarthritis and who receive joint replacements do not necessarily lose weight after surgery. Improved health outcomes are in fact better achieved from weight loss prior to surgery (Amin, et al., 2006; personal communication, Dr R Seigne, 2007).

In 2007, a new initiative was introduced at a primary centre specialising in elective orthopaedic surgery Christchurch, to assess obesity for patients requiring primary knee or hip joint replacement surgery. A designated hospital weight loss program was offered to patients who do not meet the recommended fitness for surgery criteria. Following a trial of various care models, the Nurse Led Anaesthetic Supported Preadmission (NLASP) model was chosen. Patients referred by their GP are assessed in a pre admission clinic by physiotherapists and nurses. Recommended guidelines outlined by the surgical service and a
validation scoring system using the BMI, help to assess the patients suitability for surgery. These are shown in table three.

**Table 3 Recommended Guidelines for Primary Hip and Knee Replacement**

<table>
<thead>
<tr>
<th>BMI &lt; 30</th>
<th>The surgery proceeds unless there are other contraindications.</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI 35-40</td>
<td>The surgery proceeds at the discretion of the surgeon and or anaesthetist.</td>
</tr>
<tr>
<td>BMI &gt; 40</td>
<td>The surgery is postponed, patient referred to GP managed care, hospital dietitian for weight loss management and review of patient when the patient meets the hospitals ideal BMI range of &lt; 40.</td>
</tr>
</tbody>
</table>

(CDHB, 2007-08, p.5)

Nurses in the preadmission clinic and the admitting unit have the important task of implementing physical assessments to evaluate fitness for surgery along with educating and promoting healthy living for those not eligible for surgery. Having an effective physical assessment tool relevant to today’s society is vital in making the important clinical judgments of patients’ health status and potential postoperative risks.

**2.9 Summary**

It is widely accepted that obesity is an increasing worldwide epidemic health problem that leads to major health consequences such as CVD and type II diabetes mellitus (Amin et al., 2006; Flier & Maratos-Flier, 2005; MOH, 2009a; Von Haehling, et al., 2007; WHO, 2006a). Obesity contributes to the cost of health care treatment for osteoarthritis, heart disease, hypertension, type II diabetes mellitus, asthma, some cancers and is associated with increased risk of postoperative complications. Having an effective pre-surgery health assessment tool to assess excessive body fat is vital in making important clinical judgments and to identify potential postoperative risks.

Although the BMI cut offs used to identify those who are overweight or obese are based on European body types formulated from Quetelet’s equation of the 1800’s, the BMI is the most commonly used assessment tool to evaluate the risks of morbidity and mortality today (MOH, 2009a; WHO, 2006a). Over the last 40 years the BMI has been adopted for health
insurance assessment and a medical assessment in the clinical setting as well as for government health planning (Bray, 1998; MOH, 2000; MOH, 2009a).

The literature acknowledges that there are limitations to the BMI when used as a morbidity and mortality risk indicator due to its inability to distinguish between fat and free fat mass (muscle mass) and visceral fat with its associated health risks at a population level. It has been debated for many years whether the BMI cut off points should be reclassified by consideration of ethnic populations, change in population height and visceral fat that leads to other risk factors. The international debate has focused particularly on BMI cut off points for Asian and Pacific Peoples (Duncan et al., 2004; Rush et al., 1998; WHO, 2006c).

Mandel et al. (2004) suggested that validity of BMI to measure total body fat is limited by its correlation with fat free. The study found that the relationship between height and weight and the BMI had an opposite affect for men and women. In the study tall men had a greater BMI than tall women which suggested men had an increase in fat free mass and women had a decrease in fat free mass. However at the opposite end of the height range the reverse could be said. Mandel et al. (2004) purported that the current BMI ≥ 30 cut off to define obesity has limitations for very tall or short people and that the BMI cut off to define obesity be lowered to ≥ 28.6 for women and ≥ 29.1 for men. As there is a lack of research literature in this area, it was not possible to make comparisons for this pilot study.

Waist circumference has been suggested as a better indicator of abdominal obesity because of its direct correlation to health risks including CVD and type II diabetes mellitus and the simplicity of the tool which can be used easily in the clinical setting and is easily understood by untrained lay people (Deurenberg & Yap, 1999; Dobbelsteyn, et al., 2001; Duncan, et al., 2004). It is interesting to note that that new research is in progress for example, the WHO working group. The WHO working group is currently reviewing data to evaluate the relationship between WC and morbidity and the interaction between BMI, WC and health risks (WHO, 2006c). This indicates that the use of BMI to measure obesity is becoming a focus of attention both clinically and within research. The inconclusive evidence suggests that further research is required to explore the association between BMI, WC, morbidity and associated health risks and its potential benefits for the planning of future health care.
In the author’s clinical area a pre-surgery assessment initiative to improve the patient’s journey used two different tools. These included the WC measurement and the BMI. Interest in the research question was generated from clinical experience and concerns about the validity of the BMI assessment and what is the most reliable anthropometric measurement of obesity as a prerequisite for other elective orthopaedic surgery. This concern is also reflected in the research literature reviewed for this pilot study. The aim and objectives of the pilot study are supported by the literature review and are therefore reiterated here to help underpin the research question. The next chapter presents the methods that were used for the pilot study.

2.10 Aim and Objectives

Aim
The pilot study aimed to explore which anthropometric (BMI or WC) measurement tool is best able to effectively indicate the risk of potential post-operative complications of elective joint replacement patients.

Research Question:
Which anthropometric (BMI or WC) measurement tool is best able to effectively indicate potential post-operative complications?

Objectives:
- To consider the difference between BMI and WC as an effective risk indicator tools to aid in identifying potential post-operative complications for patients who receive elective joint replacement surgery
- To consider if there is an association between the BMI and WC and the parameters for overweight and obesity.
3 Methods

3.1 Introduction

A background to the pilot study has been provided in chapter one. This chapter will outline the process undertaken to explore two routinely used anthropometric measurement tools (BMI and WC) at a primary care centre specialising in elective orthopaedic surgery. The patients are initially assessed at the preadmission clinic and by physiotherapists and nurses where the BMI is measured. On the day of admission for surgery, nurses reassess the patients’ BMI prior to surgery. The BMI is used by the multi disciplinary team, as a tool to assess suitability for surgery (see table 3, section 2.8). A BMI wheel is currently used by nurses to calculate the BMI.

The methods chapter will first outline the study design of the pilot study and provide the recruitment process including an inclusion and exclusion criteria. The details of the pre-test and ethical consideration will be presented. The variables and measures used in the pilot study will be presented in three sections. First, the baseline demographic, clinical, and anthropometric variables. Second, the independent variables (BMI and WC measurements) and third, the dependant variables provide the potential postoperative outcomes that could be associated with obesity.

3.2 Study design:

Quantitative research uses scientific methods to systematically investigate a phenomena or test a hypothesis. Findings of quantitative research are based on empirical evidence through objective reality through sight, hearing, taste, touch or smell rather than personal beliefs of the researcher or human experiences as sought in qualitative research (Polit & Beck, 2004). Quantitative research is effectively and commonly used by nurse researchers to examine and analyse a variety of problems (Polit & Beck, 2006).

This study is best described as a prospective observational design sometimes referred to as non- experimental or prospective cohort design. A prospective design starts with a presumed cause and then goes forward in time to the presumed effect. This fits with this study with the presumed cause being obesity defined by the BMI and WC cut off points and the presumed
effect being the postoperative complications (Polit & Beck, 2004). The same research participants were used to compare the effectiveness of each anthropometric measure as a risk indicator of post operative complications. The selected cohort served as their own control thus making this a within-subject comparison design. (Polit & Beck, 2004).

This pilot study is a repeated measures quantitative pilot study to explore if two different anthropometric measures routinely used in a clinical setting prior to surgery have any better utility than each other in predicting the risk of immediate postoperative outcomes. Due to the recruitment numbers required and the time restraints to meet thesis requirements, the study is a pilot study with potential for further research. The definition of a pilot study is described as “a small scale version or a trial run of a major study” (Polit & Beck, p727, 2004). This definition appears to aptly describe this research project. As a result of the small participant numbers and multiple variables, the pilot study was unable to conduct inferential statistical analysis to test the research question. The demographic characteristics, and data collected on variables of interest undertook descriptive analysis using the Statistical Package Social Sciences (SPSS) for Windows software computer package (SPSS, 2010). Descriptive statistics looked at individual characteristics of the variables which included frequency, mean, standard deviation and central tendency were appropriate.

### 3.3 Ethics

Approval was sought by the Upper South A Regional Ethics Committee (appendix A), Board of Graduate Studies in Health Sciences University of Otago, Director of Nursing (see appendix B) and the Surgical Services Nurse Manager (Health Research Council of New Zealand [HRCNZ], 2005). After consultation, approval and support for this study was obtained from the University of Otago Māori Research Manager (appendix C). Cultural safety was maintained through consultation with the Ranga Hauora Services (appendix D) and ensured the research kept within the principals of the Treaty of Waitangi and the Health Research Council of New Zealand guidelines on ethics in health research (HRCNZ 2005) and HRCNZ guidelines for researchers on health, research involving Māori (HRCNZ 2008).

Ethical consideration is vital in nursing research when the study participants are humans. Ethical principles ensure that research procedures follow professional, legal and social responsibility to the study participants. The major ethical principles include beneficence, respect for human dignity, justice and informed consent (Polit & Beck, 2004).
The first principle of beneficence involves protecting the participant from either physical or psychological harm or exploitation and maximise potential benefits for the study participants (Polit & Beck, 2004). An information sheet was provided to the participants in the pilot study about the two types of physical measurements required and how they were to be measured and the benefits of the pilot study (appendix E). The measurements were non-invasive and were conducted by nurses who were trained though a competency teaching package and therefore ensured that the participants were not at risk of the risk of physical or psychological harm as a result of the pilot study.

The second principle respect for human dignity requires the participants “right to self determination” (Polit & Beck, p727, 2004). This means that participants have the free will to choose whether they wish to participate voluntarily in a study without penalty or prejudicial treatment. Participants have the right to ask questions and the right to decline to provide information or to withdraw from the study at any time. The recruitment of participants for the pilot study ensured that the consent form provided information that participation was entirely voluntary (appendix F). Participants received both written information on the consent form and were verbally informed on the day of surgery that they were free to withdraw from the pilot study at any time. Participation or withdrawal from the pilot study would not affect their continuing health care. Participants were invited to discuss any questions about the pilot study with the researcher. Some participants phoned the researcher with their question and others had their question answered on the day of surgery. Participants were given the option of whether or not they would like to receive a copy of the completed research document.

Justice, the third principle, ensures that the participants receives the right to fair treatment during both the selection and participation of the research the right to privacy and the right to anonymity and confidentiality (Polit & Beck, 2004). Perioperative care and the delivery of standard care was unaffected by the bio physical measurements obtained in the pilot study. To maintain privacy the bio physical measurements were conducted in a private consultation room with a registered nurse. As part of the normal admission process the patient was required to wear a hospital gown, therefore maintaining the usual standard practice. To ensure anonymity and confidentiality the patient clinical notes were obtained on site and within the secure environment of the hospital. Coded identifiers replaced patient identification including the data collection and analysis.
Obtaining informed consent from the participant requires the researchers to provide sufficient information regarding the research. The participant needs to be capable of understanding the potential risks and benefits of participating in the study and that consenting or declining participation is voluntary (Polit & Beck, 2004). For this pilot study participants who met the inclusion criteria received study invitations within six weeks of their preadmission clinic appointment to allow time to consider participation in the research prior to their day of surgery. All participants were provided with written information (see appendix E) about the pilot study and a study consent form with sufficient time for consideration (appendix F).

3.4 Participant recruitment:

Participants were selected from the elective orthopaedic patient waiting list for joint replacement surgery during 2009/2010. The study aimed to recruit 150 participants scheduled for surgery. Data were collected at three points: (1) Pre admission; (2) twenty four hours post surgery; (3) during the subsequent hospital stay on the surgical ward prior to discharge. Figure three provides a summary of the recruitment process. An inclusion criteria for the study was used to define the population eligible to participate in the research. This is shown in Table four.

Table 4: Inclusion and Exclusion Criteria

<table>
<thead>
<tr>
<th>Inclusion Criteria</th>
<th>Exclusion Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 years and over</td>
<td>Those who cannot freely give consent due to language or mental capacity</td>
</tr>
<tr>
<td>Male or Female</td>
<td>Day case surgery</td>
</tr>
<tr>
<td>Inpatients receiving elective Knee, Hip,</td>
<td>Inpatient, Non joint replacement orthopaedic surgery</td>
</tr>
<tr>
<td>Shoulder, Ankle joint replacement surgery</td>
<td></td>
</tr>
<tr>
<td>All ethnic groups</td>
<td>ACC patients</td>
</tr>
</tbody>
</table>

Over a 4 month period (December 2008 - March 2009) the Canterbury District Health Board (CDHB) waiting list department sent 150 study invitations to all patients waiting to have major joint replacement surgery within six weeks of their NLASP preadmission clinic appointment. To help identify participants in the study, patients were asked to bring with them, their consent form to the admitting unit on the day of surgery. A yellow consent form
was also used to assist staff in identifying participants in the study. An additional benefit of using the colour yellow is that it would stand out from the usual clinical notepaper.

**Figure: 3 Recruitment process**

- **Secretaries in the CDHB waiting list department** sent study invitations & consent forms to patients on the elective orthopaedic patient waiting list for joint replacement surgery.

- **Participants who met the inclusion criteria** received study invitations within 6 weeks of their preadmission clinic appointment.

- **Participants either:**
  1. Presented the study consent form at the NLASP preadmission clinic. Nursing staff filed the consents in the patient’s clinical records.
  2. Presented the study consent form to nursing staff on the day of admission for surgery.

- **Participants admitted for surgery within 6 weeks to 6 months after attending preadmission clinic**.

- **Admitting Unit: On day of surgery:**

  Consent forms photocopied. Original consent returned to patient & copy placed in confidential data collection box. Waist measurements taken & recorded in patient notes.

- **Data were collected retrospectively at three points:**
  1. On day of admission, pre surgery.
  2. Within 24 hours post surgery (PACU/SCU).
  3. After 24 hours during the subsequent hospital stay (SOU) to discharge.

- **December 2008-March 2009**
  - 150 study invitations sent. Recruitment slowed and a further 200 consents sent.

- **Preadmission nursing staff filed the consents in the patient’s clinical records. Nurses in the AU were unaware of this. Problem addressed & process improved**.
3.5 Pre-test

During the pre-test stage of the pilot study, some minor changes were made to the data collection process. In the initial data collection period, participants brought in the yellow consent forms on the day of admission to hospital. However after three months recruitment this had slowed down. It was discovered that participants were presenting the consent form at the NLASP preadmission clinic and nursing staff had filed the consent forms in the patient’s clinical records. Because of this, nursing staff in the admitting unit were not aware that consent forms had been filed in the clinical notes and were unable to identify participants for the study. After consultation with nursing staff it was agreed that staff in the NLASP preadmission clinic would continue to file the consent forms but they would be filed in the front of the notes clearly visible for the admitting unit nursing staff. Posters about the study for patients were placed on the walls of the admitting unit to remind staff of the study and to encourage patients to identify themselves if they were part of the study.

It was discovered that the system to return the consent form to the patient was not successful during the pre-test stage. Initially the surgical unit ward clerk was responsible for returning the yellow consent copy to the patient via the hospital discharge pack. A photocopy of the consent form was to be placed in a yellow confidential collection box for the researcher to collect. This system did not work well, and therefore the confidential collection box was relocated to the AU where the nurses returned the yellow copy directly to the participant prior to the waist measurement procedure and placed the photocopied consent form into the confidential collection box.

It was also discovered that in March 2009, the waiting list secretary had 50 remaining study invitations and consents that had not been sent. Once this was realised the remaining consents were subsequently sent out to patients by the waiting list secretary that same month. All nursing staff within the surgical services including the outpatients department, admitting unit, PACU and the ward were consulted regularly for feedback on the process. The researcher provided education and updates on the research project informally and through monthly staff meetings. Posters were used as a resource to inform and educate staff and patients.
3.6 Variables and Measures

Baseline demographic, clinical, and anthropometric variables, were measured on the day of admission by nursing staff. The biophysiological measures in this study were WC measurements, height and weight measurements. The independent variables were the BMI and WC measurements. The dependant variables were the potential postoperative outcomes that could be associated with obesity. Data were collated by the researcher from the clinical notes at three collection points. These were on the day of admission in the AU, within 24 hours post operative, and within the patients subsequent hospital stay on the surgical ward.

3.6.1 Baseline measures

3.6.1.1 Anthropometric measures

Waist measurements were standardised through a competency teaching package for all AU nursing staff prior to the study (appendix G). The New Zealand Dietetic Association guidelines for WC measurements, in accordance with the New Zealand guidelines for waist measurements (see appendix A) and as used by the hospital dietitian was chosen for this pilot study (MOH, 2009b; The Heart Foundation of New Zealand, 2007). Table five provides the New Zealand Dietetic Association guidelines for waist circumference measurements used in this study.

<table>
<thead>
<tr>
<th>Maximum Acceptable Waist Circumference in Different Adult Ethnic Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category</td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>New Zealand European People</td>
</tr>
<tr>
<td>Pacific Island and Maori People</td>
</tr>
<tr>
<td>Asian and Indian People</td>
</tr>
</tbody>
</table>

(The Heart Foundation of New Zealand, 2007)

Nursing staff measured and recorded the waist circumference and weight on the day of surgery in the AU. The patients had fasted six hours prior to surgery as per the hospital guidelines. To measure WC, the landmark was located at the narrowest point between the lower costal (10th rib) boarder and the top of the iliac crest, perpendicular to the axis of the trunk. Measurement was taken at the end of normal expiration and measurement recorded to the nearest centimetre (MOH 2008, NHANES III, 2007).
During the pre-test, the BMI wheel used within the author’s clinical setting was found to be less reliable with providing a precise BMI than when a calculator was used. Therefore to maintain reliability and accuracy to the nearest decimal point, a calculator was used in this pilot study rather than the BMI wheel. The BMI categorises were defined using the MOH BMI cut off categories which are based on the WHO guidelines (WHO, 2011). A Gulick II self-tensioning, non-stretchable measuring tape was used. Accurate height and weight measurements were necessary for the BMI calculation, therefore to avoid any potential changes to the weight measurement taken at preadmission; participants were reweighed on the day of admission. As the height measurement was unlikely to change this was not repeated.

3.6.2 Demographic and Clinical Characteristics:

3.6.2.1 Pre Surgery Variables

Pre surgery variables were collected from preadmission documentation and included demographic information and pre-existing medical conditions that were known to be an anaesthetic risk relating to either the ASA rating$^1$ and or obesity (Chung, Mezei & Tong, 1999). Demographic information was recorded from the preadmission clinical forms to assist in interpreting and understanding the population. This information included smoking behaviour, age, height and ethnicity. It is acknowledged that the census 2006 ethnicity question was considered for this pilot study as discussed with the Māori research manager (appendix C). However as the pilot study was conducted at the author’s hospital setting it was found to be more practical to collect the ethnicity data using the CDHB level 2 ethnicity data code which is stored on the Patient Management Systems (PMS) and documented in the patient clinical file. The main groups were categorised as New Zealand European, Māori, Samoan, Cook Island Māori, Tongan, Niuean, Chinese, Indian and other (such as Dutch, Japanese, and Tokelauan). The absence or presence of a pre-existing medical condition was collected and entered onto a data collection sheet using a yes or no tick box. Pre-existing medical conditions were divided into three main categories.

---

$^1$ ASA Physical Status Classification System
Classification system adopted by the American Society of Anaesthesiologists for assessing preoperative physical status.

I. A normal healthy patient
II. A patient with mild systemic disease
III. A patient with severe systemic disease
IV. A patient with severe systemic disease that is a constant threat to life
V. A moribund patient who is not expected to survive without the operation
VI. A declared brain-dead patient whose organs are being removed for donor purposes

The addition of an ‘E’ indicates emergency surgery.

http://www.frca.co.uk/article.
Cardiovascular system (CVS); included hypertension, chronic atrial fibrillation or other arrhythmia, angina, myocardial infarct, cardiac other.

Respiratory; included asthma, chronic obstructive pulmonary disease (COPD).

Other; included type I diabetes, type II diabetes Mellitus, gastro-oesophageal reflux disease (GORD) and any other significant health history that is known to be either associated with obesity or a potential post anaesthetic complication relevant to the dependant variables. For example, a patient receiving tamoxifen therapy was more at risk of developing post operative DVT.

3.6.2.2 Post Surgery Variables

Post surgery variables where collected retrospectively from the clinical notes by the researcher. Data to support the post surgery variables included evidence of cardiovascular events. This data included recorded electrocardiographs (ECG), documented laboratory results (such as cardiac enzymes) and any medically documented events assessments and diagnosis. The observation charts recorded by nurses were also used to collect data on blood pressure, heart rate, oxygen saturation and any recorded medical events and interventions. Medically diagnosed and documented respiratory events such as pulmonary embolism (P.E), actalectasis events were recorded in radiography reports and medical documentation. These results were then compared to the results of each anthropometric measurement for each participant. A pre-test was used to test the data collection method (see section 3.5).

The early warning score (EWS) guidelines (appendix H) were used to help identify potential post operative complications relevant to the various stages of post operative recovery. Therefore some of the variables collected were slightly different at different stages. Some of the acute medical and nursing requirements of patient care within 24 hours post surgery in the PACU or SCU were different to that of the patient care needs on the subsequent ward. However the main dependant variable categories remained the same. The absence or presence of a post surgery complication was collected and entered onto a data collection sheet using a yes or no tick box.
3.6.3 Outcome Measures:

3.6.3.1 Within 24 hours post surgery

The dependant variables at collection point within 24 hours post surgery including the PACU and SCU were divided into four main categories.

**Cardiovascular system (CVS);** included new arrhythmia including: atrial fibrillation, Sinus Ventricular Tachycardia (SVT), angina, troponin (TNI) rise, hypotension requiring Phenylephrine ≥ 4 hours post operative, cardiac arrest, other CVS.

**Respiratory:** included oxygen saturation < 95% on O2 4/L min. CPAP post op only (excluding participants who normally use CPAP at home) and other respiratory. DVT or PE confirmed using CPTA, X-ray or VQ scan was also included.

**Other:** Post operative confusion/delirium, haemoglobin < 90mg/l requiring blood transfusion, paralytic ileus, post operative nausea and vomiting (PONV) unresolved with multiple antiemetics, post operative dislocation, transfer to the tertiary hospital requiring admission to ICU, ED or CCU, deceased and other.

**Length of stay:** The discharge criteria for PACU included discharge from the PACU within two hours from the time of arrival to the PACU. A stay greater than two hours was regarded as a discharge delay and was recorded on the required hospital documentation. Participants were transferred from PACU to the SCU on the day of surgery. They were then discharged to the SOU by noon the following day (day one post surgery). A discharge delay from SCU was defined as any participant that stayed longer than noon day one post surgery for medical reasons.

3.6.3.2 After 24 hours post surgery

The dependant variables at collection point during the participants’ subsequent hospital stay on the surgical ward were divided into four main categories.

**Cardiovascular system (CVS);** included new arrhythmia including: atrial fibrillation, Sinus Ventricular Tachycardia (SVT), angina, TNI rise, hypotension requiring, cardiac arrest, other CVS.

**Respiratory:** included oxygen saturation < 95% on O2 4/L min, diagnosed actalectasis, chest infection, and other respiratory. DVT or PE confirmed using CPTA, X-ray or VQ scan was also included.
**Other**: post operative confusion/delirium, slow to mobilise, any infection wound or sepsis and haemoglobin was adjusted to < 80mg/l, paralytic ileus, post operative nausea and vomiting (PONV) unresolved with multiple antiemetics, post operative dislocation, transfer to the tertiary hospital requiring admission to ICU, ED or CCU, deceased and other.

**Length of stay**: The definition of exceeding the discharge criteria at collection point two included participants that required further medical and nursing care or mobility issues after their expected discharge date from hospital or who required further rehabilitation at other healthcare facilities prior to returning home.

A summary of the dependant variables described as potential postoperative outcomes as with obesity and the independent variables described as the biophysiological measurements of BMI and WC at each collection point is shown in figure four.

**Figure 4: Outcome measures**

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Dependant Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body Mass Index</td>
<td>Collection point Admitting Unit: Demographics:</td>
</tr>
<tr>
<td></td>
<td>Pre-surgery co-morbidities:</td>
</tr>
<tr>
<td></td>
<td>• CVS</td>
</tr>
<tr>
<td></td>
<td>• Respiratory</td>
</tr>
<tr>
<td></td>
<td>• Other</td>
</tr>
<tr>
<td>Waist circumference measurements</td>
<td>Collection point one: Within 24 hours post surgery Complications post surgery (PACU/SCU)</td>
</tr>
<tr>
<td></td>
<td>CVS</td>
</tr>
<tr>
<td></td>
<td>Respiratory</td>
</tr>
<tr>
<td></td>
<td>Other</td>
</tr>
<tr>
<td></td>
<td>Discharge delay</td>
</tr>
<tr>
<td>Other baseline variables</td>
<td>Collection point two: After 24 hours post surgery Complications post surgery (SOU)</td>
</tr>
<tr>
<td>Gender, Ethnicity, Smoking history, Surgery type.</td>
<td>• CVS</td>
</tr>
<tr>
<td></td>
<td>• Respiratory</td>
</tr>
<tr>
<td></td>
<td>• Other</td>
</tr>
<tr>
<td></td>
<td>• Discharge delay</td>
</tr>
</tbody>
</table>
3.7 Summary

This chapter has outlined the process undertaken to explore two routinely used anthropometric measurement tools (BMI and WC) in the clinical setting prior to surgery. A background to the study was provided to help underpin the research question and consider the effectiveness of either BMI or WC measurement tool to indicate potential postoperative outcomes. Ethical consideration has been outlined and the recruitment process was presented. Chapter four reports the results of the analysis undertaken while chapter five will discuss the results of the pilot study in association with the reviewed literature.
4 Results

4.1 Introduction

As a pilot study, this study was never intended to provide inferential statistical analysis to test the research question due to the small sample size and multiple variables. Descriptive statistics are presented in the Results chapter. The frequencies of co-morbidities pre surgery and post operative complications at two post operative collection points and the association with the BMI and WC measurements are also presented. Post operative complications that presented at each of the two collection points were recorded as new complications. The pre surgery co-morbidity risk factors and post operative complications are divided into the following three categories: Cardiovascular System (CVS), respiratory and other. Definitions of these categories were provided in the Methods chapter.

The WHO (2006) BMI guideline was used in the pilot study to define the BMI cut off points and is therefore irrespective of gender. The cut-off points are divided into four groups and are described as the following; BMI >25 as normal weight, BMI 25-29 as overweight and BMI 30-39.9 as obese. Morbidly obese was most commonly used in the reviewed literature to describe BMI > 40, this description has also been used in the pilot study. The pilot study adapted the New Zealand Dietetic Association guidelines for waist circumference measurements to describe the WC cut off points. The cut off points were divided into two cut off groups according to the gender and are described as the following; Female with WC ≤ 88cm as healthy WC and females with WC >88cm as unhealthy WC. Males with a WC ≤ 102cm as healthy WC and males with a WC ≥ 102cm as unhealthy WC.

First, the descriptive characteristics and the pre surgery co-morbidities of the participants are presented. Second, the frequency of co-morbidities at the pre-surgery collection point compared with the BMI and WC cut off groups are described. Third, the frequency of co-morbidities at the pre-surgery collection point compared with the post operative complications at collection point one and collection point two are illustrated. This will be followed by the frequency of post operative complications at the two postoperative collection points (PACU/SCU and SOU) compared with the BMI and WC cut off groups. Lastly, the discharge delays
at two post operative collection points are described. Results are summarised at the end of the chapter

4.2 Baseline descriptive

A total of 148 participants, admitted for joint replacement surgery, were recruited over 18 months. As can be seen in table six, the average age of the participants was 68 years (SD = 9.25) of which 62% were females. The predominant ethnicity was New Zealand European (91%), with others including Māori (2%) and Indian (0.7%) and smaller groups making up 6.1%. The most frequent intended surgery was primary total hip replacement (52%) then 31.8% primary knee replacement, 14.2%, hemi knee replacement, 1.4% bilateral knee replacement and 0.7% total shoulder replacement. Most of the participants had never smoked, almost a quarter had previously smoked but no longer smoked and only a small number were currently smoking. The mean BMI was 29.71 and irrespective of gender and ethnicity the mean waist circumference for females was 95.3 cm and for males was 104.7 cm.

4.2.1 Pre surgery co-morbidities

The pre surgery co-morbidity risk factors were defined using co-morbidities known to be associated with obesity or assessed risk factors using ASA rating and EWS. The pre-existing co-morbidities were divided into three main categories, CVS, respiratory and other and are described in the Methods chapter. The frequency of the co-morbidities pre surgery ranged from no co-morbidities to three or more co-morbidities. Only 16% of participants had no pre surgery co-morbidities and therefore had no identified risk factors. Most of the participants had at least one or more pre-existing co-morbidity that were associated with potential post operative risk factors. The first component of this study was to explore the association between the pre-surgery co-morbidities and the BMI and WC measurements. First the frequency of the co-morbidities at the pre-surgery collection point were described against the frequency of post operative complications and also with the BMI and WC measurements and these are presented as tables later in the Results chapter.
<table>
<thead>
<tr>
<th>Variable</th>
<th>n (%)</th>
<th>SD</th>
<th>Ranges</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>92 (62.2%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>56 (37.8%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Age: Mean</strong></td>
<td>68 years</td>
<td>9.25</td>
<td>43-86 years</td>
</tr>
<tr>
<td><strong>Ethnicity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Zealand European</td>
<td>135 (91%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maori</td>
<td>3 (2.0%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indian</td>
<td>1 (0.7%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>9 (6.3%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Smoking History</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never smoked</td>
<td>80 (54.1%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smoker</td>
<td>6 (4.1%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Previous Smoker</td>
<td>62 (42.8%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Intended Surgery</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Knee Replacement</td>
<td>47 (31.8%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Hip Replacement</td>
<td>77 (52%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hemi Knee Replacement</td>
<td>21 (14.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bilateral Knee Replacement</td>
<td>2 (1.4%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Shoulder Replacement</td>
<td>1 (0.7%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pre surgery co-morbidities</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No co-morbidity risk factors</td>
<td>25 (16%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 co-morbidity risk factor</td>
<td>43 (29.1%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 co-morbidity risks factors</td>
<td>41 (27.7%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 or more co-morbidity risks factors</td>
<td>39 (26.4%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Biophysical Measurement</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body Mass Index categories</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 25</td>
<td>25 (16.9%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25- 29.9</td>
<td>49 (33.1%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30- 39.9</td>
<td>57 (38.5%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 40</td>
<td>17 (11.5%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI Mean</td>
<td>29.71</td>
<td>4.68</td>
<td>19-41.5</td>
</tr>
</tbody>
</table>
4.3 Frequency of co-morbidities at the pre-surgery collection point for each BMI group.

4.3.1 Frequency of pre-surgery co-morbidity risk factors for each BMI category.

This section has combined the CVS, respiratory and other co-morbidity categories and describes the frequency of the combined co-morbidities within each BMI cut off groups. (Table seven). Almost a third (32%) of the participants in the BMI >25 group did not have any pre-existing co-morbidities with more than a quarter (28%) who had one co-morbidity. A combined percentage of 40% had two or more pre-existing co-morbidities in this BMI group. In the BMI 25-29.9 cut off group, just under a quarter (24.5%) did not have any pre-existing co-morbidities. The frequency of one or more pre-existing co-morbidities in this BMI group was almost evenly spread with 22.4% with one co-morbidity, 28.6% with two co-morbidities and 24.5% who had three or more co-morbidities.

Only a small percentage (8.4%) within the BMI 30-39.9 cut off group did not have any co-morbidities with a greater percentage who had one or more co-morbidities. The frequency of participants who had one co-morbidity had the greatest percentage with 33.5%, followed by 31% who had three or more co-morbidities and lastly 26.5% of those who had two co-morbidities. There were no participants in the BMI > 40 cut off group who did not have any co-morbidity risk factors. Therefore all participants in this category had at least one or more co-morbidities. The frequency of co-morbidities was almost evenly spread with both one and two co-morbidities sharing 33.5% and 29.2% that had three or more co-morbidities.

| Table 7  Frequency of pre surgery co-morbidity risk factors for each BMI category. |
|------------------|------------------|------------------|------------------|
| BMI              | No co-morbidity risk factors | 1 co-morbidity risk factors | 2 co-morbidity risk factors | 3 or more co-morbidity risk factors |
|                  | n= 25 (%)          | n= 43 (%)         | n= 41 (%)         | n=39 (%)         |
| < 25 normal weight | 8 (32%)           | 7 (28%)           | 6 (24%)           | 4 (16%)          |
| 25-29.9 overweight | 12 (24.5%)        | 11 (22.4%)        | 14 (28.6%)        | 12 (24.5%)       |
| 30-39.9 obese     | 5 (8.4%)          | 19 (33.5%)        | 15 (26.5%)        | 18 (31.6%)       |
| > 40 morbidly obese | 0                | 6 (35.4%)         | 6 (35.4%)         | 5 (29.2%)        |
4.3.2 Frequency of pre surgery co-morbidity risk factors for each BMI category

The following section is divided into each co-morbidity category (CVS, respiratory and other) and describes the frequency of each pre surgery co-morbidity risk factor for each BMI category and is shown in table eight.

Table 8 Frequency of pre-surgery co-morbidities for each BMI category

<table>
<thead>
<tr>
<th>BMI Category</th>
<th>CVS Co-morbidity</th>
<th>Respiratory Co-morbidity</th>
<th>Other Co-morbidity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No co-morbidity risk factors</td>
<td>1 co-morbidity risk factors</td>
<td>2 co-morbidity risks factors</td>
</tr>
<tr>
<td></td>
<td>n=50 (%)</td>
<td>n=72 (%)</td>
<td>n=19 (%)</td>
</tr>
<tr>
<td>&lt; 25 normal weight</td>
<td>12 (48%)</td>
<td>11 (44%)</td>
<td>1 (4%)</td>
</tr>
<tr>
<td>25-29.9 overweight</td>
<td>18 (36.7%)</td>
<td>22 (44.9%)</td>
<td>7 (14.3%)</td>
</tr>
<tr>
<td>30-39.9 obese</td>
<td>16 (28.1%)</td>
<td>29 (50.9%)</td>
<td>8 (14%)</td>
</tr>
<tr>
<td>&gt;40 morbidly obese</td>
<td>4 (23.5%)</td>
<td>10 (58.8%)</td>
<td>3 (17.6%)</td>
</tr>
<tr>
<td>&lt; 25 normal weight</td>
<td>19 (76%)</td>
<td>6 (24%)</td>
<td>0</td>
</tr>
<tr>
<td>25-29.9 overweight</td>
<td>41 (83.7%)</td>
<td>7 (14.3%)</td>
<td>1 (2%)</td>
</tr>
<tr>
<td>30-39.9 obese</td>
<td>45 (78.9%)</td>
<td>10 (17.5%)</td>
<td>2 (3.5%)</td>
</tr>
<tr>
<td>&gt;40 morbidly obese</td>
<td>11 (64.7%)</td>
<td>6 (35.3%)</td>
<td>0</td>
</tr>
<tr>
<td>&lt; 25 normal weight</td>
<td>18 (72%)</td>
<td>5 (20%)</td>
<td>1 (4%)</td>
</tr>
<tr>
<td>25-29.9 overweight</td>
<td>26 (53.1%)</td>
<td>18 (36.7%)</td>
<td>5 (10.2%)</td>
</tr>
<tr>
<td>30-39.9 obese</td>
<td>23 (40.4%)</td>
<td>26 (45.6)</td>
<td>8 (14%)</td>
</tr>
<tr>
<td>&gt;40 morbidly obese</td>
<td>6 (35.3%)</td>
<td>10 (58.8%)</td>
<td>1 (5.9%)</td>
</tr>
</tbody>
</table>
4.3.3 Frequency of pre surgery CVS co-morbidities for each BMI category.

As can be seen in Table eight, most participants (48%) within the BMI < 25 cut off point had no CVS co-morbidity, 44% had at least one known CVS co-morbidity and a small number (8%) had two or more CVS co-morbidities. Within the BMI 25-29.9 group, less than half (44.9%) of the participants had at least one CVS co-morbidity, followed by 36.7% who had no CVS co-morbidities, 14.3% had two CVS co-morbidities and a small number (4%) had three or more CVS co-morbidities. Half of the participants (50.9%) in the BMI 30-39.9 group had at least one CVS co-morbidity. Just over a quarter (28%) had no CVS co-morbidities closely followed by 21% having two or more CVS co-morbidities. Within the BMI > 40 cut off point, the results showed this group had the highest percentage of at least one CVS co-morbidity (58.8%) with 23.5% who had no CVS co-morbidities and 17% with two or more co-morbidities.

4.3.4 Frequency pre surgery respiratory co-morbidities for each BMI category.

The following describes the frequency of respiratory co-morbidities within each BMI cut off group (Table 8). Most participants within the BMI < 25 cut off point had no respiratory co-morbidities (76%) with 24% who had at least one respiratory co-morbidity and there were no participants who had two or more respiratory co-morbidities in this group. The BMI 25-29.9 group experienced the most percentage of no respiratory co-morbidities (83.7%). A total of 16% of the participants had one to two respiratory co-morbidities. There were no participants in this group who had experienced more than two respiratory co-morbidities. There were no participants in this group which had experienced more than two respiratory co-morbidities.

Within the BMI 30-39.9 group, most participants had no respiratory co-morbidities (78.9%) and a total of 21% who had one to two respiratory co-morbidities. There were no participants in this group who had three or more respiratory co-morbidities. Participants within the BMI > 40 group had the highest percentage of one respiratory co-morbidity of 35.3% with the lowest percentage of no respiratory co-morbidities (64.7%) There were no participants in this group who had two or more respiratory co-morbidities.

4.3.5 Frequency of pre surgery other co-morbidities for each BMI category.

Table eight shows that the BMI < 25 group had the highest percentage of no other co-morbidities (72%) and had the lowest number of one to two other co-morbidities (24%). This was the only group that had three or more co-morbidities pre surgery (4%). Within the BMI
25-29.9 group, 53.1% had no other co-morbidities and a total of 46.9% of the participants had one to two other co-morbidities. There were no participants in this group who had experienced more than three other co-morbidities.

The co-morbidities within the BMI 30-39.9 group were almost evenly distributed across no co-morbidities (40.4%) and one co-morbidity (45.6%). There were no participants in this group that had three or more other co-morbidities. The BMI > 40 group had the highest percentage of one to two other co-morbidities (64.7%) and the lowest percentage of no other co-morbidities (35.3%). There were no participants in this group who had three or more co-morbidities.

4.4 Frequency of co-morbidities at the pre surgery collection point for each waist circumference category.

The frequency of each pre surgery co-morbidity (CVS, Respiratory and Other) for each WC category by gender are described in this section and are presented in table ten.

4.4.1 Frequency of pre surgery co-morbidities for each waist circumference category.

This section has combined the CVS, respiratory and other co-morbidity categories and describes the frequency of the combined co-morbidities within each WC category shown in Table nine. The Female group WC < 88cm had the largest percentage overall of no co-morbidities (37.5%) and had the lowest number of one co-morbidity (16.7%). There were 45.9% who had three or more co-morbidities pre-surgery. Within the female group WC > 88cm, 11.8% had no co-morbidities and a percentage of 30.9% who had one co-morbidity followed by 57.4% who had two or more co-morbidities.

The males in the ≤ 102cm group had nearly an even distribution of frequency across the co-morbidities pre surgery. Twenty per cent had no co-morbidities, 25% had one co-morbidity, a total of 33.3% had two co-morbidities and 20.8% had three or more co-morbidities. Males within the > 102cm group had the lowest percentage of no other co-morbidities (9.4%) and the highest percentage of one co-morbidity (37.5%). A percentage of 53% had two or more co-morbidities, slightly less than females > 88cm.
Table 9 Frequency of combined pre surgery co-morbidities for each waist circumference category.

<table>
<thead>
<tr>
<th>WC</th>
<th>No co-morbidity risk factors</th>
<th>1 co-morbidity risk factors</th>
<th>2 co-morbidity risks factors</th>
<th>3 or more risks factors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n= 25 (%)</td>
<td>n=43 (%)</td>
<td>n= 41 (%)</td>
<td>n= 39 (%)</td>
</tr>
<tr>
<td>Female &lt; 88cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>healthy</td>
<td>9 (37.5%)</td>
<td>4 (16.7%)</td>
<td>7 (29.2%)</td>
<td>4 (16.7%)</td>
</tr>
<tr>
<td>unhealthy</td>
<td>8 (11.8%)</td>
<td>21 (30.9%)</td>
<td>18 (26.5%)</td>
<td>21 (30.9%)</td>
</tr>
<tr>
<td>Male ≤ 102cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>healthy</td>
<td>5 (20.8%)</td>
<td>6 (25%)</td>
<td>8 (33.3%)</td>
<td>5 (20.8%)</td>
</tr>
<tr>
<td>unhealthy</td>
<td>3 (9.4%)</td>
<td>12 (37.5%)</td>
<td>8 (25%)</td>
<td>9 (28.1%)</td>
</tr>
</tbody>
</table>

4.4.2 Frequency of pre surgery CVS Co-morbidities each waist circumference category.

Table ten shows the frequency of CVS co-morbidities within each gender group and WC category. More female participants within the WC < 88cm group had no CVS co-morbidity (58.3%), 37.5% had at least one known CVS co-morbidity and a small number (4.2%) had three or more CVS co-morbidities. There were no participants in this group who had two co-morbidities. Females in the > 88cm group had a lower percentage in the no co-morbidity category (29.4%), while just over half (54.9%) had one CVS co-morbidity and a combined percentage of 16.1% who had two or more CVS co-morbidities.

The male WC ≤ 102 group, had almost an even distribution of frequency across the CVS co-morbidities. Those who had no CVS co-morbidity and those who had three or more co-morbidities shared the lowest percentage of 20.8%. A quarter (25%) of the males in this group had one CVS co-morbidity. A slightly higher percentage had two CVS co-morbidities (33.3%). There were slightly more males in the WC > 102 group (31.3%) who had no CVS co-morbidity than the males in the WC ≤ 102cm group. A greater number in the WC > 102cm group had one co-morbidity (40.6%) and a combined percentage of 28% had two or more CVS co-morbidities.
4.4.3 Frequency of pre surgery respiratory co-morbidities each waist circumference category.

The frequency of pre surgery respiratory co-morbidities for each WC category by gender is presented in Table ten. Females in the >88cm group had slightly less percentage of no co-morbidities (72.1%) than the females in the ≤88cm group (79.2%) and slightly more with one respiratory co-morbidity (25%) than females in the <88cm group (20.8%). A small percentage of females in the > 88cm group (2.9%) had two respiratory co-morbidities and there were no participants in this group that had three or more respiratory co-morbidities. In the females ≤88cm group there were no participants in this group who had two or more respiratory co-morbidities.

While males within the WC ≤102cm mostly had no respiratory co-morbidities, a small percentage had one respiratory co-morbidity. There were no participants in this group who had two or more respiratory co-morbidities. The males in the WC > 102cm group had almost a similar percentage (84.4%) as the males in the previous group who had no respiratory co-morbidities and shared the same percentage (12.5%) of one respiratory co-morbidity. A small percentage had two respiratory co-morbidities and there were no participants in this group who had three or more respiratory co-morbidities.

4.4.4 Frequency of pre surgery other co-morbidities each waist circumference category.

Table ten shows the frequency of other co-morbidities within each gender and WC category. The female ≤88cm group had the highest percentage of no other co-morbidities (62.5%) and had the lowest number of one to two other co-morbidities (23.3%). This was the only group that had three or more co-morbidities pre surgery (4.2%). Within the female > 88cm group, less than half (48.5%) had no other co-morbidities and a total of 51.5% of the participants had one to two other co-morbidities. There were no participants in this group which experienced more than three other co-morbidities.

Half of the males (50%) in the WC ≤102cm had no co-morbidities and less than half (41.7%) had one co-morbidity. A small percentage (8.3%) had two other co-morbidities. There were no participants in this group who had three or more other co-morbidities. Less than half (40.6%) of the males in the WC > 102cm group had no other co-morbidities. Males
in this group had the highest percentage (50%) of one other co-morbidities and a small percentage of two other co-morbidities. There were no participants in this group who had three or more co-morbidities.

Table 10 Frequency of pre surgery co-morbidities for each waist circumference category.

<table>
<thead>
<tr>
<th>WC Category</th>
<th>No co-morbidities</th>
<th>1 co-morbidity</th>
<th>2 co-morbidities</th>
<th>3 or more co-morbidities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n=49 (%)</td>
<td>n=65 (%)</td>
<td>n=24 (%)</td>
<td>n=10 (%)</td>
</tr>
<tr>
<td>CVS Co-morbidities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 88cm</td>
<td>14 (58.3%)</td>
<td>9 (37.5%)</td>
<td>0 (0%)</td>
<td>1 (4.2%)</td>
</tr>
<tr>
<td>healthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 88cm</td>
<td>20 (29.4%)</td>
<td>37 (54.5%)</td>
<td>9 (13.2%)</td>
<td>2 (2.9%)</td>
</tr>
<tr>
<td>unhealthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 102cm</td>
<td>5 (20.8%)</td>
<td>6 (25.0%)</td>
<td>8 (33.3%)</td>
<td>5 (20.8%)</td>
</tr>
<tr>
<td>healthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 102cm</td>
<td>10 (31.3%)</td>
<td>13 (40.6%)</td>
<td>7 (21.8%)</td>
<td>2 (6.3%)</td>
</tr>
<tr>
<td>unhealthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory Co-morbidities</td>
<td>n=116 (%)</td>
<td>n=29 (%)</td>
<td>n=3 (%)</td>
<td>n=0 (%)</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 88cm</td>
<td>19 (79.2%)</td>
<td>5 (20.8%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>healthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 88cm</td>
<td>49 (72.1%)</td>
<td>17 (25%)</td>
<td>2 (2.9%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>unhealthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 102cm</td>
<td>21 (87.5%)</td>
<td>3 (12.5%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>healthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 102cm</td>
<td>27 (84.4%)</td>
<td>4 (12.5%)</td>
<td>1 (3.1%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>unhealthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Co-morbidities</td>
<td>n=73 (%)</td>
<td>n=59 (%)</td>
<td>n=15 (%)</td>
<td>n=1 (%)</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 88cm</td>
<td>15 (62.5%)</td>
<td>5 (20.8%)</td>
<td>3 (12.5%)</td>
<td>1 (4.2%)</td>
</tr>
<tr>
<td>healthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 88cm</td>
<td>33 (48.5%)</td>
<td>28 (41.2%)</td>
<td>7 (10.3%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>unhealthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 102cm</td>
<td>12 (50%)</td>
<td>10 (41.7%)</td>
<td>2 (8.3%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>healthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 102cm</td>
<td>13 (40.6%)</td>
<td>16 (50.0%)</td>
<td>3 (9.4%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>unhealthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.5 Frequency of post operative complications and pre-surgery co-morbidity risk factors.

This section describes the frequency of pre surgery co-morbidities in relation to the number of post operative complications and the association with BMI and WC measurements at two collection points. These results are presented in tables. The post operative complications were divided into four main categories, CVS, respiratory, other and delayed discharge. Delayed discharge will be presented later in the results chapter. Potential acute post operative complications within the first 24 hours differ to that of post operative complications after 24 hours post operative and are described in the Methods chapter.

4.5.1 Frequency of post operative complications and pre surgery co-morbidities at collection point one.

Table eleven shows that a higher percentage of participants who had no pre surgery co-morbidity risk factors also experienced no post operative complication within the first 24 hours. There was a slight rise in the frequency of participants who had at least one pre surgery co-morbidity risk factor and who also experienced one post op complication. However the frequency of one or more pre surgery co-morbidity risk factors and two or more post operative complications appeared to decline.

4.5.2 Frequency of post operative complications and pre surgery co-morbidity complications at collection point two.

The frequency of pre surgery co-morbidity risk factors in relation to frequency of post operative complications at collection point two is shown in Table 11. The number of postoperative complication events appeared to have increased after 24 hours (during the surgical ward stay). There was a small percentage of participants who had no pre surgery risk factors who did not experience any post operative complications within the first 24 hours. Participants who had no risk factors, experienced more post operative complication at collection point two than at collection point one. The percentage of participants who had one or more risk factors and experienced one-two post op complications was evenly represented on the whole. The total percentage that experienced three or more post operative complications was small, irrespective of the number of risk factors.
Table 11 Frequency of post operative complications for each pre-surgery co-morbidity group.

<table>
<thead>
<tr>
<th>Collection Point One (PACU/SCU)</th>
<th>No post operative complications (n=96)</th>
<th>1 post operative complication (n=35)</th>
<th>2 post operative complications (n=9)</th>
<th>3 or more post operative complications (n=8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No co-morbidity risk factor</td>
<td>23 (92%)</td>
<td>1 (4%)</td>
<td>1 (4%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>1 co-morbidity risk factor</td>
<td>26 (60.4%)</td>
<td>13 (30.2%)</td>
<td>2 (4.7%)</td>
<td>2 (4.7%)</td>
</tr>
<tr>
<td>2 co-morbidity risk factors</td>
<td>30 (73.2%)</td>
<td>10 (24.4%)</td>
<td>1 (2.4%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>&gt; 3 co-morbidity risk factors</td>
<td>17 (43.6%)</td>
<td>11 (28.2%)</td>
<td>5 (12.8%)</td>
<td>6 (15.4%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Collection Point Two (SOU)</th>
<th>(n=51)</th>
<th>(n=34)</th>
<th>(n=32)</th>
<th>(n=30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No co-morbidity risk factor</td>
<td>9 (36%)</td>
<td>7 (28%)</td>
<td>6 (24%)</td>
<td>3 (12%)</td>
</tr>
<tr>
<td>1 co-morbidity risk factor</td>
<td>18 (41.9%)</td>
<td>10 (23.3%)</td>
<td>4 (9.3%)</td>
<td>11 (25.6%)</td>
</tr>
<tr>
<td>2 co-morbidity risk factors</td>
<td>15 (36.6%)</td>
<td>7 (17.1%)</td>
<td>11 (26.8%)</td>
<td>8 (19.5%)</td>
</tr>
<tr>
<td>&gt; 3 co-morbidity risk factors</td>
<td>9 (23.7%)</td>
<td>10 (26.3%)</td>
<td>11 (28.9%)</td>
<td>8 (21.1%)</td>
</tr>
</tbody>
</table>

4.5.3 Pre surgery co-morbidity risk factors summary.

Data collected at the pre surgery collection point were presented as tables in this section. First, the frequency of pre surgery co-morbidities correlated with the BMI and WC groups were presented. Second, the frequency of pre-surgery co-morbidities and post operative complications were presented. The frequency of pre-surgery co-morbidities was used to explore the association between post operative complications and the BMI and WC measurements. The next section will describe the frequency of the post operative complications at two post operative collection points for BMI and WC categories.
4.6 Post operative complications at two postoperative collection points

This section will describe the frequency of the post operative complications (CVS, respiratory, other) at the two postoperative collection points.

4.6.1 Frequency of post operative complications at two postoperative collection points.

Table twelve presents the frequency of post operative complications at the two postoperative data collection points (PACU/SCU and SOU). At collection point one (PACU/SCU) more than half (64.9%) of participants experienced no post operative complication within the first 24 hours and just under a quarter (23.6%) experienced one post operative complication within the first 24 hours. At collection point two (SOU), there appeared to be a higher frequency of post surgery complications during the SOU stay than during the PACU/SCU stay.

Table 12 Frequency of post operative complications at two collection points

<table>
<thead>
<tr>
<th></th>
<th>No complications</th>
<th>1 complication</th>
<th>2 complications</th>
<th>3 or more complications</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n=96 (%)</td>
<td>n=35 (%)</td>
<td>n=9 (%)</td>
<td>n=8 (%)</td>
</tr>
<tr>
<td>Collection Point: One</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(PACU /SCU) within 24</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hours</td>
<td>96 (64.9%)</td>
<td>35 (23.6%)</td>
<td>9 (6.1%)</td>
<td>8 (5.5%)</td>
</tr>
<tr>
<td></td>
<td>n=51 (%)</td>
<td>n=34 (%)</td>
<td>n=32 (%)</td>
<td>n=28 (%)</td>
</tr>
<tr>
<td>Collection Point: Two</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(SOU) after 24 hours</td>
<td>51 (34.7%)</td>
<td>34 (23%)</td>
<td>32 (21.8%)</td>
<td>28 (19%)</td>
</tr>
</tbody>
</table>

4.7 Post-operative complications at collection point one (PACU and SCU).

First, this section describes the frequency of the combined post operation complications (CVS, Respiratory and Other) for each BMI category at collection point one. Second, the frequency of each post operation complication category in association with each of the BMI categories is described. Third, the frequency of the combined post operation complications for each WC category is presented. Lastly the frequency of each post operation complication category associated with each WC category is described. The post operative complications
within the first 24 hours are described in the Methods chapter section. The results showed that there was no data collected for cardiac events, angina, confirmed. DVT or PE paralytic illius and post operative dislocation within 24 hours post operation.

4.7.1 Collection point one: Frequency of combined post operation complications for each BMI category.

The following section describes the frequency of all the postoperative complication categories within the first 24 hours for each BMI category and is illustrated in Table thirteen. Within the BMI < 25 group, more than half (60%) of the participants had no post operative complications within the first 24 hours post operation. This group had the highest frequency of one post operation complication (28%) and 12% had two post operation complications within the first 24 hours post operation. There were no participants in this group that had three or more post operation complications. Sixty nine of the participants in the BMI 25–29.9 group had no post operation complications followed by nearly a quarter (24.5%) who had one post operation complication. A combined percentage of 6.1% had two or more post operation complications.

The BMI group 30-39.9 also had just over half of the participants that experienced no post operation complication with 21.1% that experienced one complication and a combined percentage of 12.2% that experienced two or more post operation complication. The participants in the BMI > 40 group had the least percentage of no complications (52.9%) followed by 23.6% that had one post operation complication and a combined percentage of 23.5% had two or more post operation complications.

Table 13 Collection point one: Frequency of combined post operative complications for each BMI category

<table>
<thead>
<tr>
<th>BMI</th>
<th>No complications $n=96$ (%)</th>
<th>1 complication $n=35$ (%)</th>
<th>2 complications $n=9$ (%)</th>
<th>3 or more complications $n=8$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 25 normal weight</td>
<td>15 (60%)</td>
<td>7 (28%)</td>
<td>3 (12%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>25-29.9 overweight</td>
<td>34 (69.4%)</td>
<td>12 (24.5%)</td>
<td>2 (4.1%)</td>
<td>1 (2%)</td>
</tr>
<tr>
<td>30-39.9 obese</td>
<td>38 (66.7%)</td>
<td>12 (21.1%)</td>
<td>1 (1.7%)</td>
<td>6 (10.5%)</td>
</tr>
<tr>
<td>&gt; 40 morbidly obese</td>
<td>9 (52.9%)</td>
<td>4 (23.6%)</td>
<td>3 (17.6%)</td>
<td>1 (5.9%)</td>
</tr>
</tbody>
</table>
4.7.2 Collection point one: Frequency of post operative CVS complications for each BMI category.

The following section describes the frequency of CVS complications post operation at collection point one within each BMI cut off group. This is presented in table fourteen. Most participants (84%) within the BMI < 25 group did not experience any CVS complications. Twelve percent had one CVS complication and a combined percentage (4%) had two CVS complications post operation. There were no participants in this group who had three or more post operation complications. Within the BMI 25-29.9 group, 81.6% of participants did not experience any CVS complications post operation, 16.3% experienced one CVS complication, followed by 2% who had two CVS complications. There were no participants in this group who had three or more post operation complications.

Eighty four per cent of participants in the BMI 30-39.9 group had no CVS complications post operation. The frequency of no CVS complications in this group was similar to that of the < 25 BMI group. This group had the lowest frequency of one CVS complication (10%) and 5.3% had two CVS complications. There were no participants in this group who had three or more post operation complications. The > 40 BMI group had the least percentage of no CVS complications (64.7%) and the most percentage (35.3%) of one CVS complication post operation. There were no participants in this group who had two or more post operation complications.

4.7.3 Collection point one: Frequency of post operative respiratory complications for each BMI category

Table fourteen shows the frequency of respiratory complications post surgery at collection point one within each BMI cut off group. Almost all (96%) of the participants within the BMI < 25 group had no respiratory complications within the first 24 hours post operation and 4% had one respiratory complication. There were no participants within this group that had two or more respiratory complications. The BMI 25-29.9 group experienced a high percentage (95.8%) of no respiratory complications with an equal number (2.1%) that experienced one or two respiratory complications respectively. There were no participants in this group who experienced more than three respiratory complications. Within the BMI 30-39.9 group, most participants had no respiratory complications (87.7%) with more who experienced one respiratory complication (5.3%) and two respiratory complications (7%)
compared to the other BMI groups. There were no participants in this group who had three or more respiratory complications.

4.7.4 Collection point one: Frequency of post operative other complications for each BMI category.

The frequency of other complications post surgery at collection point one within each BMI cut off group is illustrated in Table fourteen. The BMI < 25 group had 81.6% who did not experience any post operation complications and less than a quarter (20%) who experienced one other complication. A small percentage (4%) experienced two post operation complications and there were no participants who experienced three or more. Participants within the BMI 25-29.9 group had the highest percentage (85.7%) of no other post operation complications and a total of 10.2% who had one other post operation complication. A small percentage (4%) experienced two post operation complications and there were no participants in this group who experienced three or more other post operation complications.

More than three quarters (80.7%) of the participants within the BMI 30-39.9 group did not experience any post operation complication. The percentage of participants who experienced one complication was 15.8% and a combined percentage of 3.6% who experienced two or more post operation complications. The BMI > 40 group had less than three quarters (70.6%) who did not experience any post operation complication and less than a quarter (23.5%) experienced one post operation complication. A small percentage (5.9%) experienced two complications and no participants in this BMI group who had three or more other post operation complications.
Table 14 Collection point one: Frequency of post operative complications for each BMI category

<table>
<thead>
<tr>
<th>BMI Category</th>
<th>No complications</th>
<th>1 complications</th>
<th>2 complications</th>
<th>3 or more complications</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n=120 (%)</td>
<td>n=23 (%)</td>
<td>n=5 (%)</td>
<td>n=0 (%)</td>
</tr>
<tr>
<td>CVS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 25 normal weight</td>
<td>21 (84%)</td>
<td>3 (12%)</td>
<td>1 (4%)</td>
<td>0</td>
</tr>
<tr>
<td>25-29.9 overweight</td>
<td>40 (81.6%)</td>
<td>8 (16.4%)</td>
<td>1 (2%)</td>
<td>0</td>
</tr>
<tr>
<td>30-39.9 obese</td>
<td>48 (84.2%)</td>
<td>6 (10.5%)</td>
<td>3 (5.3%)</td>
<td>0</td>
</tr>
<tr>
<td>&gt; 40 morbidly obese</td>
<td>11 (64.7%)</td>
<td>6 (35.3%)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Respiratory</td>
<td>n= 136</td>
<td>n=6</td>
<td>n=6</td>
<td>n=0</td>
</tr>
<tr>
<td>&lt; 25 normal weight</td>
<td>24 (96%)</td>
<td>1 (4%)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>25-29.9 overweight</td>
<td>47 (95.8%)</td>
<td>1 (2.1%)</td>
<td>1 (2.1%)</td>
<td>0</td>
</tr>
<tr>
<td>30-39.9 obese</td>
<td>50 (87.7%)</td>
<td>3 (5.3%)</td>
<td>4 (7%)</td>
<td>0</td>
</tr>
<tr>
<td>&gt; 40 morbidly obese</td>
<td>15 (88.2%)</td>
<td>1 (5.9%)</td>
<td>1 (5.9%)</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>n= 119</td>
<td>n=23</td>
<td>n=5</td>
<td>n=1</td>
</tr>
<tr>
<td>&lt; 25 normal weight</td>
<td>19 (81.6%)</td>
<td>5 (20%)</td>
<td>1 (4%)</td>
<td>0</td>
</tr>
<tr>
<td>25-29.9 overweight</td>
<td>42 (85.7%)</td>
<td>5 (10.2%)</td>
<td>2 (4.1%)</td>
<td>0</td>
</tr>
<tr>
<td>30-39.9 obese</td>
<td>46 (80.7%)</td>
<td>9 (15.8%)</td>
<td>1 (1.8%)</td>
<td>1 (1.8%)</td>
</tr>
<tr>
<td>&gt; 40 morbidly obese</td>
<td>12 (70.6%)</td>
<td>4 (23.5%)</td>
<td>1 (5.9%)</td>
<td>0</td>
</tr>
</tbody>
</table>

4.7.5 Collection point one: Frequency of combined post operation complications for each waist circumference category.

Table fifteen shows the frequency of combined post operation complications at collection point one in relation to each WC cut off group. Three quarters (75%) of the female group with a WC ≤ 88cm who had no complications and less than a quarter (16%) had one complication. A small percentage (8.3%) had two complications. There were no participants in this group who had three or more co-morbidities. Females within the WC > 88cm group had over half
(61%) who had no complications followed by a quarter (25%) who had one complication and a combined percentage of (13.2%) who experienced two or more complications.

In the male \( \leq 102\)cm group there were more than half (61.8%) who had no complications and more than a quarter (29.2%) had one post operation complication. The percentage of males who experienced two complications was the same as the female WC \( \leq 88\)cm group (8%). There were no participants in this group who had three or more complications. Sixty-five per cent of the males within the \( > 102\)cm group did not experience any post operation complication and nearly a quarter (21.9%) had one complication. A combined percentage of 12.5% experienced two or more post operation complications.

Table 15 Collection point one: Frequency of combined post operation complications for each waist circumference category.

<table>
<thead>
<tr>
<th>WC</th>
<th>No complications (n=96) (%)</th>
<th>1 complication (n=35) (%)</th>
<th>2 complications (n=9) (%)</th>
<th>3 or more complications (n=8) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| \( \leq 88\)cm
healthy    | 18 (75%)                      | 4 (16.7%)                  | 2 (8.3%)                   | 0 (0%)                            |
| \( > 88\)cm
unhealthy | 42 (61.8%)                    | 17 (25%)                   | 2 (2.9%)                   | 7 (10.3%)                         |
| Male     |                               |                            |                            |                                   |
| \( \leq 102\)cm
healthy    | 15 (62.5%)                    | 7 (29.2%)                  | 2 (8.3%)                   | 0 (0%)                            |
| \( > 102\)cm
unhealthy | 21 (65.6%)                    | 7 (21.9%)                  | 3 (9.4%)                   | 1 (3.1%)                          |

4.7.6 Collection point one: Frequency of post operative CVS complications for each waist circumference category.

The frequency of CVS complications post surgery and WC at collection point one is shown in Table sixteen. The frequency of CVS complications within 24 hours post surgery ranged from no cardiovascular complication to two complications. There were no participants who experienced three or more CVS complications. Males in the WC \( \leq 102\)cm category had the most frequent CVS complications with 25% who experienced one to two CVS complications. This is followed by 22% males with WC cut off of 102cm or greater and 20% of females with a WC cut off of 88cm or greater. The female category of WC cut off 88cm or greater had only one participant that experienced one CVS complication.
4.7.7 Collection point one: Frequency of post operative respiratory complications for each waist circumference category.

Table sixteen illustrates the frequency of post operative respiratory complications at collection point one in association with each WC cut off group. All the females (100%) in the WC ≤ 88cm category did not experience any respiratory complication post operation. Females within the WC > 88cm category had over three quarters (86.8%) who had no complications followed by 5.9% of participants who had one complication and 7.4% who had two respiratory complications. There were no participants in this group who had three or more complications.

No males (100%) in the WC ≤ 102cm category experienced any respiratory complications post operation. Likewise, almost all males (90.6%) in the WC > 102cm category did not experience any respiratory complications. A percentage of 6.3% had one respiratory complication and a very small percentage (3.1%) had two complications. There were no participants in this group who had three or more complications.

4.7.8 Collection point one: Frequency of other post operative complications for each waist circumference category.

The frequency of other post operation complications at collection point one relative to each WC category is shown in Table sixteen. Three quarters (75%) of females within WC ≤ 88cm experienced no other complications post operation followed by less than a quarter (20.8%) who had one complication and 4.2% who had two other complications. There were no participants in this group who had three or more complications. The females in the WC > 88cm include just over three quarters (77.9%) who experienced no other complications post operation. There were 16.2% who had one respiratory complication followed by 5.9% who experienced two or more respiratory complications post operation.

Males in the ≤ 102cm group who experienced other post operative complication had the highest percentage in the no complications category (87.5%). The percentage of males within the > 102cm group who experienced other complications included 84.4% who experience no other complications and 15.6% who had one other complication. There were no participants in this group who had two or more other complications post operation.
Table 16 Collection point one: Frequency of post operative complications for each waist circumference category.

<table>
<thead>
<tr>
<th>WC category</th>
<th>No complications n=120 (%)</th>
<th>1 complication n=23 (%)</th>
<th>2 complications n=5 (%)</th>
<th>3 or more complications n=0 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CVS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 88cm</td>
<td>23 (95.8%)</td>
<td>1 (4.2%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>healthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 88cm</td>
<td>54 (79.4)</td>
<td>12 (17.6%)</td>
<td>2 (2.9%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>unhealthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 102cm</td>
<td>18 (75%)</td>
<td>5 (20.8%)</td>
<td>1 (4.2%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>healthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 102cm</td>
<td>25 (78.1%)</td>
<td>5 (15.6%)</td>
<td>2 (6.3%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>unhealthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory</td>
<td>n=136 (%)</td>
<td>n=6 (%)</td>
<td>n=6 (%)</td>
<td>n=0 (%)</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 88cm</td>
<td>24 (100%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>healthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 88cm</td>
<td>59 (86.8%)</td>
<td>4 (5.9%)</td>
<td>5 (7.4%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>unhealthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 102cm</td>
<td>24 (100%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>healthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 102cm</td>
<td>29 (90.6%)</td>
<td>2 (6.3%)</td>
<td>1 (3.1%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>unhealthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>n=119 (%)</td>
<td>n=23 (%)</td>
<td>n=5 (%)</td>
<td>n=1 (%)</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 88cm</td>
<td>18 (75%)</td>
<td>5 (20.8%)</td>
<td>1 (4.2%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>healthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 88cm</td>
<td>53 (77.9%)</td>
<td>11 (16.2%)</td>
<td>3 (4.4%)</td>
<td>1 (1.5%)</td>
</tr>
<tr>
<td>unhealthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 102cm</td>
<td>21 (87.5%)</td>
<td>2 (8.3%)</td>
<td>1 (4.2%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>healthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 102cm</td>
<td>27 (84.4%)</td>
<td>5 (15.6%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>unhealthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The results of the data collected during the participants stay in the PACU and SCU and within the first 24 hours post operation, has been presented as tables in this section. The results described the frequency of post operative complications (CVS, respiratory, other) in relation to the BMI and WC groups. The next section presents the frequency of post operation
complications associated with the BMI and WC groups after 24 hours post operation at collection point two (SOU).

4.8 Post-surgery complications at collection point two (SOU).

First this section describes the frequency of the combined post operation complications (CVS, Respiratory and Other) for the BMI at collection point two. Second the frequency of each post operation complication category for each BMI category is described. Third, the frequency of the combined post operation complications for each WC category is described followed lastly by the frequency of each post operation complication category for each WC category. The post operative complications within the first 24 hours are described in the Methods chapter. The results showed that there were no data collected for cardiac events, angina, confirmed. DVT, paralytic illius and post operative dislocation after 24 hours post operation.

4.8.1 Collection point two: Frequency of all post operation complications for each BMI category.

Table seventeen illustrates the frequency of total post operation complications for each BMI category. Within the BMI < 25 group, there were fewer participants (28%) who experienced no post operative complications than those who experienced one post operation complication (40%) within the first 24 hours post operation. The BMI 25–29.9 groups had an almost equal distribution across frequency of post operation complications. The percentage of participants who had no complications was 28.6%, this was followed by 26.5% who had two complications and 22.4% who had one post operative complication. The percentage of participants that had three or more post operative complications was 20.4%.

The BMI group 30-39.9 had almost an equal frequency of no complications (40.4%) and two or more complications (42.1%). The frequency of one complication was the lowest with 17.5% in this group. The frequency of no complications in the BMI > 40 group was similar to that of the previous BMI group (41.2%). The frequency of post operative complications was again similar to the previous BMI group. The percentage that experienced on complications was 17.6% and the percentage who experienced two or more complications was 41.1%.
Table 17 Collection point two: Frequency of all post operation complications for each BMI category

<table>
<thead>
<tr>
<th>BMI</th>
<th>No complications ( n=51 ) (%)</th>
<th>1 complications ( n=34 ) (%)</th>
<th>2 complications ( n=32 ) (%)</th>
<th>3 or more complications ( n=30 ) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 25 normal weight</td>
<td>7 (28%)</td>
<td>10 (40%)</td>
<td>3 (12%)</td>
<td>5 (20%)</td>
</tr>
<tr>
<td>25-29.9 overweight</td>
<td>14 (28.6%)</td>
<td>11 (22.4%)</td>
<td>13 (26.5%)</td>
<td>10 (20.4%)</td>
</tr>
<tr>
<td>30-39.9 obese</td>
<td>23 (40.4%)</td>
<td>10 (17.5%)</td>
<td>13 (22.8%)</td>
<td>11 (19.3%)</td>
</tr>
<tr>
<td>&gt; 40 morbidly obese</td>
<td>7 (41.2%)</td>
<td>3 (17.6%)</td>
<td>3 (17.6%)</td>
<td>4 (23.5%)</td>
</tr>
</tbody>
</table>

The BMI < 25 group had the highest frequency of postoperative complications with 72% that experienced one or more post operative complication during the surgical ward stay. This was followed by the BMI 25-29.9 group with 69.3% of the participants that experienced one or more post operative complication, next the BMI 30-39.9 group had 59.6% of the participants had one or more post surgery complications and lastly the BMI > 40 group with 58.7% who had experienced one or more post surgery complications.

4.8.2 Collection point two: Frequency of post operative CVS complications for BMI category.

The following section represents the frequency of post operative CVS complications at collection point two in relation to each BMI cut off group. This is presented in table 18. Participants within the BMI < 25 group had the least frequency of no CVS complications (80%) and 16% had one CVS complication followed by 4% who had two CVS complications post operation. There were no participants in this group who had three or more post operation complications. Within the BMI 25-29.9 group, 85.7% of participants did not experience any CVS complications post operation, 10.2% experienced one CVS complication, followed by 2% who had two CVS complications. There were no participants in this group who had three or more post operation complications.

Eighty six per cent of participants in the BMI 30-39.9 group had no CVS complications post operation. The frequency of no CVS complications in this group was a similar to that of the 25-29.9 BMI group. This group had the lowest frequency of one CVS post operative complication.
complication (7%) and 7% had two CVS complications. There were no participants in this group who had three or more post operation complications. Participants within the > 40 BMI group included 82.4% who did not have a postoperative complication. Eleven per cent had one post operative complication and 5.9% had two post operative CVS complications. There were no participants in this group who had three or more post operation complications.

4.8.3 Collection point two: Frequency of post operative respiratory complications for each BMI category.

The following section describes the frequency of respiratory complications post surgery at collection point two relative to each BMI cut off group. This is shown in Table eighteen. Eighty-eight per cent of participants within the BMI < 25 group had no respiratory complications post operation. While 8% had one respiratory complication and 8% had two or more respiratory complications. Within the BMI 25-29.9 group 81.6% experienced no respiratory complications, 14.3% of the participants experienced one respiratory complication and 2% that experienced two respiratory complications. There were no participants in this group who experienced more than three respiratory complications.

Within the BMI 30-39.9 group, 73.7% of the participants had no post operative respiratory complications. This group had the greatest percentage of two or more post operative respiratory complications (14.1%) than the other BMI groups. Twelve percent experienced one post operative respiratory complication. The > 40 BMI group had the lowest percentage of no respiratory complications (70.6%) and most percentage (17.6%) of one respiratory complication post operation. There were 11.8% who had two or more post operation complications.

4.8.4 Collection point two: Frequency of other post operative complications for each BMI group.

Table eighteen represents the frequency of other post operative complications at collection point two in relation to each BMI cut off group. The BMI < 25 group included just over a third (36%) who did not experience any post operation complications and 44% who experienced one other complication. Less than a quarter (20%) experienced two or more post operation complications. Participants within the BMI 25-29.9 group had less than a third (30.6%) who had no other post operation complications and a total of 36.7% had one other
post operation complication. A combined percentage of 30.6% had two or more complications post operation.

The BMI 30-39.9 group had the largest percentage (49.1%) who did not experience any post operation complication. A third (33.3%) experienced one complication and a combined percentage of 17.5% who experienced two post operation complications. There were no participants in this group who had three or more other post operation complications. The BMI > 40 group had an equal 41.2% who experience no complication and one complication respectively and 17.7% had two or more complications post operation.

Table 18 Collection point two: Frequency of post operative complications for each BMI category.

<table>
<thead>
<tr>
<th>BMI</th>
<th>No complications</th>
<th>1 complication</th>
<th>2 complications</th>
<th>3 or more complications</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n=125</td>
<td>n=15</td>
<td>n=7</td>
<td>n=0</td>
</tr>
<tr>
<td>CVS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 25 normal weight</td>
<td>20 (80%)</td>
<td>4 (16%)</td>
<td>1 (4%)</td>
<td>0</td>
</tr>
<tr>
<td>25-29.9 overweight</td>
<td>42 (85.7%)</td>
<td>5 (10.2%)</td>
<td>1 (2%)</td>
<td>0</td>
</tr>
<tr>
<td>30-39.9 obese</td>
<td>49 (86%)</td>
<td>4 (7%)</td>
<td>4 (7%)</td>
<td>0</td>
</tr>
<tr>
<td>&gt; 40 morbidly obese</td>
<td>14 (82.4%)</td>
<td>2 (11.8%)</td>
<td>1 (5.9%)</td>
<td>0</td>
</tr>
<tr>
<td>Respiratory</td>
<td>n=115</td>
<td>n=19</td>
<td>n=6</td>
<td>n=7</td>
</tr>
<tr>
<td>&lt; 25 normal weight</td>
<td>21 (84%)</td>
<td>2 (8%)</td>
<td>1 (4%)</td>
<td>1 (4%)</td>
</tr>
<tr>
<td>25-29.9 overweight</td>
<td>40 (81.6%)</td>
<td>7 (14.3%)</td>
<td>1 (2%)</td>
<td>0</td>
</tr>
<tr>
<td>30-39.9 obese</td>
<td>42 (73.7%)</td>
<td>7 (12.3%)</td>
<td>3 (5.3%)</td>
<td>5 (8.8%)</td>
</tr>
<tr>
<td>&gt; 40 morbidly obese</td>
<td>12 (70.6%)</td>
<td>3 (17.6%)</td>
<td>1 (5.9%)</td>
<td>1 (5.9%)</td>
</tr>
<tr>
<td>Other</td>
<td>n=59</td>
<td>n=55</td>
<td>n=23</td>
<td>n=10</td>
</tr>
<tr>
<td>&lt; 25 normal weight</td>
<td>9 (36%)</td>
<td>11 (44%)</td>
<td>2 (8%)</td>
<td>3 (12%)</td>
</tr>
<tr>
<td>25-29.9 overweight</td>
<td>15 (30.6%)</td>
<td>18 (36.7%)</td>
<td>9 (18.4%)</td>
<td>6 (12.2%)</td>
</tr>
<tr>
<td>30-39.9 obese</td>
<td>28 (49.1%)</td>
<td>19 (33.3%)</td>
<td>10 (17.5%)</td>
<td>0</td>
</tr>
<tr>
<td>&gt; 40 morbidly obese</td>
<td>7 (41.2%)</td>
<td>7 (41.2%)</td>
<td>2 (11.8%)</td>
<td>1 (5.9%)</td>
</tr>
</tbody>
</table>
4.8.5 Collection point two: Frequency of combined post operation complications for each waist circumference category.

The frequency of the combined post operative complications in relation to the WC groups at collection point two is shown in Table nineteen. A total percentage of 55% males and 73.5% female participants from all WC cut off categories experienced post surgery complications that ranged from one complication to more than three complications. Forty-five per cent of males from all WC cut off categories did not experience any post surgery complication while 26.5% of females did not experienced any post surgery complications. Females with a WC cut off of \( \leq 88 \text{cm} \) had more post surgery complications with 75% that experienced one to more than two complications, followed by 70.6% females with a WC cut off \( > 88 \text{cm} \). The male participants who experienced one to more than three post surgery complications were almost evenly divided with just over 54.2% males with a \( \leq 102 \text{cm} \) WC cut off and 53.2% of males with a WC cut off \( > 102 \text{cm} \).

The frequency of the post operative complications after 24 hours post surgery was higher than within first 24 hours, with almost two thirds of the females in both WC groups who experienced a post operative complication and almost half of the males in both WC groups who experienced post operative complications. The lower the WC did not necessarily mean less complications, however, the percentage was similar for both the female and male groups. The other difference is that all WC categories had one to three or more complications after 24 hours post surgery. While only the WC \( > 88 \text{cm} \) females and \( > 102 \text{cm} \) males had three or more complications within the first 24 hours post surgery.

Table 19 Collection point two: Frequency of combined post operation complications for each waist circumference category.

<table>
<thead>
<tr>
<th>WC</th>
<th>No risk factors ( n=51 ) (%)</th>
<th>1 risk factors ( n=34 ) (%)</th>
<th>2 risks factors ( n=32 ) (%)</th>
<th>3 or more risks factors ( n=30 ) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Female</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \leq 88 \text{cm} ) healthy</td>
<td>6 (25%)</td>
<td>7 (29.2%)</td>
<td>6 (25%)</td>
<td>5 (20.8%)</td>
</tr>
<tr>
<td>( &gt; 88 \text{cm} ) unhealthy</td>
<td>19 (27.9%)</td>
<td>17 (25%)</td>
<td>13 (19.1%)</td>
<td>18 (26.5%)</td>
</tr>
<tr>
<td><strong>Male</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \leq 102 \text{cm} ) healthy</td>
<td>11 (45.8%)</td>
<td>6 (25%)</td>
<td>3 (12.5%)</td>
<td>4 (16.7%)</td>
</tr>
<tr>
<td>( &gt; 102 \text{cm} ) unhealthy</td>
<td>15 (46.9%)</td>
<td>4 (12.5%)</td>
<td>10 (31.3%)</td>
<td>3 (9.4%)</td>
</tr>
</tbody>
</table>
4.8.6 Collection point two: Frequency of post operative CVS complications for each waist circumference category.

The following section presents the frequency of CVS within each gender group and WC category at collection point two and are presented in Table twenty. Most female participants within the WC $\leq 88$cm group had no CVS co-morbidity (83.4%) and an equal percentage (8.3%) had either one CVS complication or two CVS complications. There were no participants in this group who had three CVS complications. Females in the $> 88$cm group had 86.5% who had no CVS complications, 7.6% had one CVS co-morbidity and a small percentage (5.9%) who had two CVS complications. There were no participants in this group who had three CVS complications.

Three quarters (75%) of males in the WC $\leq 102$ group had no CVS complications. A quarter (25%) of the males in this group had one CVS complication and there were no participants in this group who had two or more CVS complications. There were more males in the WC $> 102$ group (90.6%) who had no CVS co-morbidity than the males in the WC $< 102$cm group. A small percentage (6.3%) in the WC $> 102$cm group had one co-morbidity and 3.1% had two CVS complications. There were no participants in this group who had three or more CVS complications.

4.8.7 Collection point two: Frequency of post operative respiratory complications for each waist circumference group.

The frequency of respiratory co-morbidities pre surgery and the WC cut off point are shown in Table twenty. The following section describes the frequency of respiratory co-morbidities by gender and WC category. The majority of females (79.2%) in the $\leq 88$cm group had no respiratory complications and 12.5% had one respiratory. A small percentage (4.2%) had two complications and three complications respectively. Females in the $> 88$cm group had the lowest frequency overall (71.6%) of no respiratory complications and had the greatest percentage overall (14.9%) of one respiratory complication. A small percentage (6%) had two respiratory complications and 7.5% had three or more respiratory complications.

Most males within the WC $\leq 102$cm had no respiratory complications (87.5%) and a small percentage (8.3%) had one respiratory complication. There were no participants in this group that had two respiratory complications but 4.2% who experienced three or more
complications. The males in the WC > 102cm group had 84.4% that had no respiratory complications and shared the same percentage (12.5%) with females WC ≤ 88cm of one respiratory complications. A small percentage (3.1%) who had two respiratory complication and there were no participants in this group who had three or more respiratory complications.

4.8.8 Collection point two: Frequency of other post operative complications for each waist circumference category.

The frequency of other post operation complications in relation to each gender and WC category at collection point two is shown in Table twenty. Just over a quarter (29.2%) of females within WC ≤ 88cm did not experience any respiratory complications post operatively. However there were 41.7% in this group who experienced one complication in the other category and under a quarter (20.8%) who had two other complications. A small percentage (8.4%) had three or more complications. The females in the WC > 88cm had just over a third (35.8%) who experienced no other complications post operation. There were 40.3% who had one other complication followed by under a quarter (20.8%) who experienced two other complications post operation and 9.5% who had three or more other complications.

Just over half (54.2%) of the males in the ≤ 102cm group experienced no respiratory complications post operations and a third (33.3%) of males had one respiratory complication. The remainder (21.9%) had two other complications and there were no participants in this group who had three or more respiratory complications post operation. Just under half (46.9%) of the males in the > 102cm group had no other complication with just under a third (31.3%) who had one other complication. Almost a quarter (21.9%) experienced two other complications and there were no participants in this group who experienced three of more other complications.
Table 20 Collection point two: Frequency of post operation complications for each waist circumference category.

<table>
<thead>
<tr>
<th>WC</th>
<th>No complications n=125 (%)</th>
<th>1 complication n=15 (%)</th>
<th>2 complications n=7 (%)</th>
<th>3 or more complications n=0 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CVS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 88cm</td>
<td></td>
<td>20 (83.4%)</td>
<td>2 (8.3%)</td>
<td>2 (8.3%)</td>
</tr>
<tr>
<td>Healthy</td>
<td></td>
<td>58 (86.5%)</td>
<td>5 (7.6%)</td>
<td>4 (5.9%)</td>
</tr>
<tr>
<td>&gt; 88cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unhealthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td>18 (75%)</td>
<td>6 (25%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>≤ 102cm</td>
<td></td>
<td>29 (90.6%)</td>
<td>2 (6.3%)</td>
<td>1 (3.1%)</td>
</tr>
<tr>
<td>Healthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 102cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unhealthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory</td>
<td>n=115 (%)</td>
<td>n=19 (%)</td>
<td>n=6 (%)</td>
<td>n=7 (%)</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 88cm</td>
<td></td>
<td>19 (79.2%)</td>
<td>3 (12.5%)</td>
<td>1 (4.2%)</td>
</tr>
<tr>
<td>Healthy</td>
<td></td>
<td>48 (71.6%)</td>
<td>10 (14.9%)</td>
<td>4 (6.0%)</td>
</tr>
<tr>
<td>&gt; 88cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unhealthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td>21 (87.5%)</td>
<td>2 (8.3%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>≤ 102cm</td>
<td></td>
<td>27 (84.4%)</td>
<td>4 (12.5%)</td>
<td>1 (3.1%)</td>
</tr>
<tr>
<td>Healthy</td>
<td></td>
<td>24 (35.)</td>
<td>27 (40.3%)</td>
<td>9 (13.4%)</td>
</tr>
<tr>
<td>&gt; 102cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unhealthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>n=59 (%)</td>
<td>n=55 (%)</td>
<td>n=23 (%)</td>
<td>n=10 (%)</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 88cm</td>
<td></td>
<td>7 (29.2%)</td>
<td>10 (41.7%)</td>
<td>5 (20.8%)</td>
</tr>
<tr>
<td>Healthy</td>
<td></td>
<td>24 (35.)</td>
<td>27 (40.3%)</td>
<td>9 (13.4%)</td>
</tr>
<tr>
<td>&gt; 88cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unhealthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td>13 (54.2%)</td>
<td>8 (33.3%)</td>
<td>2 (8.3%)</td>
</tr>
<tr>
<td>≤ 102cm</td>
<td></td>
<td>15 (46.95%)</td>
<td>10 (31.3%)</td>
<td>7 (21.9%)</td>
</tr>
<tr>
<td>Healthy</td>
<td></td>
<td>24 (35.)</td>
<td>27 (40.3%)</td>
<td>9 (13.4%)</td>
</tr>
<tr>
<td>&gt; 102cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unhealthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.8.9 Summary: Post-surgery complications at collection point two (SOU).

This section has presented the data collected during the participants stay in the SOU and after 24 hours post operation. The results were presented as tables and described the frequency of post operative complications (CVS, respiratory, other) in relation to the BMI and
WC groups. Discharge delays at two post operative collection points are presented in the next section of this chapter.

4.9 Discharge delays

4.9.1 Discharge delays at two post operative collection points.

During the hospital stay, discharge criteria are used in all areas to assess the patient prior to transferring to the next stage of the post surgery recovery journey. The following section describes the discharge criteria and the frequency of discharge delays due to medical reasons and the discharge destination at both post operative collection points (see table twenty-one). The data collection used the clinical pathway guidelines to define the discharge delay criteria at each collection point. The expected discharge criteria were used to help explore the relationship between discharge delay and the association with post operative complications and body fat composition.

4.9.2 Collection point one (PACU/SCU)

At collection point one, only 1.4% participants were delayed from discharge within the first two hours post operation and 4.1% were delayed from discharge from the SCU (that is within first 24 hours post operation). One participant (0.7%) was transferred to the tertiary hospital with post operative complications but did not return to the primary hospital for medical reasons. Therefore the number of participants was reduced from 148 at collection point one (within the first 24 hours post surgery) to 147 participants at collection point two (after 24 hours post surgery).

4.9.3 Collection point two (SOU)

Although a total of 9.5% of the participants exceeded their expected discharge criteria, only a total of 5.4% exceeded their expected discharge date to medical reasons and 4.1% were discharged to another hospital for further rehabilitation or convalescence prior to returning home. There were no participants discharged from SOU (at the primary hospital) to the tertiary hospital with post operative complications requiring further medical care.
Table 21 Discharge delay at two post operative collection points.

<table>
<thead>
<tr>
<th>Post operative data collection points</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PACU</strong></td>
<td></td>
</tr>
<tr>
<td>discharge delayed &gt; 2 hours for medical reasons</td>
<td>2 (1.4%)</td>
</tr>
<tr>
<td><strong>SCU</strong></td>
<td></td>
</tr>
<tr>
<td>discharge delayed for medical reasons</td>
<td>6 (4.1%)</td>
</tr>
<tr>
<td>Transferred to tertiary hospital (ICU, CCU, Emergency Department) within initial postoperative 24 hours and did not return to primary hospital</td>
<td>1 (0.7%)</td>
</tr>
</tbody>
</table>

**Discharge from the Surgical Orthopaedic Unit**

| Discharged home at expected discharge date | 133 (91.%) |
| Exceeded expected discharge date for medical reasons | 8 (5.4%) |
| Discharged to other ward/hospital for further Rehabilitation | 6 (4.1%) |
| Transferred to tertiary hospital (ICU, CCU, Emergency Department) after 24 hours postoperative and did not return to the primary hospital | 0 (0%) |

### 4.10 Summary

This chapter presented the descriptive statistics of the study population, along with frequencies of complications and discharge delays by BMI and WC categories. Tables were used to present the results of the data collection. Although the pilot study was unable to test the hypothesis through inferential statistical analysis due to the small participant numbers and multiple variables, descriptive statistics were used to consider the research question “Which anthropometric measurement tool may be best able to effectively indicate potential post-operative health risks in today’s clinical setting?” Chapter five will discuss the results presented in this chapter and will include the limitations of the pilot study and recommendations for further research. The frequencies of co-morbidities pre-surgery and post surgery at two post operative collection points and the association with the BMI and WC measurements will be used to explore the pilot study objectives in Chapter five.
5 Discussion

5.1 Introduction

The pilot study investigated the association between two assessment tools used to measure body fat and post operation complications following elective joint replacement surgery. A total of 148 participants who were admitted for joint replacement surgery, were recruited over a period of 18 months. Due to the small participant numbers and multiple variables, inferential statistical analysis was not able to test the research question. Descriptive statistics are presented as tables in the results chapter and these looked at individual characteristics of the variables and include the range, frequency, mean and standard deviation.

This pilot study aimed to evaluate the BMI with WC Measurement as risk indicators of postoperative complications for elective joint replacement patients. An important concept was considered as to whether the BMI is still the best tool to use as a health risk indicator in today’s clinical setting. Within the pilot study consideration was also given to explore the association between the BMI and WC measurements as effective risk indicator tools to help in identifying potential post-operative complications for patients who receive elective joint replacement surgery.

This chapter will discuss the findings of the results and the limitations of the pilot study. First, the chapter will discuss and compare the demographics findings (age, gender, ethnicity, smoking, obesity and joint replacement and BMI) with the information from the literature. Second, the chapter will discuss the findings at the three collection points (pre surgery, with 24 hour post operation and after 24 hour post operation) and compare the results with the literature. To maintain consistency with the descriptions of the BMI and WC categories used in the Results chapter and in the reviewed literature, these definitions will be used throughout the discussion chapter. The limitations of the pilot study will be discussed with suggestions for future studies. Research implications and a conclusion will follow the discussion chapter.
5.2 Demographics

5.2.1 Age

To provide an understanding of the demographics of the sample group, age was collected as part of the demographic information (Table 6, page 50). The average age of the participants in the pilot study was 68 years. This is similar to the New Zealand National Joint Register where the average age recorded in 2008 for primary THR was 66.84 years and for TKR was 68.71 years (New Zealand Orthopaedic Association [NZOA] 2009). Naylor, Harmer, and Heard (2008) study had an average age of 65 years for THR and 70 years for TKR. Other studies such as Andrew et al. (2008) and Foran, Mont, Etienne, Jones & Hungerford, (2004) also had similar average ages to that of the sample population in the pilot study. Andrew et al.’s (2008) study had an average age of 69.1 years in a non obese group and 65.5 years in an obese group. Foran’s (2004) study had an average age of 70 years in a non obese group and 66 years in an obese group. However a study by Oka et al. (2008) had a lower mean age compared to that of other studies. Men had an average age of 50.4 years and women an average age of 51.5 years. The narrower recruitment age range (38–60 years) of the population may have influenced the lower mean age in Oka et al. (2009) study where as other studies appeared to have a wider age range of the population (Andrew et al., 2008; Foran et al., 2004; Naylor et al., 2008). These studies included an age range of 21.3-94.9 years (Andrew et al., 2008) and 35-83 years in the Foran et al. (2004) study. Naylor et al. (2008) did not provide an age range. It is interesting to note that the demographic age of the participants in pilot study age was of similar average these other studies.

The literature review discussed whether age may influence body fat composition. It is considered that menopausal women may have more of a predisposition to increased abdominal adipose tissue than the younger population and therefore have a greater risk of developing metabolic diseases such as type II diabetes mellitus and cardiovascular disease (Oka et al., 2009; Woo et al., 2002). The trends in the pilot study suggested that obesity may not be the only contributing factor to the complexity of post operative complications. An age range of 43 to 86 years may indicate that women of menopausal and post menopausal age were included in this pilot study. As age generally has an influence on the ASA score, it is possible that age may be a contributing factor towards post operative outcomes in this pilot
study. To better understand the associations between age and obesity and health outcomes post surgery, further research needs to be undertaken.

5.2.2 Gender

Gender was collected as part of the demographic information in this pilot study (Table 6, page 50). The information was used to help interpret and understand the population. The pilot study had more female (62.2%) than male (37.8%) participants who received joint replacement surgery. The higher number of females than males in this pilot study was consistent with other studies. Most of the studies found that, irrespective of the sample size, there were greater percentages of female than male participants in their studies (Andrew et al., 2008; Foran et al., 2004; Lubbeke et al., 2007; Lubbeke et al., 2008). The literature supports the concept that more females than males are receiving TKR, and likewise OA is a more common clinical issue with females than males (Andrew et al., 2008; Lubbeke, Stern, Garavaglia, Zurcher & Hoffmeyer, 2007; Liu, Della Valle, Besculides, Gaber & Memtsoudis, 2009; Memtsoudis, Della Velle, Besculides, Gaber, & Laskin, 2009b). The 2008 New Zealand National Joint Register recorded 10% more females than males receiving primary THR and 6.4% more females than males receiving primary TKR (NZOA 2009). This raises the question as to whether more females in the population are requiring joint replacement surgery as a result of OA than males?

Depending on the anthropometric measurement used, the definition of obesity can vary by gender. Only one study could be found that explored the association between gender, body composition and orthopaedic surgical outcomes using BMI and Waist Height Ratio (WHR). The findings of Gandi, Dhotar, Tsvetkov and Mahomed (2010) showed that when BMI was used to define obesity, there were slightly more females than males defined as obese (38% and 42% respectively). In comparison, more males than females were defined as obese when the WHR was used to define obesity (92% and 82% respectively). The two guidelines used to define obesity in this pilot study were the WHO BMI guidelines and the New Zealand Dietetic Association guidelines for waist circumference measurements. The WHO guidelines did not differentiate between gender and BMI whereas the New Zealand Dietetic Association guidelines do make a distinction between gender and WC. For that reason gender was included in defining the WC categories but not for the BMI categories in this pilot study. Although the relationship between gender, BMI groups and type of surgery was not
specifically looked at in this pilot study, a trend between gender and the type of surgery was observed.

While it appears more females than males are undergoing a total knee replacement (TKR) due to OA, in association with obesity, the question naturally rises as to whether gender makes a difference to outcomes following joint replacement surgery? The first study known to explore the gender differences between related to outcomes in obese patients undergoing primary total hip replacements (THR) was conducted by Lubbeke et al. (2007). Of the 2,186 patients in this study, 1,217 were female and 969 were male and of this cohort, there were more obese males than females (26.7% and 20.5% respectively). Non obese males had a higher rate of infection than obese males, females and non obese females. Of the female group, more obese females than non obese females had a higher rate of deep wound infections. Obese females also had a greater risk of dislocations resulting in the need for revision of the hip joint surgery. The five year follow up study found that although there was an association with obesity and an increase in infection, dislocation and subsequent revision, obese females had less quality of life from co-morbidities, satisfaction and general health than the males. The study suggested that more attention preoperatively is needed for females defined as obese and that weight loss prior to surgery would be advantageous in preventing the increased risk of complications among obese females (Lubbeke et al., 2007). To better understand the associations between gender and obesity and predictive health outcomes post surgery, further research needs to be undertaken.

5.2.3 Ethnicity

The ethnicity data collected in this pilot study was used to provide an understanding of the demographic profile of the population (Table 6, page 50). However the population in this pilot study was too small to explore the relationship between ethnicity, BMI, WC and post operative complications. Likewise the literature was limited on this subject. It is important to note that the population of Asian Indians in New Zealand is estimated to increase by 13% within the next 10 years and therefore the role of ethnicity in understanding body composition and post operative complications is an important one that requires further investigation. It is widely accepted that obesity contributes to type II diabetes mellitus and because of this it is important that the appropriate assessment of body fat composition specific to the different ethnic groups is used. This is especially relevant as the diagnosis of type II diabetes mellitus
among Asian Indians in New Zealand currently exceeds that of the Māori and Pacific Peoples (Duncan et al., 2004).

The use of BMI, WC and the reclassification of cut off points for different ethnic populations remains a contentious issue. It is purported that based on the same body size at a given BMI, Māori and Pacific Peoples have a lower percentage of body fat and higher fat free mass than New Zealand European adults and Asian ethnic groups have a higher level of body fat than New Zealand European adults. This puts the Asian ethnic groups at greater risk of obesity related diseases at relatively lower BMI scores (Duncan et al., 2004; Hughes et al., 2004, Swinburn et al., 1998). Further studies are needed to understand the health needs of the ethnic groups in New Zealand and to include the use of appropriate obesity assessments to help tailor preventative health strategies.

5.2.4 Smoking

To help describe and understand the population in this pilot study, smoking status of the participants was collected (Table 6, page 50). Included in the pilot study were 54.1% who had never smoked, 41.9% who were previous smokers and 4.1% who were current smokers. The low percentage of current smokers in the pilot study could be contributed by the greater opportunities for people to be smoke free with the help of the introduction of smoke free hospitals and smoke free campaigns promoting smoking cessation programmes. During the patient journey, patients on the elective surgery list for joint replacement surgery are given opportunities to become smoke free over a six month period. Patients are given opportunities initially by their GP, this is then followed up at the orthopaedic outpatient clinic by nurses, surgeons and anaesthetists and again on the day of admission for surgery. While the aim of the pilot study was to examine the BMI and WC as a risk indicator of postoperative complications, it was not necessary to examine the association between smoking status, obesity and joint replacement surgery. However this is an interesting and clinically relevant topic and warrants further research.

A study by Azodi, Bellocco, Eriksson and Adami (2006) under took a retrospective study of patients undergoing primary hip replacement and examined the impact of tobacco use and BMI on the length of stay in hospital and the risk of post operative complications. Length of stay will be discussed further in this chapter. Of the 3,309 participants in the study, 11.3% developed one or more post operative complication. The risk of post operative complications
for smokers compared with non smokers was 43% for previous smokers, and 56% for current smokers. The obese patient had a 58% greater risk of post operative complications than non obese patients. Smoking and obesity increase the risk of developing chronic health problems which contribute to the co-morbidity risk factors for surgery. The findings of Azodi et al.’s (2006) study showed that there was an increased risk of post operative complications related to smoking and a high BMI after a primary hip replacement. A deeper understanding of the association between smoking, obesity and post operative complications is needed and should be considered for future studies.

5.2.5 Obesity and joint replacement surgery

The pilot study examined the relationship between joint replacement surgery, obesity and postoperative complications to help provide an understanding of the sample group (Table 6, page 50). This pilot study had an even split of 50% of participants in the non obese group (normal weight and overweight) and 50% in the obese and morbidly obese group. While more THR surgery (52%) was undertaken in this pilot study than TKR surgery (31.8%) it was inconclusive as to whether more obese and morbidly obese individuals required joint replacement than the non obese group and therefore could not support other studies either way.

As previously discussed in the literature, it is widely accepted that obesity is on the increase globally. It has been suggested that obesity not only contributes to both musculoskeletal and metabolic co-morbidities but may also be associated with end stage OA resulting in joint replacement surgery (Amin et al., 2006; Andrew et al., 2008; Dowsey & Choong, 2008; Lubbeke et al., 2007; Stein & Colditz, 2004; Vincent et al., 2007; Wang et al., 2009). Two separate overseas studies showed obesity as a significant factor predisposing people to joint replacement. A study by Wang et al. (2009) found obesity contributed more toward hip replacements however Lubbekke et al. (2007) showed a higher prevalence in knee replacements in the obese individual. Hip and knee replacement surgery introduced in the 1960’s, is used worldwide for the treatment of end stage OA. Since then the number of THR and TKR surgery has dramatically increased, especially in the USA. The number of THR surgeries performed in the USA from 1990 to 2004 increased by 158% and the number of TKR surgeries increased by 125%. The annual number of TKR surgery in the USA is expect to increase to almost to half a million by the year 2030 (Memtsoudis et al., 2009 b; Liu et al., 2009; Wang et al., 2009). The study by Liu et al. (2009) suggested that the need for joint
replacements (especially THR), is increasing at a greater rate than population growth or ageing.

The number of patients registered on the New Zealand national joint register between 1999 and 2008 has also increased. The increase in annual joint registration since 1999 includes 56.6% more primary TKR and 70% more primary THR (NZOA 2009). The latest figures of primary hip and knee replacement performed in New Zealand includes 63,694 and 46,091 respectively in 2009. The number of hip replacements performed in New Zealand is estimated to increase by 10,000 per year by 2051 (NZOA, 2003). Statistics retrieved from monthly surgical reports of the primary care hospital for elective orthopaedic surgery in Christchurch, have shown that the percentage of elective joint replacement surgery between 2001 and 2010 has increased by 87%. In 2007 a fourth operating theatre was built at the primary hospital for elective orthopaedic surgery to meet the demand of the increased need for joint replacement surgery. From 2007 there has been an increase of 14.2% joint replacement surgery performed at the hospital. Further research is needed to explore the relationship between joint replacement surgery, obesity and postoperative complications.

5.2.6 Body Mass Index

This pilot study found that when BMI was used to define obesity, 38.5% were obese, 33.1% were overweight, 16.9% were of normal weight, and 11.5% were morbidly obese (Table 6, page 50). The difference in percentages appeared to be similar to that of previous studies. Of the 80 participants in Bowditch and Villar’s (1999) study 35% were overweight and 23% were obese. In another study of 1,421 participants 23% were obese and 1.3% were morbidly obese (Andrew et al., 2008). The low occurrence of morbidly obese participants in the pilot study could be explained by the pre surgery assessment and the CDHB recommended guidelines for primary THR and TKR (see Table three, section 2.8) This concurs with Andrew et al. (2008) study that also suggested that the low number of morbidly obese patients in their study was possibly as a result of pre surgery assessment where patients are encouraged to reduce weight prior to surgery or are considered unfit for surgery.

While studies agree that BMI is the most commonly used measure of obesity and has a strong risk indicator for hip and knee replacement surgery, BMI is unable to distinguish from muscle mass and body fat (Amin et al., 2006; Duncan et al., 2004; Han et al., 2006; Rush et al., 1998; Wang et al., 2009). Further study is needed to examine the association between
anthropometric measurements and body fat distribution with joint replacement patients and OA. In a previous study both BMI and WC were found to be a strong risk indicator for hip and knee replacement surgery. Waist circumference measurements were found to be a stronger indicator than WHR. WHR was a strong risk indicator for knee replacement surgery but a weak risk indicator for hip replacement surgery (Wang et al., 2009).

The increase in obesity rates worldwide and the growing strain on health resources discussed in the literature review raises the question of the link between the increase in obesity and increase in joint replacement surgery, in particular THR. The literature suggests that the number of obese patients presenting for THR is increasing and concerns have been raised that this population group have an increased risk of post operative complications. It has been reported that obese joint replacement patients tend to have more peri-operative complications than non-obese patients. It is thought that the longer operating time required with the morbidly obese may contribute to the increased chances of post operative complications than with non obese groups (Andrew et al., 2008; Bamgbade, Rutter, Nafiu & Dorji, 2007; Dowsey & Choong, 2008; Finkelstein, et al., 2009; Lubbeke et al., 2007, Stein & Colditz, 2004; Swinburn et al., 1997).

In 2005 a strategy was initiated in the United Kingdom (UK) that denied patients requiring THR surgery on the basis of obesity. Due to pressure on hospital budgets, some hospitals in Suffolk in the UK governed that patient with a BMI > 30 would not be eligible for surgery. This decision created debate across the medical profession and patient advocacy services (Obese patients denied operations, 2010). However Andrew et al. (2008) and Horan (2006) do not supported this view and argue that patients should not be denied surgery on the basis of obesity. Andrew et al. (2008) and Horan (2006) both agree that while obese patients should not be denied surgery, it is only the morbidly obese patients who are at greater risk of post operative complications. Furthermore the Andrew et al. (2008) study observed that morbidly obese patients undergoing TKR are more likely to have poorer post operative results than morbidly obese patient undergoing THR surgery.

Previous studies have discussed the association between obesity and OA, particularly TKR in females and the increased risk of the obese patient requiring joint replacement surgery as a result of OA. Obesity is described in previous studies as a co-morbidity for surgery. In this pilot study the co-morbidities known to be associated with post operative complications
and obesity were used to help identify the association between obesity and post operative complications.

5.3 Co-morbidity categories

The BMI and WC measurements were used to independently define obesity in this study and were used to explore which measurement tool may be best able to identify pre-existing co-morbidities. Co-morbidity categories in relation to post operative outcomes in this pilot study were consistent with the co-morbidities associated with post operative outcomes found in the literature (Chung, Mezei & Tong, 1999; Liu et al., 2009; Memtsoudis et al., 2009a). The co-morbidities included in Chung et al. (1999) associated with post operative outcomes included the following; hypertension and intraoperative cardiovascular complications, obesity, asthma and smoking and intra operative and post operative respiratory complications, GORD and intubation related complications. In Chung et al.’s (1999) study type II diabetes mellitus and COPD did not appear to be a risk factor for PE. Although some studies disagree that obesity is a risk factor for PE, they also suggest that results from these studies have limitations due to small sample size (Karunakar, Shah & Jerabek, 2005; Memtsoudis et al., 2009a). The risk factors for PE following hip and knee replacement surgery was explored in an American study by Memtsoudis et al. (2008). Co-morbidities such as cerebrovascular and renal disease, obesity and dementia were associated with the increased risk of PE. However patients with diagnosed coronary artery disease had a decrease in PE rates. It was suggested that the reason for this was the pre surgery assessment and careful postoperative management plan that included close monitoring and anti-platelet therapy which may decrease the risk of PE. Renal failure was identified as a risk factor for venous thromboembolism in the post operative patient including orthopaedic patients.

In this pilot study all of the participants in the morbidly obese group had at least one or more co morbidity (Table 7, page 51). The trend showed that the majority of those in the obese group had one or more co morbidity followed by those in the overweight group. Participants in the healthy weight group just over half (68%) having one or more co-morbidity. The trend showed that the higher the BMI the greater the frequency of co-morbidities with the morbidly obese at greatest risk of co-morbidities. There appeared to be greater association between BMI and CVS and other co-morbidities than between BMI and respiratory co-morbidity (Table 8, page 52).
The WC was divided into gender specific cut off points (Table 9, page 55). The results for WC as an indicator of post operative outcomes in this pilot study showed that more females fell into the healthy group (76.1%) than unhealthy group (23.9%). More males also fell into the healthy group (57.1%), than the unhealthy (42.9%). However there appeared to be a smaller variance between the healthy and unhealthy male groups than the healthy and unhealthy female groups. Both genders showed a trend whereby the greater the WC the more co-morbidities were present. The findings of Gandi et al. (2010) when WHR was used to define obesity were similar to that of the pilot study. The trends in the pilot study showed that a greater number of males were defined as obese compared to females when WC was used.

Females with an unhealthy WC observed a greater trend for multiple co-morbidities than females with a healthy WC. Females with a healthy WC observed a lower trend of CVS co-morbidities than unhealthy WC (41.7% and 70.6% respectively) (Table 10, page 57). However the results were reversed for men. Males with a healthy WC had a greater trend of CVS co-morbidity than men with an unhealthy WC (88.4% and 68.7% respectively). The CVS co-morbidities in relation to males with an unhealthy WC did not appear to be linked. As a greater percentage of males in this study had an unhealthy WC than females with an unhealthy WC (42.9% and 23.9% respectively), this trend was unexpected, especially as the literature suggests that the measurement of abdominal fat using either WC or WHR are better predictors of chronic diseases including type II diabetes and CVS disease than BMI (Deurenberg & Yap, 1999; Duncan et al., 2004; Ness-Abramof & Apovian, 2008).

Males with an unhealthy WC appeared have a more linear relationship with respiratory and other co-morbidities than CVS co-morbidities (Table 10, page 57). However the trends between the frequency of co-morbidities and the two male WC groups showed a marginal difference. The results from this study suggest that obesity appears to be a potential indicator of co-morbidities. Waist circumference may be a more useful co-morbidity indicator for females than males. The BMI may be useful as an indicator for CVS and other co-morbidities but possibly less useful as an indicator for respiratory co-morbidities.

5.3.1 Pre-surgery co-morbidity described with post operative complications.

Bamgbade et al. (2007) conducted a study in a large teaching hospital in the state of Michigan in the USA. The 2005 study showed that while 25% of the Michigan population...
were obese, 32.7% of the post operative complications occurred in the obese patient. It is interesting to compare this to figure with the annual incidence of post operative complications in the USA of patients receiving general surgery. Mangano, (2004) reported that of the 33 million patients per year undergoing surgery in the USA, 4% experienced medical post operative complications. This may suggest that obese individuals may have a higher rate of post operative complications than non obese individuals.

Post operative complications are not only associated with age, gender and smoking but also with co-morbidities. Co-morbidities are defined when a chronic illness develops into multiple chronic health problems (Bamgbade et al., 2007; Verbrugge et al., 1989, Williams, Dunning & Maias, 2007). Most studies agree that the presence of co-morbidities (such as type II diabetes mellitus, hypertension, pulmonary, coronary, renal, peripheral and vascular disease and obesity) increase the risk of developing post operative complications including wound infection or impaired wound healing and myocardial infarction. Obesity is also a known co-morbidity for surgery and is often referred to as an independent risk factor for chronic health problems that increases the risk of post operative complications (Andrew et al., 2008; Bamgbade et al., 2007; Best, 2005, Karunakar et al., 2007; Liu et al., 2009; Lubbeke et al., 2008).

Anaesthetists use the ASA score as an indicator of co-morbidity risk factors rather than a surgical risk indicator (Bamgbade et al., 2007). A definition of the ASA score is provided in the Methods chapter. The ASA score for participants included in the pilot study ranged from ASA 1 (a normal healthy patient) to ASA 3 (a patient with severe systemic disease). Bamgbade et al. (2007) showed that the obese patient was classified as a high ASA rating based on the obesity and co-morbidities and suggested that obesity itself is a co-morbidity risk factor that increases the ASA score. The pre surgery variables used in this pilot study were divided into three main co-morbidity categories; CVS, respiratory and other. To help identify the pre surgery variables, the ASA score was used along with the EWS. The objective of the pilot study examined the association between BMI, WC and obesity and was never intended to look at the association between ASA score and obesity. However the association between the ASA score and obesity is something that warrants further research and could be explored in a future study.
5.3.2 Co-morbidities and post operative complications.

The association between co-morbidities and the frequency of post operative complications described in this pilot study were observed at two post operative collection points (Table 11, page 59). First, the trend between the number of co-morbidities and the frequency of post operative complications at collection point one (within the PACU and SCU) showed that of those who had no co-morbidities, almost all (92%) had no post operative complications. Whereas 43.6% of those with ≥ 3 co-morbidities, had no post operative complications. The trend was that the more co-morbidities, the greater the frequency of post operative complications within the first 24 hours post surgery. Second, the trend between the number of co-morbidities and the frequency of post operative complications at collection point two (SOU) showed that of participants who had no co-morbidities, 36% had no post operative complications. However of those with ≥3 co-morbidities, 23.7% had no post operative complications. As one could anticipate, co-morbidities have an influence on the post operative outcomes. There may be a nonlinear relationship between co-morbidities and post operative complications within the first 24 hours and a linear relationship between co-morbidities and post operative complications > 24 hours post surgery. The complexity of the post operative complications associated with co-morbidities and obesity at the two collection points may explain the difference in the linear relationship. This is discussed further in this section.

Some studies suggest that co-morbidities may increase the presence of post operative complications by as much as 10.3% and can be useful predictors for postoperative complications. The main co-morbidities that lead to post operative complications include obesity, diabetes, hypertension and pulmonary disease (Chung et al., 1999; Memtsoudis et al., 2009a). An Australian study by Williams et al. (2007) examined the continuity of care and wellbeing of patients with co-morbidities in a cohort of 20 patients undergoing primary total hip and knee arthroplasty. The study found that the greater the frequency of co-morbidities the more additional stress of surgery was felt by the participant. The co-morbidities appeared to influence post operatively events such as depression, vertigo, lower back pain, angina and urological problems. Post-operative pain did not appear to be a problem during the perioperative phase but a more important issue on discharge. The results of this pilot study concurs with previous studies that co-morbidities may have an association with post operative complications. The time frame of when the most critical complications occur within the post
operative phase is an important issue. This is explored later in this chapter when the postoperative complications at collection point one and two are discussed.

### 5.3.3 Frequency of post operative complications at two post operative collection points.

The frequency of post operative complications at the two postoperative data collection points showed a higher frequency of post surgery complications during the SOU stay than during the first 24 hours post surgery (PACU/SCU) (Table 12, page 60). At collection point one, 35.2% participants had one or more post operative complications within the first 24 hours, however there was an increase of 63.8% after 24 hours. Irrespective of the number of co-morbidities, there was a higher frequency of post operative complications after the initial 24 hours, than within the first 24 hours. One possibility could be the shorter length of stay required in the PACU and SCU and the longer stay of four to five days on the SOU. It is speculated that the longer length of stay on the SOU could allow for more time to present post operative complications. This hypothesis seems to be consistent with a four year study undertaken from 2000 to 2004 that showed serious post operative complications are more likely to be observed within the first few days after surgery (Memtsoudis et al., 2009a).

Although the pilot study showed greater frequency of complications > 24 hours post operation, the complexity of the post operative complications and level of nursing and medical care at both collection points should not be over looked. During the stay in the PACU and SCU the individuals are continuously monitored with Datex monitors and closely observed by a 1:2 nurse patient ratio and medical care that includes anaesthetists and a senior house officer. Potential post operative complications may be identified earlier allowing for early intervention of treatment. Individuals who did not meet the discharge criteria to transfer to the SOU either remained in the SCU or were transferred to the tertiary hospital for further intensive monitoring or treatment.

This was evident when one participant was transferred to the tertiary hospital for further intensive care following a life threatening post operative complication. This participant remained in the tertiary hospital to receive further intensive treatment and was discharged home from that hospital. Since the participant did not return to the primary hospital and that the data for the pilot study were only relevant to the primary hospital, information was not collected at collection point two. The important factor here is the complexity and critical level of the post operative complication within the first 24 hours.
5.4 Post-operative complications at collection point one (PACU/SCU).

5.4.1 Overall post operation complications with 24 hours post surgery.

Findings by Karunakar et al. (2005) concluded that the higher the BMI the higher the risk of post operative complications in the orthopaedic patient such as estimated blood loss, wound infection and DVT. This study also found that those with a BMI ≥ 30 had 2.6 times greater risk of developing DVT compared with those who had a BMI < 25. Despite this finding the pilot study did not have any confirmed DVT events within the first 24 hours post surgery.

The trends in this pilot study (Table 13, page 61) did not appear to concur with Karunakr et al. (2005) study as a higher the BMI did not necessarily increase the occurrence of post operative complications within the first 24 hours post surgery. Of those who experienced more than one post surgery complication, the morbidly obese group had the highest percentage of 47% followed by the healthy weight group (40%). The trends for the overweight and obese groups showed a marginally lower percentage. The trends showed that although the obese group had the least percentage of post operative complications, this was the only group that had the greatest percentage of three or more post operative complications (10.5%) compared to the overweight (2%), morbidly obese (5.9%) and normal weight (0%) groups. The findings of this pilot study suggest that although the morbidly obese group had the greater percentage of overall post operative complications than the obese group, the obese group may be at greater risk of complex post operative complications than the other BMI groups within the first 24 hours post surgery.

The association between WC by gender and overall post operative complications, within the first 24 hour post operative period, showed a marginal difference of post operative complications within the female unhealthy WC category and male healthy WC category (Table 15, page 65). While the female and male healthy WC groups did not experience any more than two postoperative complications, the female and male unhealthy WC groups where the only groups who experienced three or more post operative complications. This suggests that the unhealthy WC groups may be at greater risk of experiencing more complex post operative complications compared to the healthy WC groups. All of the obese BMI groups and both unhealthy WC groups where the only groups who experienced three or more post
operative complications. This raises the question as to whether an increase in body fat
distribution also increases the frequency of post operative complications and whether this also
increases the complexity of the post operative complications. The association between the
three post operative complication categories observed within the first 24 hours and the BMI
and WC are discussed next.

5.4.2 Post operative CVS complications within 24 hours post surgery.

Obesity is known to be associated with an increased risk of cardiovascular complications.
In obese adults with hypertension a chronic increase in stroke volume can increase the
likelihood of acute myocardial ischemia and infarction, heart failure, complex ventricular
arrhythmias and sudden death (Dunn, 2005). The CVS complications observed at collection
point one in the pilot study were consistent with other studies (Gandhi et al., 2010; Zacharias
et al., 2005). The literature suggests that central obesity is the greatest contributor to chronic
diseases and the strongest risk predictor for myocardial infarction, cerebral infarction,
diverticular disease and overall mortality, regardless of BMI (Deurenberg & Yap, 1999;
Duncan et al., 2004; Ness-Abramof & Apovian, 2008). There were no events involving
cardiac arrest or angina experienced within the first 24 hours post surgery.

The results of CVS complications within the first 24 hours post surgery in this pilot
study, in relation to BMI showed trends of those who were morbidly obese or overweight
experienced more CVS complications than those who were obese or had a healthy (Table 14,
page 64). Females with an unhealthy WC had a trend towards more CVS complications than
females with a healthy WC (20.5% and 4.2% respectively) within the first 24 hours post
surgery (Table 16, page 67). However there was a marginal difference between males with a
healthy WC and males with an unhealthy WC (25% and 21.9% respectively).

One could therefore suggest that within the first 24 hours post surgery the WC may be a
more useful indictor for CVS complications in obese females compared with obese males.
The BMI may be a useful indictor for potential CVS complications in the morbidly obese and
overweight group in this pilot study.
5.4.3 Post operative respiratory complications within 24 hours post surgery.

The respiratory complications observed within the first 24 hours in this pilot study were consistent with those found in the literature. The post operative respiratory complications collected in the pilot study are provided in the Results chapter. Studies report that most respiratory complications are seen within the early postoperative period lasting for at least 24 hours after surgery. Atelectasis is a common respiratory complication observed in the obese patient over a few days after surgery (Pelosi & Gregoretti, 2010; Zoremba, Dette, Gerlach, Wolf & Wulf 2009).

Anaesthetic and analgesia medication, such as opioids are known to have an effect on the respiratory system. The drug interaction of patient’s own medication and anaesthetic drugs and compromised airway due to difficult intubation and OSA contribute to post operative complications especially for the morbidly obese patient (Pelosi & Gregoretti, 2010; Zoremba et al., 2009). The anaesthetic and analgesic drugs remaining in the adipose tissue can be released in to the body which may either re-sedate or compromise the respiratory system of the obese patient (Dunn, 2005; Pelosi & Gregoretti, 2010). This is certainly a factor that needs to be considered when caring for the obese patient within the first 24 hours post surgery. This could be a contributing factor to the complexity of the post operative complications in the PACU and SCU but not during the SOU stay.

To help prevent post operative respiratory complications, studies suggest that a non invasive ventilation therapy could be beneficial within the first 24 hours post surgery for obese and morbidly obese patients. The use of CPAP and incentive spirometers have been suggested as tools to help upload the inspiratory muscles which improve lung volume and prevent postoperative respiratory complications (Dunn, 2005; Hatfield & Tronson, 2004, Pelosi & Gregoretti 2010).

The primary hospital in this pilot study currently uses the BMI as a pre surgery assessment tool for elective orthopaedic patients to help identify potential risk of postoperative respiratory complications. Obese patients who are identified as a potential risk of developing a postoperative respiratory complication may be prescribed CPAP therapy by the anaesthetists. More commonly an incentive spirometer may be issued to the obese patient by the nurse if a patient is symptomatic. The BMI is currently used to assess for potential respiratory complications related to obesity, but the question naturally arises as to whether or
not WC measurements could also be used as a risk predictor for potential post operative respiratory complications.

A trend in the pilot study observed that the higher the BMI the more post operative respiratory complications (Table 14, page 64). The obese and morbidly obese had more post operative respiratory complications than those of normal weight or overweight. The results showed a trend of unhealthy WC and post operative respiratory complications (Table 16, page 67). More females in the unhealthy WC experienced respiratory complications than females with healthy WC. More males with an unhealthy WC experienced respiratory complications than males with a healthy WC.

Overall there was a higher frequency of CVS complications than respiratory complications within the first 24 hours (Table 14, page 64). This may suggest that there is a greater risk for CVS complications within the immediate postoperative period than respiratory complications. Nevertheless respiratory complications may still be observed greatest in the obese (> 30 BMI) than the non-obese (BMI ≤ 30) individual. The findings therefore suggest that both the BMI and WC used in this pilot study may be useful indicators for postoperative respiratory complications within the first 24 hours.

5.4.4 Other Post operative complications with 24 hours post surgery.

Bowditch and Villar (1999) and Karunkar et al. (2005) both agree that obesity is a risk factor for increase intraoperative and post operative blood loss especially in patients undergoing total hip replacement surgery. Bowditch and Villar (1999) compared the amount of blood loss in obese (> 30 BMI) and non obese (BMI ≤ 30) THR patients. The obese patient had a 30% greater increase in intra operative and post operative blood loss than non obese patients. The reason for this is thought to be because of the larger adipose surface area and possibly more tissue fluid, consequently this may result in greater tissue fluid loss as well as blood loss. Other factors that influence blood loss include the type of anaesthetic and the changes to the cardiorespiratory system. Spinal anaesthesia for example, is reported to have less blood loss because of the effect on the lower central and peripheral nervous pressures (Bowditch & Villar, 1999).

The amount of blood loss was not included in this pilot study. Participants who met the criteria for a blood transfusion within the first 24 hour post surgery were included. “Other”
post operative complications observed in this pilot study are described in the Results chapter. It is widely accepted that not only does obesity contribute to the development of type II diabetes mellitus but these two co-morbidities are believed to be two of the biggest predispositions to post operative complications (Amin et al., 2006; Memtsoudis et al., 2009a; MOH, 2009a; Von Haehling et al., 2007; WHO, 2006c). Therefore it is not surprising that unstable blood sugars are seen in the pilot study as a post operative complication within the first 24 hours post surgery. Although there were no post operative dislocations in this pilot study within the first 24 hours post operatively, some studies agree that there appears to be a slight increase in the frequency of dislocation in the morbidly obese and obese patient (Andrew et al., 2008; Bamgbade et al., 2007; Dowsey & Choong, 2008; Lubbeke et al., 2007).

The pilot study suggested that neither the BMI or WC groups appeared to have a linear relationship with the frequency of “other” post operative complications. The morbidly obese and healthy weight group had a greater trend for other post operative complications (29.4% and 24% respectively) (Table 14, page 64). The obese and overweight groups showed the lower trend for “other” post operative complications (19.4% and 14.3% respectively). The trends for WC showed that more females with a healthy WC experienced a higher percentage of “other” post operative complications than females with unhealthy WC (Table 16, page 67). More males with an unhealthy WC than males with healthy WC had “other” post operative complications. The trends suggest that although BMI was able to identify “other” post operative complications in the morbidly obese and WC identified males with an unhealthy WC, the non obese participants and females with a healthy WC were also at risk of other postoperative complications. Further research is needed to explore the association between BMI and WC and “other” post operative complications.

5.5 Frequency of post-operative complications collection point Two (SOU).

5.5.1 Overall post operation complications after 24 hours post surgery.

While some studies suggest that there is no association between obesity and post operative complications (Dindo, 2003), other studies agree that obese joint replacement patients tend to have more peri-operative complications than non-obese patients (Best, 2005). The findings of the pilot study did not appear to observe an association between BMI and
overall post operative complications after 24 hours post surgery (Table 17, page 69). There appeared to be a higher frequency of overall postoperative complications with the normal weight and overweight groups (72% and 69.3% respectively) followed by the obese group and morbidly obese group (59.6% and 58.7% respectively).

In this pilot study the association between WC and one or more post operative complications showed that there was a greater trend of females with a healthy WC who experienced more overall post operative complications than females with an unhealthy WC (75% and 70.6 respectively) (Table 19, page 72). Males with a healthy WC experienced more operative complications than males with an unhealthy WC (54.2% and 53.2% respectively). A marginal difference between healthy and unhealthy WC in both genders and post operative complications was observed. It is interesting to note that it was the non obese (BMI < 30) groups that experienced more overall post operative complications than the obese and morbidly obese groups.

The results of this pilot study noted that during the first 24 hours only the female and male with unhealthy WC experienced one or more post operative complications, whereas after 24 hours post operation all the WC groups had three or more complications. This may suggest that WC is a useful post operative risk indicator in the immediate post operative period. However neither the BMI nor WC may not be good at indicating potential overall post operative complications after 24 hours post surgery.

To further explore the association between the BMI and WC and post operative complications after 24 hours post operation, a breakdown of the overall complications into three health categories is needed. The following section discusses the WC and BMI used to indentify CVS, respiratory and other post operative complications after 24 hours post surgery.

5.5.2 Post operative CVS complications after 24 hours post surgery

Some studies suggest that the WHR measurements for central obesity is a better predictor of myocardial infarct independent of BMI (Gandhi et al., 2010; Zacharias et al., 2005). Zacharias et al. (2005) suggests that postoperative atrial fibrillation (Afib) is associated with high BMI (BMI > 30) in patients with no pre-existing Afib. The types of CVS complications observed in this pilot study at collection point two are presented in the results chapter.
Although there were no events in this pilot study involving cardiac arrest or angina however there were some who presented with an arrhythmia after 24 hours post surgery.

The results in this pilot study for CVS complications after 24 hours post surgery in relation to BMI showed that the rates of CVS complications were higher in the healthy weight and the morbidly obese groups, and marginally lower in the obese and overweight groups (Table 18, page 71). The WC results showed that females in the healthy WC had a higher rate of CVS complications than the females with an unhealthy WC. Males in the healthy WC group had more CVS complications than males in the unhealthy WC group (Table 20, page 75).

The use of BMI and WC as indicators for post operative CVS complications in this pilot study did not appear to be consistent with the results of other studies (Deurenberg & Yap, 1999; Duncan et al., 2004; Dunn, 2005; Ness Abramof 2008; Zacharias et al., 2005). The results were unable to identify whether BMI or WC were able to best indicate post operative CVS complications after 24 hours post surgery. When BMI was used, those in the morbidly obese and healthy weight groups appeared to have the most post operative CVS complications. The morbidly obese group was consistent with other studies but the healthy weight was unexpected (Best, 2005; Karunakar et al., 2005; Turley et al., 2006; Zacharias et al., 2005). The findings of the WC measurements indicated that both of the healthy WC groups had more CVS complications than the unhealthy WC groups after 24 hours post surgery.

5.5.3 Post operative respiratory complications after 24 hours post surgery

Factors that have been suggested to increase the risk of PE in the obese patient after hip or knee replacement surgery include, slow to mobilise after surgery, under dosing of anti coagulants and ineffectiveness of mechanical compression devices (Mentzosoudis et al., 2009a). Some studies suggest that the obese patient may in fact have a decreased risk than that of non obese patients of developing PE post operatively (Karuncar et al., 2005). However Karuncar et al. (2005) found that obese patients were 2.6 times more likely to develop a DVT than those in the non obese group. While this pilot study did observe the presence of PE after 24 hours post surgery, there were no reports of confirmed DVT. The lack of DVT events could be contributed by the routine application of mechanical compression devices (foot pumps) as per hospital protocol to all participants. The foot pumps are commenced at the time
of arrival into the PACU and discontinued 48-72 hours post operation. The participants with a history of PE or DVT were commenced on anti coagulant therapy routinely as per the hospital protocol.

The types of respiratory complications at collection point two in the pilot study were described in the Methods chapter. The results presented in this pilot study showed that there was a trend for greater occurrence of post operative respiratory complications during the surgical ward stay than within the first 24 hours post surgery. During the surgical ward stay the obese and morbidly obese groups had the greatest frequency of respiratory complications. The normal weight and overweight groups both shared the lowest percentage of respiratory complications. Females in the unhealthy WC group experienced a greater percentage of respiratory complications than females in the healthy WC group. Males in the unhealthy WC group had a greater percentage of respiratory complications than males with a healthy WC.

A trend is suggested whereby when BMI was used, post operative respiratory complications were more strongly identified in the obese and morbidly obese groups than the overweight and normal weight groups (Table 18, page 71). When the WC was applied, both females and males with an unhealthy WC were identified as having the most risk for respiratory complications (Table 20, page 75). It appears from these results that both BMI and WC could equally be useful at predicting the risk of respiratory complications after 24 hours post surgery.

5.5.4 Other post operative complications after 24 hours post surgery

Some studies agree that the rate of post operative complications has been found to be increased in the obese and morbidly obese patient compared to that of the non obese patient (Bamgbade et al., 2007; Foran et al., 2004; Lubbeke et al., 2007). Results from Foran et al. (2004) study found that the obese group had a slightly higher rate of post operative complications than the non obese group. Of the 68 obese patients in the study, 3% experienced post operative complications compared to none of the 68 non obese patients. Although the percentage of post operative complications in the obese group was low in Foran et al. (2004) study, it is interesting to note that the non obese group had no reports of post operative complications. Although these figures should be viewed with circumspect because of the small study cohort, the types of post operative complications associated with obesity are relevant to the pilot study.
“Other” types of complications that were found at collection point two in the pilot study were presented in the Results chapter. The types of “other” complications observed in the pilot study were also present in other studies (Bamgbade et al., 2007; Chung et al., 1999; Dowsey & Choong, 2008; Foran et al., 2004). It was noted in the pilot study that there were a small number of post operative foot drop and nerve palsy and urinary problems. The possibility of foot drop, nerve palsy and urinary complications in obesity was not expected although they have been found in other studies (Bamgbade et al., 2007; Foran et al., 2004). Conversely Karunakar et al. (2005) suggests that there is no association between the rate of nerve palsy and the non obese and obese individuals. Nevertheless this is an area that could be explored further.

Bowditch & Villar (1999) proposed that obese patients receiving a THR were 2.1 times more likely to have a post operative blood loss > 750 mls than that of the normal weight individual. Although the amount of blood loss was not included in this pilot study, the criterion for a blood transfusion after 24 hours post surgery was included. The Hb < 80mg/L indicated that the participant had had a significant blood loss that required a blood transfusion guided by the DHB policy. The percentage of participants who received a blood transfusion and the association with obesity was too small to analyse as an independent variable and was therefore included as part of the “other post operative” data collection.

Studies suggest that the obese and morbidly obese groups are more likely than the overweight and normal weight groups to develop wound infection or wound dehiscence. The rate of wound infection in the morbidly obese was five times higher than those in the normal weight group. The reason for the higher rate of wound infection in the obese individual is thought to be because of the reduction in subcutaneous tissue perfusion and oxygenation and hyperglycaemia (Bamgbade et al., 2007; Lubbeke et al., 2007). While the pilot study reported on wound issues such as infection, cellulitis, oozing/bleeding and excessive swelling, the sample size was too small to explore the association between post operative wound infection and obesity. The incidences of wound infection in the pilot study was included as part of the “other post operative data collection.

There were no reports of post operative dislocations in the pilot study results. However dislocations of the primary THR have been reported in other studies. The dislocation rate in
Lubbeke et al. (2007) study was found to be 2.3 times higher in the obese group than the non-obese group. In the immediate post operative periods, non-compliance to hip precautions may contribute to hip dislocations. Excess weight placed on the component and the adjacent bone is also a contributor for component failure. Other predisposing factors include gender, the presence of motor function disorders such as Parkinson’s disease, dementia and age. Those older than 80 years have a predisposition for dislocation by 4% perhaps due to poor muscle tone, dementia and complications from hip fractures (Best, 2005).

In this pilot study, there appeared to be a greater percentage of other post operative complications at collection point two than at collection point one. The pilot study observed that the BMI may be a less reliable indicator of other post operative complications after 24 hours post surgery. The overweight and normal weight groups experienced the most percentage of “other” post operative complications followed by the morbidly obese and obese groups (Table 18, page71). The WC may be a better indicator of “other” post operative complications for males with an unhealthy WC than females. Females with a healthy waist had a slightly higher percentage of other complications than females with an unhealthy WC (Table 20, page 75). In the male group males with an unhealthy WC had a higher percentage of “other” post operative complications than males with a healthy WC.

However, obesity did appear to have a negative association with the rates of post operative complications after discharge (Foran et al., 2004; Naylor et al., 2008). Therefore it would be interesting to include information on the post operative complications after discharge in future studies. Further research is needed to explore BMI and gender along with WC and gender.

5.6 Discharge delays at two post operative collection points.

The length of hospital stay for patients is factored into hospital budgets. Obesity has an effect on the financial cost of hospital resources and the efficiency and quality of care. The LOS for obese patients tends to vary depending on the surgery (Hauck & Hollingsworth, 2010). Two previous studies found that the LOS tended to be extended for obese patients receiving a joint replacement (Epstein et al., 1987, Hauck & Hollingsworth, 2010). The reasons given to explain the extended LOS included first the presence of co-morbidities in the obese patient may increase the complexity of post operative complications and second, the
transfer of the obese patient to other hospitals post operation. The rationale for the hospital transfers was not given and the study acknowledged that further research was required to better understand the relation between obesity and hospital LOS.

This pilot study included data on the discharge delays from collection point one and two to explore discharge delay and the association between body fat composition and post operative complications (Table 21, page 77). Both collection points shared the same percentage of discharge delay due to medical reasons. At collection point one, the groups with the highest percentage of post operative complication overall were seen in the BMI normal weight and the morbidly groups. For WC groups both the healthy and unhealthy groups had the greatest percentage of complications. At collection point two the groups with the highest percentage of post operative complication overall were the BMI normal weight and overweight groups. For WC groups the healthy groups also had the highest percentage. This may suggest that obesity may have contributed to the delay at collection point one though there did not appear to be an association between discharge delays and obesity at collection point two. The findings of the pilot study suggest that further investigation is needed to better understand the association with discharge delays and obesity.

5.7 Chapter Summary

BMI and WC to define obesity

The BMI and WC measurements were used in this pilot study to define obesity and to identify risk factors pre and post surgery. When the BMI was used to identify obesity there was an equal divide between the participants who were defined as obese and morbidly obese and of the participants defined as overweight and normal weight. There were more participants who had a health WC than an unhealthy WC when WC measurements were used to define obesity.

Co-morbidities

The findings of the pilot study agreed with other studies that co-morbidities increased the risk of postoperative complications (Chung et al., 1999; Liu et al., 2009; Memtsoudis et al., 2009a). There appeared to be a significant disparity between no-co-morbidities versus no post operative complications and three or more co-morbidities versus no co-morbidities within 24 hours post surgery (PACU/SCU). This suggested that the more co-morbidities the greater the
occurrence of post operative complications within the immediate postoperative period. After 24 hours post operation (SOU) there appeared to be a strong trend between co-morbidities and post operative complications. However the co-morbidities were observed to be evenly distributed across the three post operative complication categories. The BMI may be a useful indicator for CVS and other co-morbidities (including diabetes type II mellitus). There was a trend for WC to indentify co-morbidities in both males and females with an unhealthy WC. The WC measurement may be a stronger indicator of CVS co-morbidities in females with an unhealthy WC than all male groups.

BMI

Although high BMI (obese and morbidly obese) tended to be associated with pre-surgery co-morbidities, the BMI appeared less useful post surgery in terms of complications. There appeared to be an association between the morbidly obese group and CVS and other post operative complications within and after 24 hours post surgery. However there was a nonlinear trend with the other BMI group as risk indicators for CVS and other post operative complications. Both morbidly obese and obese groups appeared to be associated with greater risk of respiratory complications within and after 24 hours post surgery. This may suggest that morbidly obese patients are at greater risk of post operative complications than the obese or non obese patients which is a theory also supported by Andrew et al. (2008), Horan (2006) and Karunkar et al. (2005) However it should be noted that only the obese BMI group in the pilot study had the highest percentage of more than two post operative complications, suggesting that the body fat distribution may contribute to the complexity of post operative complications.

WC

When WC was used as a risk indictor for post operative complications, females with an unhealthy WC and males with a healthy WC appeared to a greater risk of CVS within 24 hours post surgery. However neither females nor males with unhealthy WC appeared to have an association with CVS complications after 24 hours post surgery. Both females and males with an unhealthy WC appeared to have an association with respiratory complications within and after 24 hours post surgery. There also appeared to be an association between females and males with an unhealthy WC and “other” complications within 24 hours post surgery. Although only males with an unhealthy WC had an association with “other” complications after 24 hours post surgery. Overall the WC appeared to be a useful indictor of CVS,
respiratory and “other” post operative complication for females with an unhealthy WC within the immediate post surgery period. While for men the WC appeared to be a useful indicator of respiratory and “other” post operative complications after 24 hours post surgery.

The findings in this pilot study suggest that there may be an association between obesity and post operative complications within 24 hours post surgery. The BMI may be a useful indicator for co-morbidities but may not be a consistently reliable indicator of post operative complications. The WC may be a more useful indicator of co-morbidities and complications during the immediate postoperative period but appeared less reliable after 24 hours post surgery.

This pilot study recruited a greater number of females than males. However when WC was used to measure obesity more males were defined as obese than females. The pilot study observed that while more males were defined as obese than females, the obese females had a greater occurrence of post operative complications than obese males. The WC measurement may be a stronger indicator of CVS in obese females than obese males. The relationship between gender and post operative complications should be considered for future studies.

5.8 Limitations

The WC measurement used in this pilot study was a new assessment tool for nursing staff working in the AU. However the WC measurement was not a new tool during the pre surgery patient assessment as it was routinely used by the hospital dietitian. As the WC measurements was a new intervention within the AU, the study information and consent forms were required to be sent to patients six weeks prior to their surgery. The majority of patients who received the pilot study information and consent form agreed to participate.

5.8.1 Recruitment

The plan to gain consent to participate in the pilot study, six weeks prior to surgery contributed to two main limitations. First, the time delay between sending the consent forms and the patients’ actual day of surgery varied from six weeks to six months. This was a major drawback in the study. There were fluctuations in the eventual numbers going ahead for
surgery. The reasons for this included the following: cancellation of elective lists in favour of the acute trauma list; temporary interruption of surgical services when the autoclave exploded and patients who were postponed due to poor health or cancelled if they no longer required the surgery. It was also discovered that the waiting list department had not sent out all the study invitation and consent forms to the patients.

Second, the six week turnaround time meant that not all elective patients on the elective waiting lists had received the pilot study information prior to surgery and this saw approximately 50 potential study participants’ were missed in the data collection on the day of surgery. There were occasions when on the day of surgery, patients who had not been sent the pilot study information and consent form, volunteered to participate in the study. To maximise the collection of the data within the research time frame, approval from the Ethics Committee was granted to send additional study invitations and consent forms directly to potential participants two to four weeks prior to their surgery and further consent forms were subsequently sent out to patients by the waiting list secretary.

Improvements to the data collection could have included the utilisation of two pre surgery WC measurement collection points. The combined collaboration of the Outpatients department and AU nursing staff may have helped to inform the patients of the study while allowing time for the patient to consider their participation. Most patients on the elective joint replacement list are seen at the NLAP preadmission clinic where the BMI is measured and recorded. Therefore if all the patients had their WC measured at the NLASP preadmission clinic along with the BMI, then this could help to improve the recruitment process. The AU nursing staff could have then measured the remaining participants, or those that required to be re-measured if it had been longer than six weeks, as per the AU protocol for weight measurements.

The hospitals’ nursing management supported the WC measurements as a routine assessment tool in the AU during the pilot study. Nursing staff completed a WC measure competency assessment and received ongoing education. However the use of the new assessment tool may have placed a strain on nursing resources and time restraints during the admission process, which consequently may have slowed recruitment and the subsequent data collection. The ideal solution would be to have a full time researcher available on a daily basis
to measure WC. Nevertheless this would have had to be a full time commitment which was not possible for a part-time thesis.

5.8.2 Sample size

The limitation of the small sample size and multiple variables meant that the inferential statistical analysis could not be undertaken to test the research question. The problem with the small sample sizes of this pilot study has been found to be similar to that of other studies (Andrew et al., 2008; Dowey & Choong, 2008; Foran et al., 2004). The study by Dowey and Choong (2008) suggested that to test the association between obesity and post operative complications, a sample size > 1000 would be required (2008). It has been suggested by Andrew et al. (2008) that a longitudinal study conducted over five years may provide more robust findings and they further suggest that it would be advantageous to have a follow up period of seven to ten years.

A larger cohort and longer study period is needed to conduct test of statistical significance. To increase the likelihood of this, a suggestion for future research is to recruit across other hospitals throughout New Zealand and allow a longer recruitment period. The advantage of the longer time frame used in follow up studies is that it is useful for studying changes over time and is commonly used in health studies, particular when interventions or clinical treatments are followed up (Polit & Beck, 2004). In this case it will be used to compare which anthropometric tool was best able to identify the potential outcome of the health status of participants over a specific time frame.

5.8.3 Gender

Two gender limitations of the pilot study were:

1. The over representation of females. The disproportional representation of gender was similarly found to be a limitation by Foran et al. (2004) study which included a cohort of n=156. To achieve a more balanced representation of male and female in future studies, an over recruitment of males may be necessary. However the findings that more females were recruited in this pilot study and in other studies may still have some significance in regard to the specific health needs of this group.
2. The BMI groups not separated per gender as was seen in the WC groups. It would have been more useful to have divided the BMI cut off point categories and gender along with WC cut off point categories and gender

5.8.4 Ethnicity

The small sample size in this pilot study was unable to collect sufficient ethnicity data to examine the relationship between ethnicity, BMI, WC and post operative complications. This type of limitation has been found in similar studies (Gandhi et al., 2010, Memtsoudis et al., 2009b). The literature supports that there is an association between WC, type II diabetes mellitus and cardiovascular disease. However currently there are no studies relevant to the New Zealand population. The importance of ethnicity, BMI and WC cut off points and obesity related diseases in New Zealand has been raised in some studies but requires further investigation (Duncan et al., 2004; Hughes et al., 2004, Swinburn et al., 1998). The representation of ethnicity in the pilot study may also be due to the demographic makeup of those in the area of New Zealand where the study took place. Because of the low representation of non European New Zealanders, a disproportionate sampling design may provide a fairer representation of minority ethnic groups in future studies given that ethnicity is a factor in obesity (Polit & Beck, 2004).

Further limitation occurred in regard to ethnicity data collection. First, the ethnicity classification recorded by the DHB may have differed to the patients’ own perception of ethnicity. Second, the CDHB ethnicity classifications infrequently record multiple ethnic identities. Clear definitions of the various ethnic groups were not provided on the CDHB ethnicity classifications. This may have contributed to the lack of awareness from the patient that multiple ethnicities could not be recorded. It was noted by the researcher that although Maori were included in the study they were not always recorded as Māori on the clinical records but as New Zealand European. This may have resulted in a limitation in the representation of Māori and other non New Zealand European participants.

For prospective research it may be useful to use self reported ethnicity in collaboration with the researcher. To help meet the MOH New Zealand Health Strategy to reduce health inequalities in New Zealand, multiple ethnicity should be included in demographic data collection and the definition between ethnicity, nationality and culture needs to be better defined (MOH 2002, 2007). Statistics New Zealand (2005) acknowledges that the definition
of ethnicity is a complex issue and that more investigation is required to provide reliable and valid ethnicity information.
6 Conclusion

6.1 Research Implications

This pilot study explored the BMI and WC measurements as risk indicators of postoperative complications that may adversely influence health outcomes for elective joint replacement patients. The BMI and WC were used to define obesity and to identify risk factors pre and post surgery. Potential areas for further research were identified in the pilot study and are summarised in this section.

6.1.1 Ethnicity

Although the pilot study was unable to look at the association between ethnicity, BMI, WC and post operative complications due to the small amount of ethnicity data collected, this question should not be overlooked in future studies. The limitations section has discussed the small ethnicity data in the pilot study and suggested recommendations. The application of suitable anthropometric tools in the planning and initiating of preventive health policies is especially important in reducing inequalities in health within the ethnic groups in New Zealand. This is particularly significant for the population of Asian Indian, Māori and Pacific Peoples of New Zealand.

As discussed earlier in the literature review that not only does type II diabetes mellitus among the Indian population exceed that of the Māori and Pacific Peoples, it has been estimated that the population of Asian Indian peoples in New Zealand will increase 12% by the year 2021 (MOH 2006). Studies published on ethnicity and the relationship between obesity and the health needs of the ethnic groups in New Zealand is limited and therefore warrants further investigation. The significance of the Asian Indian population in New Zealand and the health needs of this group seem to have been over looked in previous studies. Future studies need to include Asian Indian along with Māori, Pacific Peoples and New Zealand European in the demographics. This view is also supported by the MOH (2006).
6.1.2 Gender

The observation that more obese female with OA were receiving joint replacement surgery was unanticipated in this pilot study. However the trends observed did concur with Lubbeke et al. (2006) study. The findings of the pilot study suggested that WC may be a more useful assessment tool for women than men. Further studies are required to examine the relationship between gender and obesity as comorbidities and risk factor that may contribute towards post operative complications. Therefore it would be useful to include gender in prospective research as a co-variable. This could therefore be used to help underpin the fitness for surgery guidelines through implementing suitable health assessment tools specific to gender and thus improve patient outcomes post surgery.

6.1.3 Age

Age was included in the pilot study as part of the demographic data. The association between age, obesity and post operative complications was not the focus of this pilot study. The literature review has discussed the significance between age and the distribution of body fat composition between genders. It has been suggested that once women reach menopausal age, the body fat distribution changes and abdominal adipose tissue increases. This may predispose menopausal and post menopausal women at greater risk of type II diabetes mellitus and CVS disease (Oka et al., 2009; Woo et al., 2002). The findings of this pilot study suggest that age may be a contributing risk factor for post operative complications particularly in menopausal and post menopausal women. The association between age, obesity and post operative complications is relevant in the planning of patient care and the assessments of potential post operative risks and warrants further research.

6.1.4 Smoking

The pilot study could not include smoking as a co-variable because inferential statistics were not calculated although smoking behaviour was collected as part of the demographic data. There are limited studies that explore the association between obesity, smoking and post operative complications in joint replacement patients are limited. However the findings of one study showed that there was an increased risk of post operative complications related to
smoking and a high BMI after a primary hip replacement (Azodi et al., 2006). This highlights the importance of including smoking as a co-variable in future studies to investigate the relationship between smoking obesity and post operative complications in joint replacement patients. The data collected on previous smoking behaviour in the pilot study and in Azodi et al. (2006) study did not examine the time frame of smoking cessation. The time frame of smoking cessation and the implications this may have towards obesity and/or postoperative complications needs to be better understood. To develop further insight into this research question, not only should smoking status be included in future studies as a co-variable but also the time frame of smoking cessation needs to be considered.

6.1.5 Nursing implications.

Nurses, in collaboration with the multi-disciplinary team, have the important task of detecting and assessing for early post operative complications, through meticulous pre and post operative assessment and nursing care. This role includes implementing physical assessments to evaluate fitness for surgery, and education to promote healthy living for those not fit for surgery (Best, 2005). Studies have suggested that as the obese joint replacement patient has a greater predisposition toward peri-operative complications than non obese patients, this potentially generates additional demands on hospital resources. Therefore having an effective physical assessment tool relevant to today’s health standards is vital in making the important clinical judgments of patient’s health status and potential post operative risks. The advantages and disadvantages of both the BMI and WC have been discussed in the pilot study. The question around the 200 year old BMI formula and the more recently introduced WC as effective assessment tools to define obesity continues to be debated and still remains an area worthy of ongoing research and discussion.

6.2 Summary

This pilot study explored the association between two assessment tools used to measure body fat and to indicate potential post operation complications following elective joint replacement surgery. The Introduction chapter provided a background to the research question and a review of the literature. The Results chapter provided descriptive statistics looking at individual characteristics of the variables and included the range, frequency, mean and standard deviation. Due to the small participant numbers and multiple variables, this pilot
study was unable to conduct the inferential statistical analysis to test the research question. The discussion chapter expands on the findings of the pilot study and limitations and research implications.

The findings of this pilot study were unable to answer the research question either way: “Which anthropometric (BMI or WC) measurement tool is best able to effectively indicate potential post-operative health risks in today’s clinical setting”? The pilot study agreed with the literature that obesity appears to be a potential indicator of co-morbidities. However it is uncertain which anthropometric measure was best able to assess obesity and identify co-morbidities and potential post operative complications.

The first objective explored how the WC compares to the BMI as an effective risk indicator tools to aid in identifying potential post-operative complications for patients who receive elective joint replacement surgery. The BMI appeared to be a useful indicator for CVS and other co-morbidities but possibly less useful as an indicator for respiratory co-morbidities. Within the first 24 hours post surgery the BMI appeared to be useful in identifying the potential CVS complications in the morbidly obese and overweight group but was not a specific indicator after 24 hours post surgery.

The findings suggest the WC may be a more useful co-morbidity indicator for females than males. Within 24 hours post operation the WC appeared to be a more useful in identifying CVS complications in the female unhealthy WC group than with the male groups. The WC also appeared to be a useful indictor of respiratory complications in both the female and male unhealthy WC groups. This may suggest that WC is a useful post operative risk indictor particularly in the immediate post operative period.

The second objective considered if there is an association between the BMI and WC measurements and parameters for overweight and obesity. Both BMI and WC used in the pilot study identified co-morbidities and post operative complications with the first 24 hours post surgery. Neither the BMI nor WC appeared to be a specific indicator of potential post operative complications after 24 hours post surgery. A limitation of the BMI including the cut off points for ethnicity and gender continues to be debated. The pilot study was unable to explore ethnicity in the analysis due to the small sample size. The WHO guidelines were used in the pilot study to identify participants who were morbidly obese or obese and therefore did
not differentiate between male and female. When WC was used to assess obesity more males than females were obese nevertheless females with unhealthy WC appeared to have more CVS post operative complications during the immediate post operative period than males.

The advantages and disadvantages of both the BMI and WC have been discussed in the pilot study. Obese joint replacement patient have an increased risk of a post operative complication than non obese patients. Therefore it is vitally important that having an effective physical assessment tool to assist nurses and the multidisciplinary team in making clinical judgments of patient’s health status and assessing for potential post operative risks. Further research is needed to explore which of the two different anthropometric measures (BMI and WC) have any better utility than each other in predicting the risk of postoperative complications.
APPENDIX A:
Letters of Upper South A Regional Ethics Committee Approval
28 October 2008

Natacha Maher
35A Harker Street
Christchurch 8024

Dear Natacha Maher,

*Anthropometric assessment tools as postoperative risk indicators in adult orthopaedic patients: A pilot study*

*Investigators: N Maher, G Halksworth-Smith (supervisor)*

*Locality: Burwood Hospital*

*Ethics ref: URA/08/10/070*

Thank you for the above application which was considered by Upper South A Ethics Committee at its meeting on 20 October 2008. The committee also wishes to thank you and Gill Halksworth-Smith for attending the meeting.

The following points require attention before ethical approval can be confirmed.

**Information sheet**

1. Please refer to the committee as the Upper South A Regional Ethics Committee.
2. Include the following statement: "With your permission, data from this study will be used in future related studies, which have been given ethical approval from a Health & Disability Ethics Committee."

**Consent form**

3. Include the following statement: "I consent to the use of my data for future related studies, which have been given ethical approval from a Health & Disability Ethics Committee."
4. Include a statement consenting to researchers accessing medical notes.

**General**

5. It is recommended to follow the Good Clinical Practice definitions for waist measurement as defined in the New Zealand guidelines.

Please forward your response in letter format with amended documents to the Committee administrator. Your response will be reviewed by a committee member and if the above points have been addressed to their satisfaction, final ethical approval will be given by the Chairperson under delegated authority.

The Committee forwards the following suggestion, which does not affect the application's ethical approval status.

**Suggestion**

6. Consent form page 1, 1st statement: it is suggested to add the word 'for' after the space for the date in the first sentence.
If you have any queries, please contact me.

Yours sincerely

[Signature]

Alieke Dierckx
Upper South A Ethics Committee Administrator

Email: alieke_dierckx@moh.govt.nz
13 November 2008

Natacha Maher
35A Harker Street
Christchurch 8024

Dear Natacha Maher,

**Anthropometric assessment tools as postoperative risk indicators in adult orthopaedic patients: A pilot study**
*Investigators: N Maher, G Halksworth-Smith (supervisor)*
*Locality: Burwood Hospital*
*Ethics ref: URA/08/10/070*

The above study has been given ethical approval by the **Upper South A Ethics Committee**.

**Approved Documents**
Information sheet and consent form version 2 dated 7 November 2008

**Accreditation**
The Committee involved in the approval of this study is accredited by the Health Research Council and is constituted and operates in accordance with the Operational Standard for Ethics Committees, April 2006.

**Progress Reports**
The study is approved until **31 August 2010**. The Committee will review the approved application annually and notify the Principal Investigator if it withdraws approval. It is the Principal Investigator’s responsibility to forward a progress report covering all sites prior to ethical review of the project in November 2009. The report form is available at [http://www.ethicscommittees.health.govt.nz](http://www.ethicscommittees.health.govt.nz). Please note that failure to provide a progress report may result in the withdrawal of ethical approval. A final report is also required at the conclusion of the study.

**Amendments**
It is also a condition of approval that the Committee is advised of any adverse events, if the study does not commence, or if the study is altered in any way, including all documentation eg advertisements, letters to prospective participants.

Please quote the above ethics committee reference number in all correspondence.

It should be noted that Ethics Committee approval does not imply any resource commitment or administrative facilitation by any healthcare provider within whose facility the research is to be carried out. Where applicable, authority for this must be obtained separately from the appropriate manager within the organisation.
We wish you well with your study.

Yours sincerely

Alicke Dierckx
Upper South A Ethics Committee Administrator
Email: alieke_dierckx@moh.govt.nz
Dear Natacha Maher,

Anthropometric assessment tools as postoperative risk indicators in adult orthopaedic patients: A pilot study
Investigators: N Maher, G Halksworth-Smith (supervisor)
Locality: Burwood Hospital
Ethics ref: URA/08/10/070

Amendment
- to send invitations and consents directly to participants 2-4 weeks prior to their surgery instead of 6 weeks prior

Thank you for your letter of 17 October 2009 outlining the above request. This matter has been considered by one member and the Chairperson of the Upper South A Regional Ethics Committee, and approved under delegated authority.

Thank you also for forwarding the progress report. Ethical approval for this study is confirmed for a further 12 months from the report due date. We look forward to receiving another report from you in August 2010.

Yours sincerely

Alieke Dierckx
Upper South A Ethics Committee Administrator
Alieke_dierckx@moh.govt.nz
11 October 2010

Natacha Maher
35A Harker Street
Christchurch 8024

Dear Natacha Maher,

**Anthropometric assessment tools as postoperative risk indicators in adult orthopaedic patients: A pilot study**

**Investigators: N Maher, G Halksworth-Smith (supervisor)**

**Locality: Burwood Hospital**

**Ethics ref: URA/08/10/070**

Thank you for the progress report for the above study, which was considered by a member of the Upper South A Regional Ethics Committee under delegated authority.

Ethical approval is confirmed until 31 December 2010. We look forward to receiving another report from you then.

Yours sincerely

[Signature]

**Alicke Dierckx**

Administrator

Upper South A Regional Ethics Committee

Alicke_dierckx@moh.govt.nz
APPENDIX B:
Letter of support from the Director of Nursing
22nd August 2008

The Chairperson
Board of Graduate Studies in Health Sciences
University of Otago
P O Box 4345
Christchurch Mail Centre 8140

Dear Sir / Madam

Student Natacha Maher, No. 1314114

Proposed Research Title:
Assessment Tools as Post-operative Risk Indicators in Adult Orthopaedic Patients: A Pilot Study

I am writing to support this prospective observational pilot study. It is intended that patients having elective orthopaedic surgery at Burwood Hospital, who fit the inclusion criteria, be invited to participate in the study. Subject to Ethics approvals I am happy to support the following:

- The study’s consent form be given out at pre-admission allowing patients to consider participation.
- On the day of admission nursing staff in the Admitting Unit at Burwood Hospital take the waist measurement of the patient.
- Training in waist measure will be given to nursing staff by the Early Dietetic Intervention Dietitian at Burwood Hospital.
- Access to patients’ clinical notes to review their post-operative progress.

The nursing staff in Pre-admission and the Admitting Unit are willing to assist the researcher in the pilot study.

I would like to endorse this research study and provide support to the researcher on site.

Yours sincerely,

Diana Gunn
Director of Nursing
Burwood Hospital

Nursing dir of nsg/Dir NAfata Maher Proposed Research Aug 08
APPENDIX C:
Letter of support from the
University of Otago Māori Research Manager
7 April 2008

Dr Shelagh Dawson
Centre for Postgraduate Nursing Studies
University of Otago, Christchurch

Tena koe, Shelagh

Thank you for meeting with me and Natacha Maher at the University of Otago, Christchurch on Wednesday 2 April, to discuss your research study titled:

**Anthropometric measurements: which tool is best able to effectively identify potential post-operative health risks in today's clinical setting?**

I note that the research is a Masters thesis.

It was apparent in your summary of the research that there could be a small number of Maori participants and that this research may have impact on Maori health and that is important.

We also discussed the relevance of the research in regard to improving Maori health status and referred to *Decades of Disparity II: Socioeconomic mortality trends in New Zealand 1981 - 1999*, March 2005. The other reference that is available is *Hauora Maori Standards of Health: A study of the years 1970-1991* by Eru Pomare, Maori Health Research Unit, Wellington School of Medicine. Both provide Maori specific information on a range of health issues. The recent publication *Tatau Kahukura*, Ministry of Health, 2006, is an update relating to the socio economic determinants of health, health status and service utilisation of the Maori population.

Further references are available from the HRC’s *Guidelines for Researchers on Health Research Involving Maori* (page 22), www.hrc.govt.nz.

It was agreed that there is a need to acknowledge the issues pertaining to ethnicity and to consider how ethnicity data will be collected in your study. Also, given the poor ethnicity data collection in hospital databases this information should be collected in demographic information as part of the research. Through our discussion the Census 2006 ethnicity question was considered to be the preferred tool in recording ethnicity.

It was pleasing to hear that Natacha had discussed her research proposal with Mere Hibbs, Maori liaison person for Burwood. It was reassuring that Mere would be kept up to date with the progress of the research project.
As stated in the HRC’s Guidelines for Researchers on Health Research Involving Maori it is important that research results contribute to Maori development. Some instances where Maori have been powerless to stop the inappropriate dissemination of information have generated unease within Maori communities. Researchers must take care to ensure that Maori participants understand and agree on which information is to be published in what formats and forums.

It is a requirement of the ethics approval process that a final report be submitted when the research is complete. A copy of the report should be provided to me at that time as findings from this project may contribute to the development of future research hypotheses or projects. It is therefore important that appropriate Maori organisations, Maori health professionals and Maori researchers are aware of your findings. The Research Office of the University of Otago, Christchurch and in particular myself as the Research Manager of Maori health would be willing to assist in the dissemination of your findings once your project has reached a successful conclusion.

My suggestions do not necessarily relate to ethical issues with the research, including methodology. Other committees may also provide feedback in these areas. I hope this letter will suffice in terms of the application. Please contact me should you need any other information that may not have been included in the letter relevant to our conversation.

I wish you well in your research.

Kia manawatū

e noho ra

[Signature]

Elizabeth Cunningham
Research Manager - Maori
APPENDIX D:
Letter of support from the Ranga Hauora Services
31st March, 2008

Natasha Maher RCpN, PGDipHealSc
P.A.C.U.
Burwood Hospital
Private Bag 4708
Christchurch

RE: ‘Anthropometric measurements: Which tool is best able to effectively identify potential post-operative health risks in today’s clinical setting?’

Aim: This research proposal will compare the Body Mass Index with waist circumference measurements and Bioelectrical Impedance Analysis (BIA) to evaluate which tool is the most efficient risk indicator of potential postoperative complications that may adversely influence rehabilitation outcomes for elective joint replacement patients.

Tena Koe Natasha,

Following our discussion, I write in support of the proposed research project.

Through Ranga Hauora Service, access to the appropriate resources and support to meet the cultural requirements of the participants who identify as Māori and the researcher will be available. Ranga Hauora will receive a report on the outcome at completion of the project.

Ranga Hauora, Māori Health Services consist of a Kaumatau, Kaiwhakahaere/Pou-Whakaako, Kaitiaki, Komiti Kaiwhakahaere (Burwood Hospital Māori Staff) and Kaumatua Whakaruruhau (community elders). All consultation and information with community groups and consumers can be accessed through Ranga Hauora, Māori Health Services, Burwood Hospital.

We wish you well with your research.

Heoi ano

Mere Hibbs
Kaiwhakahaere/Pou-Whakaako
Ranga Hauora
Burwood Hospital
APPENDIX E:
Pilot Study Participant Information Sheet
A Study of the Body Mass Index (BMI) Measurements and Waist Circumference Measurements used as part of the pre surgery health assessment. A Pilot Study.

Dear Sir/Madam

I am registered nurse at Burwood Hospital and I am currently undertaking a Postgraduate Masters Degree in Health Sciences Endorsed in Nursing through the University of Otago.

I am conducting a pilot study of two types of measurements used routinely to assess body fat and compare which measure was best able to help plan for rehabilitation and encourage well-being after surgery. Participants for the study will be selected from the orthopaedic elective joint replacement waiting list over a 3-month period. The study will contribute towards my academic learning and meet the academic requirements of the University of Otago. The research results could possibly be used within patient health assessment and help plan patient recovery post surgery.

Please find enclosed information regarding the pilot study and a consent form. If you decide to participate in the study your medical information will be kept confidential and you will not be identified in anyway without your consent.

Please bring the signed consent form with you on the day of your hospital admission for surgery and present the consent form to the Receptionist at Burwood Hospital Admitting Unit

If you decide not to participate in the study this will not affect the care you receive from Canterbury District Health Board in the future.

If you wish to discuss this study further please refer to the patient information sheet for contact details.

Thank you for you consideration and I wish you well for your surgery.

Kind regards
Natacha Maher RCpN, PGDipHealSc
Patient Information Guide Sheet

Study Title: A Study of the Body Mass Index (BMI) Measurements and Waist Circumference Measurements used as part of the pre surgery health assessment. A Pilot Study.

Dear Sir/Madam

I am registered nurse undertaking a Postgraduate Masters Degree in Health Sciences Endorsed in Nursing through the University of Otago. The study will contribute towards my academic learning and meet the academic requirements of the University of Otago. The study will focus on two types of measurements used routinely to assess body fat and compare which measure was best able to help plan for rehabilitation and encourage well being after surgery.

*Please take your time to think about whether you wish to take part in this study. Taking part is completely voluntary (your choice) and if you decide you don’t wish to take part, it will not affect your continuing health care in any way.*

Why are you being asked?

The study will contribute to the routine hospital health assessment check, which is required before surgery. This may help promote better surgery results and patient satisfaction.

The study will follow you during your hospital stay. It will begin on the day of admission and then 24 hours after surgery and during your hospital stay and will stop on the day of discharge. Participants for the study will be selected from the orthopaedic elective joint replacement waiting list over a 3-month period. The inclusion criterion includes male and female aged over 18 years old. Participants excluded from the study will be those who wish to decline from the study. You may have a friend, family or whanau support go through the information sheet with you to help understand the requirements of the study.

Anthropometric Assessment Tools as Postoperative Risk Indicators in Adult Orthopaedic Patients:
A Pilot Study
25/11/08  page 1  Version 3
What happens during the study?

The study will take place at Burwood Hospital. It will start on the day of surgery in the Admitting Unit and will continue during your journey through Burwood Hospital including the Recovery Unit, Special Care Unit and Surgical Orthopaedic Unit.

- Should you agree to take part in the study you will be asked to have your weight and waist measured on the day of surgery. This should take no more then 5 minutes during the routine nurse admission assessment.
- The weight and waist measurements will take place in a private consultation room with a registered nurse. As part of the normal admission process, you will be asked to change out of your street clothes and wear a hospital gown. You will need to remove your socks and shoes.
- You will be asked to stand on electronic scales to measure your weight.
- You will be measured around your waist with a tape measure.

The results of your body measurement will not affect your right to fair treatment and standards of care and any medical conditions will be fairly attended to.

Normal eligibility for surgery will still apply regardless of the body measurements taken of the purpose of the study.

- The researcher will access your clinical notes to collect information during your hospital stay that is only relevant to your surgery and the research. Information collected will include: Observation recordings routinely taken by nurses, routine blood test results, any medical assessments undertaking by the medical team and any additional medical conditions relevant to the study. The waist and weight measurements will be recorded on a data sheet and results presented on a graph. No material, which could personally identify you, will be used in any reports on this study.
**Confidentiality**

Gender, age and ethnicity will be included in the results, however to maintain patient confidentiality all patient names and hospital identification numbers will be replaced with an identifier code only to be used by the researcher and will be used in all research documents rather than your name.

All patient information will be kept confidential.

Data collected will need to be kept in secure storage and will be destroyed after 10 years.

**Approval.**

With your permission, data from this study will be used in future related studies, which have been given ethical approval from a Health and Disability Ethics Committee.

This study has received ethical approval from Upper South A Regional Ethics Committee

If you need more information about the study please contact:

Natacha Maher: Registered Nurse/Researcher
Burwood Hospital Admitting Unit Ph: 383 6835

Natacha.maher@cdhb.govt.nz

You may have a friend, family or whanau support to help you understand the risk and/or benefits of this study and any other explanation you may require.

*If you would like a copy of the research results please tick the box on the consent form.*

If you have any questions or concerns about your rights as a participant in this research study you can contact an independent health and disability advocate. This is a free service provided under the Health and Disability Commissioner Act.

Telephone: (NZ wide) 0800 555 050

Free fax: (NZ wide) 0800 2787 7678 (0800 support)

Email: (NZ wide) advocacy@hdc.org.nz
APPENDIX F: Pilot Study Participant Consent Form
Participant Consent Form

Research Title:
A Study of the Body Mass Index (BMI) Measurements and Waist Circumference Measurements used as part of the pre surgery health assessment: A Pilot Study

<table>
<thead>
<tr>
<th>English</th>
<th>I wish to have an interpreter.</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maori</td>
<td>E hiahia ana ahau ki tetahi kaiwhakamaori/kaiwhaka pakeha korero.</td>
<td>Ae</td>
<td>Kao</td>
</tr>
<tr>
<td>Samoan</td>
<td>Oute mana’o ia iai se fa’amatala upu.</td>
<td>Ioe</td>
<td>Leai</td>
</tr>
<tr>
<td>Tongan</td>
<td>Oku ou fiema’u ha fakatotulea.</td>
<td>Io</td>
<td>Ikai</td>
</tr>
<tr>
<td>Cook Island</td>
<td>Ka inangaro au i tetai tangata uri reo.</td>
<td>Ae</td>
<td>Kae</td>
</tr>
<tr>
<td>Niuean</td>
<td>Fia manako au ke faka’aoga e taha tagata fakahokohoko kupu.</td>
<td>E</td>
<td>Nakai</td>
</tr>
</tbody>
</table>

1. I have read the information sheet dated 25/11/08 for this study and have had details of the study explained to me and I have had time to consider whether to take part. My questions about the study have been answered to my satisfaction and I understand that I may ask questions at any time. I know who to contact if I have any questions about the study.

2. My participation in the study is entirely voluntary (my choice). I also understand that I am free to withdraw from the study at any time and this will in no way affect my future/continuing health care.

3. I wish to participate in the study under the conditions set out in the information sheet and understand that the study will have no effect on my access to fair treatment and proper standards of care.

4. I agree to provide information to the researcher and give consent for the researcher to access my medical records, under conditions of confidentiality and in accordance with the Treaty of Waitangi and as set out in the information sheet.

Anthropometric Assessment Tools as Postoperative Risk Indicators in Adult Orthopaedic Patients: A Pilot Study
Page 1 of 2 25/11/08 Version 3
Participant Consent Form

Research Title: A Study of the Body Mass Index (BMI) Measurements and Waist Circumference Measurements used as part of the pre surgery health assessment: A Pilot Study.

5. My participation in the study is confidential and no information that could identify me will be used in any reports on this study.

7. I consent to the use of my data for future related studies, which have been given ethical approval from the Health and Disability Ethics Committee.

I would like to receive a copy of the completed research document.
• Please tick the box if Yes    □

I __________________________________ hereby consent to take part in this study.

(Please print Full Name)

__________________________ Date __/__/____
(Signature of participant)

Principal Investigator: Natacha Maher RCpN, PGDipHealSc

__________________________ Date __/__/____
(Signature of principal investigator)

Principal Investigator: Natacha Maher RCpN, PGDipHealSc
Contact Phone Number: Burwood Hospital Admitting Unit Ph: 383 6835
Email address: Natacha.maher@cdhb.govt.nz
University of Otago Supervisor: Gill Halksworth-Smith

A copy of the completed consent will be supplied to the participant.

Anthropometric Assessment Tools as Postoperative Risk Indicators in Adult Orthopaedic Patients: A Pilot Study

Page 1 of 2 25/11/08 Version 3
APPENDIX G:
Waist Circumference Teaching Package for Nursing Staff
Waist Girth/ Circumference Measurements
Information Sheet

Definition: The circumference of the abdomen its narrowest point between the lower costal (10th rib) boarder and the top of the iliac crest, perpendicular to the axis of the trunk.

The patient stands and the nurse, positioned at the right of the subject, palpates the upper hip bone to locate the right iliac crest. Just above the upper most lateral border of the right iliac crest, a horizontal mark is drawn, and then crossed with a vertical mark on the midaxillary line. The measuring tape is placed in a horizontal plane around the abdomen at the level of this marked point on the right side of the trunk. The plane of the tape is parallel to the floor and the tape is snug, but does not compress the skin. The measurement is made at a normal minimal respiration

Equipment: Gulick II self-tensioning measuring tape. Fig 1

![Fig 1](image)

Method:
The cross-hand technique is used for measuring waist girth. Refer Fig 2. The objective is to minimise the gaps between the tape and body surface, and to minimise indentations of the body surface wherever possible. This is not always achievable. Where the contour of the surface of the body becomes concave (for example, across the spinal column), continuous contact with the surface is neither achievable nor desirable.

The waist measurement is normally taken at the level of the narrowest part of the waist. To obtain an accurate measurement it is recommended to hold the tape measure against the skin, horizontal to the floor. The level of the measurement will be verified by the patient / participant and nurse.
1. Ask the patient to stand upright in a relaxed manner, feet comfortably apart, weight evenly balanced on both feet and with their arms hanging by their side.

2. Position the tape by asking the patient to hold the casing of the tape in their right hand against the marked landmark points. The nurse holds stub end of tape in left hand walks around patient anti clockwise direction.

3. While facing the patient and standing to the right hand side of the patient, take the casing end with your right hand, which then holds both the stub and casing. This leaves your left hand free to manipulate the tape at the correct level. Use enough tension on the tape with the right hand to hold it where you position it.

4. Ask the patient/participant to put the tape at their waist level. When the right level has been identified, use your left hand to ensure the tape is horizontal.

5. When satisfied with the position of the tape, reach underneath the casing with you left hand to take hold of the stub again and pull it across to your left into the cross-hand position keeping enough tension on the tape to prevent it slipping out of position. Refer fig 2.

6. Move the tape sideways with both hands as needed to position the zero line nearer the patients/participant’s side rather then middle.

7. When the tape is where you want it, remind the patient/participant to breathe normally. This is important as most wont without a reminder.
8. Apply gentle pressure on the tape. Using the self tensioning tape, ensure that only one of the red beads are in view at the edge of the black cover. Refer to Fig 3. Ensure that the tape is parallel and the tension is fairly firm, not kinked or wrinkled. Read the measurement at eye level. Take the reading to the nearest 0.1cm at the end of a normal expiration.

![Image of measuring arm with tape]

Fig 3

9. Remove the tape measure gently when finished measuring.

10. Record the reading

   Comments or instructions to the patients/participant

   “Please stand in a relaxed position.”

   Please take the end of the tape. Pass it around your waist and hand it back to me. Thank you.”

   “Please help me to position the tape at the level of your waist.”

   Good now just breathe normally and relax arms by your side.”

   “Thank you.”

Reference List


Anthropometric Assessment Tools as Post operative Risk indicators in Adult Orthopaedic Patients: A Pilot Study

Page 3 of 3 2/12/08 version 1
Cited MOH 2008 protocol for collecting height, weight and waist measurements in New Zealand health monitors (NZHM) surveys, NHANES III protocol and Dietetics Association of New Zealand.

**Definition:** The circumference of the abdomen its narrowest point between the lower costal (10th rib) boarder and the top of the iliac crest, perpendicular to the axis of the trunk.

**Equipment:** Self-tensioning measuring tape

**Assessors:** Researcher Natacha Maher and Dietician Shelley Hargadon
### Waist Circumference Measurements Competency Checklist

**July 2009**

<table>
<thead>
<tr>
<th>Competency</th>
</tr>
</thead>
<tbody>
<tr>
<td>ONE: Achieved Competency Practiced on buddy</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Signed by Assessor</th>
<th>TWO: Consolidated Competency Measured waist circumference on a patient in AU</th>
<th>Date</th>
<th>Signed By Assessor</th>
</tr>
</thead>
</table>

1. Nurse ensures privacy and dignity is maintained during the W/C measurement.

2. Patient is informed and consents to W/C measurement.

3. 
   - Instructs the patient to stand upright in a relaxed manner.
   - Arms hanging by their side
   - Feet comfortably apart
   - Weight evenly balanced on both feet

4. Locates the landmark at the narrowest point of the waist as per guidelines and instruction sheet. i.e. locating the iliac crest & lower costal boarder (10th Rib)
   (Optional: Applying Micropore tape and marking point on Miropole tape with a pen can be used to temporarily mark the located point of measurement.)

5. Nurse knows that to achieve a most accurate W/C measurement the measurement should be taken next to the skin.

6. 
   - Nurse stands on right side of patient.
   - Patient holds stub end of tape measure in right hand against the skin inline with the landmarks.
   - Nurse holds casing end of tape in left hand walks around patient anti clock wise.
   - Tape measure is kept inline with the waist landmarks and is held against the skin.
   - Once back in front of patient, nurse stands on the right hand side and receives casing end in right hand.

7. 
   - Nurse holds both casing end and stub in right hand
   - Nurse ensures that the tape measure is horizontal and no kinks or twists in the tape using the left hand.

---

Anthropometric Assessment Tools as Post operative Risk indicators in Adult Orthopaedic Patients:
Page 1 of 2 13/07/09 version 2
<table>
<thead>
<tr>
<th>Competency</th>
<th>Date</th>
<th>One: Signed by Assessor</th>
<th>Date</th>
<th>Two: Signed By Assessor</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.  - Once the correct position of the tape is confirmed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Nurse takes hold of the stub end with left hand</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Pulls across to the left into the cross hand position.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.  - Tension is maintained on the tape to prevent it slipping out of place.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. - Measurement is taken at the point the tape meets at the cross over while the nurse sides on the right side of the patient.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. - Instructs the patient to breathe normally and not to hold their breath and to relax arms by their side.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. - Applies gentle pressure on the tape to ensure it is parallel with no indentations and fairly firm.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Ensures that only on red bead is visible while applying gentle tension.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Take the recording to the nearest 0.1cm at the end of a normal expiration.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. - Nurse releases the tape and pulls away gently from patient without causing any flicking of the tape maintaining patient safety.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Wipe tape after use with Alcohol based wipes i.e. “Azo wipe” or IV alcohol wipe.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. - Record W/C measurement on CDHB Pre and peri operative check sheet, blue and white QRM0000 in the vital signs box (bottom left corner).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX H:
Data Collection Sheet
ID

NHI

Gender

Codes
Female 1
Male 2

Ethnicity Codes
New Zealand European 1
Maori 2
Samoan 3
Cook Island Maori 4
Tongan 5
Niuean 6
Chinese 7
Indian 8
Other such as Dutch, Japanese Tokelauan 9

Gender
Age

Ethnicity

Smoking History
Never Smoked 1
Smoker 2
Previous smoker 3

Surgery
Total Knee Replacement 1
Total Hip Replacement 2
Hemi Knee Replacement 3
Bilateral Knee Replacement 4
Bilateral Hip replacement 5
Total shoulder Replacement 6
Hemi Shoulder Replacement 7

BMI

Waist Circumference

Pre-existing health history

1: Cardio Vascular System (CVS)
Hypertension
Chronic Fibrillation
Or other arrhythmia
Angina
MI
Cardiac other

2: Respiratory
asthma
COPD
Obstructive sleep disorder (OSD)
Other respiratory
Previous PE / DVT
Respiratory Other

3: Other
Type 1 Diabetes
Type 2 Diabetes
GORD/reflux
Other

Pre-existing health Codes
Yes 1
No 2
### Postoperative: Admission to Recovery & SCU

<table>
<thead>
<tr>
<th>Post op complication Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
</tr>
</tbody>
</table>

1: **Cardio Vascular System (CVS)**
- New arrhythmias (AFIB/SVT/VT)
- Angina
- TNI rise
- Hypotension requiring
- Phenylephrine > 4 hours post op
- Cardiac arrest
- Other CVS

2: **Respiratory**
- Oxygen saturation < 95%
- O2 4L/min
- CPAP post op only
- Other Respiratory

3: **PE/DVT**
- DVT confirmed
- PE confirmed (CPTA, X-ray, QV scan)

4: **Length of Stay**
- *Arrival Time PACU:*
- *Dx Time PACU:*
- *PACU Dx delayed medical reasons > 2 hours.*
- *Arrival Time SCU:*
- *Dx Time SCU:*
- *SCU Dx delayed medical reasons*

5: **Other**
- Post op Confusion / Delirium
- HB < 90 requiring blood transfusion
- Paralytic illus
- PONV unresolved with multiple antiemetics
- Post op dislocation
- Transfer to CPH, ICU/A&E/CCU
- Deceased
- Other:

### Admission to Surgical Orthopaedic

#### Ward (SOU) - discharge.

<table>
<thead>
<tr>
<th>Post op complication Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
</tr>
</tbody>
</table>

1: **Cardio Vascular System (CVS)**
- New Arrhythmia (AFIB/SVT/VT)
- Angina
- TNI rise
- Cardiac arrest
- Other CVS

2: **Respiratory**
- Diagnosis or Investigation PE/DVT
- Diagnosed Actalectasis
- Chest infection
- Oxygen saturation < 95%
- O2 4L/min
- Other Respiratory

3: **PE/DVT**
- DVT confirmed
- PE confirmed (CPTA, X-ray, QV scan)

4: **Length of stay**
- Exceeded expected discharge date
- r/t medical reasons or mobility issues
- Discharged to other ward / hospital
- For further rehabilitation
- Discharged home

5: **Other**
- Post op Confusion / Delirium
- Slow to mobilise (physio guidelines)
- HB < 80 requiring blood transfusion
- Paralytic illus
- PONV unresolved with multiple antiemetics
- Post op dislocation
- Any infection i.e. wound, sepsis
- Transfer to ICU or other hospital for further treatment or investigation
- Deceased
- Other:
APPENDIX I:
Early Warning Score and Management Pathway
Burwood Hospital Early Warning Score and Management Pathway

### Early Warning Score (EWS)

<table>
<thead>
<tr>
<th>Score</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airway</td>
<td></td>
<td></td>
<td></td>
<td>Patent</td>
<td></td>
<td></td>
<td>*Under threat</td>
</tr>
<tr>
<td>Breathing RR/min</td>
<td>&lt;9</td>
<td>9-14</td>
<td>15-20</td>
<td>21-29</td>
<td>≥30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heart rate/min</td>
<td>&lt;40</td>
<td>41-50</td>
<td>51-100</td>
<td>101-110</td>
<td>111-120</td>
<td>&gt;120</td>
<td></td>
</tr>
<tr>
<td>Systolic BP</td>
<td>≤80</td>
<td>81-90</td>
<td>90-100</td>
<td>101-170</td>
<td>171-199</td>
<td>&gt;200</td>
<td></td>
</tr>
<tr>
<td>Conscious level/AVPU</td>
<td>New confusion/agitation</td>
<td>Alert (A)</td>
<td>responds to voice (V)</td>
<td>responds to pain (P)</td>
<td>no response (U)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urine output*</td>
<td>≤10</td>
<td>11-20</td>
<td>21-30</td>
<td>&gt;30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temp °C</td>
<td>≤35</td>
<td>35-38</td>
<td>38.1-39</td>
<td>&gt;39</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Urine output to be averaged over 4 hrs. If no IDC score zero initially and consider bladder scan/IDC if concerned

* For severe respiratory compromise activate a Clinical Emergency

- Record and document all the patient's vital sign observations
- Using the Early Warning Score (EWS) table calculate the EWS
- Follow the Management Pathway for appropriate and timely management

### Early Warning Score (EWS) Management Pathway

#### Score 1 - 2
- Optimise treatment
- Increase frequency of recordings to Q2H or more frequently if required
- Consider medical review
- Inform nurse in charge

#### Score 3 - 5 or one score of 3
- Optimise treatment
- Increase frequency of observations to Q30 mins
- Medical review within 30 mins - call doctor Mandatory registrar/specialist telephone advice or review
- Plan to be formulated and documented
- Inform nurse in charge
- If patient not seen call Clinical Emergency Team - Emergency button or 777

#### Score ≥6
- Optimise treatment
- Observations minimum Q30 mins
- Call Clinical Emergency Team - Emergency button or 777
- Consider transfer to Christchurch
- Contact ICU Outreach registrar Pg 8155
- Plan to be formulated and documented

If unsure re EWS or for support with patient page 9111-Duty Manager

If Cardiac or Respiratory Arrest is imminent call a Clinical Emergency Immediately

If you are unsure re EWS or for support with your patient Contact Duty Manager - pg 9111

Intensive Care Outreach and Followup Service- Burwood version September 2008
References


Dobbelsteyn, C., Joffres, M., MacLean, D., Flowerdew, G., & The Canadian heart health


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